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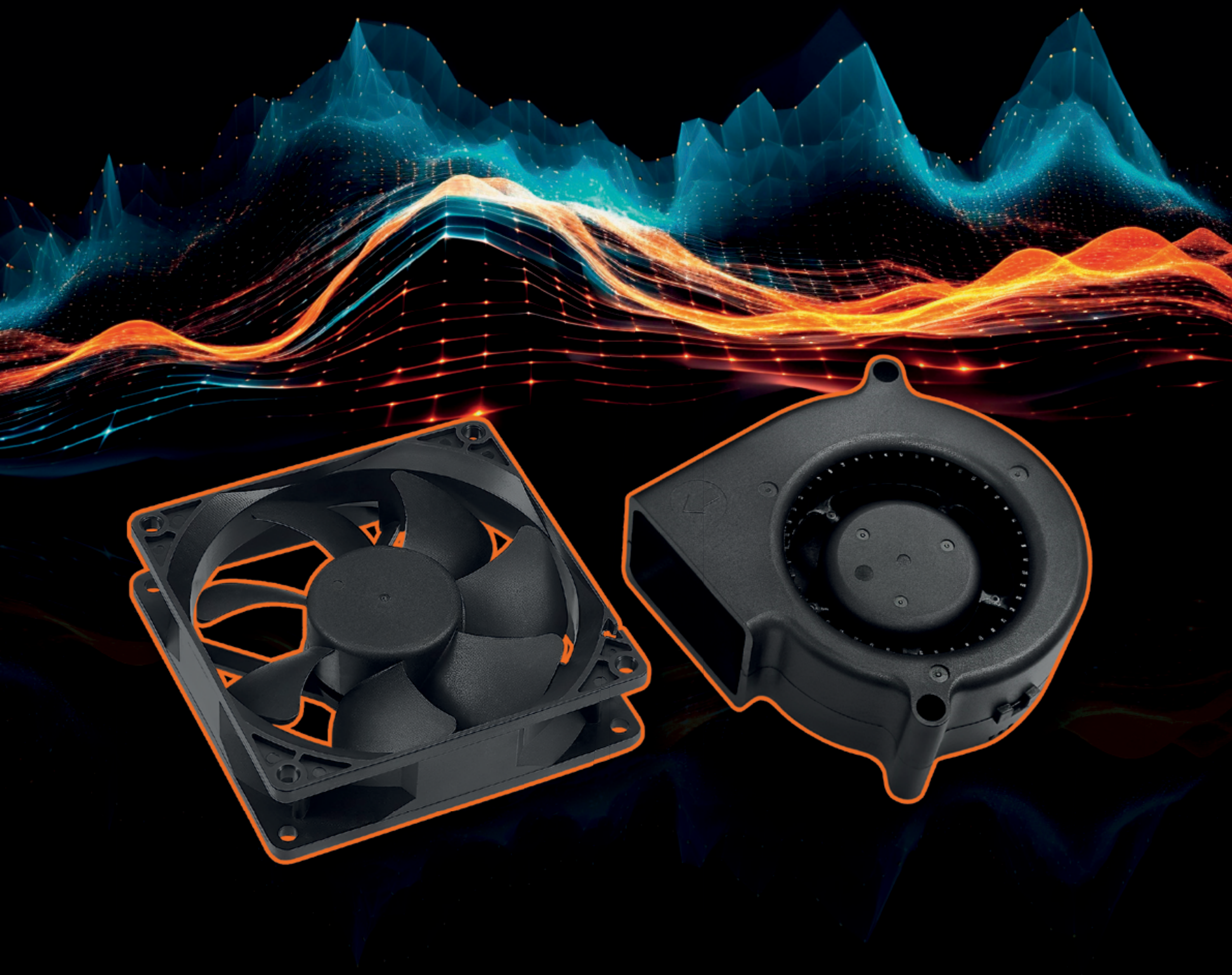
Bodo´s Power Systems®

Electronics in Motion and Conversion

April 2024



Noise Optimization of Fan-Based Cooling Solutions

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

WIDE RANGE OF MODELS

7 models available with maximum test current from 100A to 10000A and maximum pulse energy from 1350J to 15000J

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

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

Technological leader in pulsed inductance measurement for 18 years

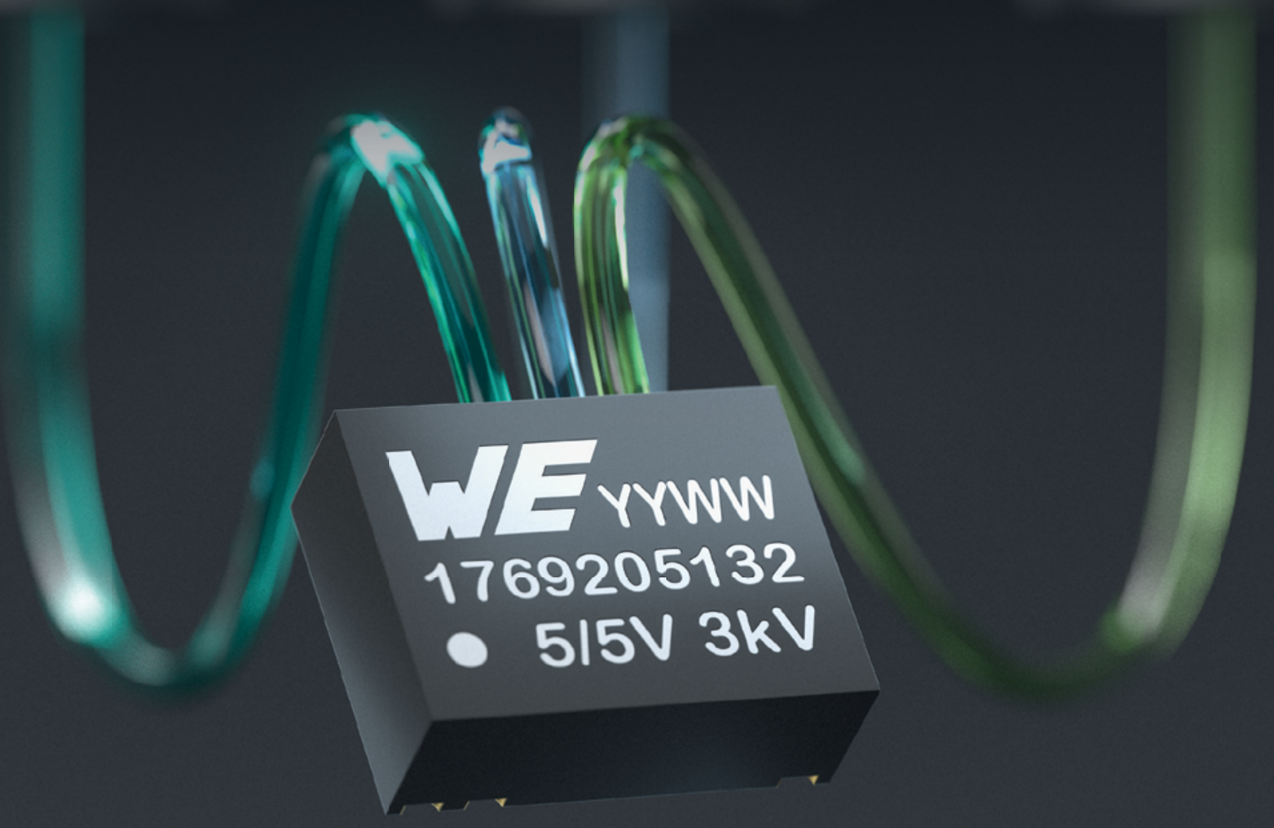
www.ed-k.de

Content

Supporters & Friends

WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

COMPACT. EFFICIENT. SILENT.
INFUSED BY INNOVATION.



© eiSos

WE meet @ embedded world

Hall 2-110

State of the Art Power Modules

The MagI³C FIMM Fixed Isolated MicroModule series combines the features of an isolated power module with those of a classic MicroModule. It is realized in an LGA-7 housing and impresses with its miniaturized dimensions. The 1 W output power can be provided up to an ambient temperature of TA = 100 °C without derating. Features like continuous short circuit protection (SCP) and dynamic power boost up to 300 mA for 500 ms ensures a robust performance for industrial applications. The module complies with EN55032 (CISPR-32) class B conducted and radiated emissions standard and requieres no external components for operation.

www.we-online.com/INFUSEDBYINNOVATION

#FIMM

Highlights

- LGA-7 housing (9 mm x 7 mm x 3.1 mm)
- Ambient temp range from -40 °C to +125 °C
- Typ. 8 pF parasitic coupling capacitance
- Efficiency up to 91 %
- Certified according UL62368-1
- Dynamic and static power boost

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Datacenter and Servers

The "Applied Power Electronics Conference" is without a doubt one of the highlights of the year, and I am very pleased that we were able to travel to Long Beach at the end of February. Visiting the US is always something special, and the concept of the event, alternating its location, gives us the chance to see different places and venues - another benefit of APEC. This year, the organizers reported that the event achieved a new record high number of attendees. Congratulations!

During the many meetings that Bodo and I had, the dominant topics were datacenter and servers, and how the continuing adoption of Artificial Intelligence (AI) and machine learning will heavily increase the demand for power, and thus efficient servers and infrastructure. The industry expects this field to grow constantly in the coming years, in both technical innovations and increased sales. Because, let's be honest, without earning any money, in the end even designing the most advanced components and techniques will not satisfy the shareholders and top management. Especially in times when electromobility, as one of the most promising industries over the last years, has seemed to slow down for some reason during recent months!

Another first at APEC was the concept they introduced on the stages within the exhibition hall. They used headphones for the audience and speakers, so the people at the stands around the stage would not be affected by any noise whatsoever. In my opinion, this was a very smart idea and I really hope this can be adopted by other events. And, as I know this question will instantly arise: Yes, they sanitized every single one after each session!

A huge THANK YOU goes out to Power Integrations for sponsoring the press room once again. It makes our work at the event so much more convenient. The press room was very busy all of the time, as you can imagine. But where were all the German editors you could meet there in past years? Who knows, but next year we'll most likely bring one of them back with us!

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

My Green Power Tip for the Month:
Let the server farms take a rest and enjoy your time off-line. Spring is coming, and the best things in life happen in the real world!

Kindest regards,

Holger Moscheik

Events

embedded world 2024
Nuremberg, Germany April 9 – 11
www.embedded-world.de

PE International 2024
Brussels, Belgium April 16 – 17
www.peinternational.net

smart systems integration 2024
Hamburg, Germany April 16 – 18
www.smartsystemsintegration.com

Power Electronics Expo 2024
Silverstone, UK April 25
www.powerelectronicsexpo.co.uk

Thermal Management Expo 2024
Novi, MI, USA April 30 – May 1
www.thermalmanagementexpo.com

Fortronic 2024
Bologna, Italy May 7 – 8
www.e-tech.fortronic.it

CWIEME Berlin 2024
Berlin, Germany May 14 – 16
https://berlin.cwiemeevents.com

ECCE Asia 2024
Chengdu, China May 17 – 20
www.ipemc-conf.com

ISPSD 2024
Bremen, Germany June 2 – 6
www.ispsd2024.com

New EMEA Headquarters for Distributor

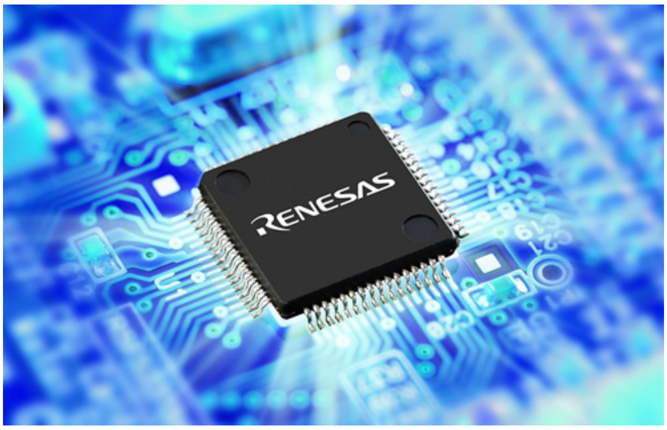
Mouser Electronics has opened its new EMEA headquarters in Munich. The opening took place in the presence of distinguished guests from customers, manufacturers, members of the media, TTI and local support companies. The new office, which is located relatively close to the Olympic stadium and directly above a subway station, is already in operation: People from 23 nations work there. Mark Burr-Lonnon, Senior Vice President Global Service provided a look at the company history from $ 21 million of sales in 2008 to far more than $ 1 billion in 2023 – and all of this just in Europe. While Europe participated less than 10 % to Mouser's worldwide sales in 2008 it contributed almost exactly one third to Mouser's worldwide turnover in 2023. And this is why Mark Burr-Lonnon invited all guests to participate in an office tour after enjoying a piece of a Mouser celebration cake, that he cut in person.

www.mouser.com

Semiconductor Manufacturer to buy PCB Design Company

Renesas intends to acquire Altium by way of a Scheme of Arrangement. The acquisition is said to enable "two industry leaders to join forces and establish an integrated and open electronics system design and lifecycle management platform that allows for collaboration across component, subsystem, and system-level design".

Together, Renesas and Altium, aim to build an integrated and open electronics system design and lifecycle management platform that unifies the steps from component selection and evaluation to simulation and PCB physical design at a system level. The acquisition brings together Altium's cloud platform capabilities with Renesas' semiconductor portfolio. The combination will also enable integration with third-party vendors across the ecosystem to execute all electronic design steps seamlessly on the cloud. The electronics system design and lifecycle management platform will deliver integration and standardization of various electronic design data and functions and enhanced component lifecycle management, while enabling seamless digital iteration of design processes to increase overall productivity. This is said to bring "significantly faster innovation" and to "lower barriers to entry for system designers by reducing development resources and inefficiencies". Altium's history began in 1985 from Australia as one of the world's first printed-



circuit board (PCB) design tool providers. The transaction has been unanimously approved by the boards of directors of both companies and is expected to close in the second half of 2024. Altium will continue to be led by CEO Aram Mirkazemi as a wholly-owned subsidiary of Renesas.

www.renesas.com

Energy Harvesting Workshop in Italy

A Workshop named EnerHarv 2024 is said "to bring together experts from around the world working on all technical areas relevant to energy harvesting, power management and its IoT applications".

This non-profit workshop, organized and sponsored by the Power Sources Manufacturers Association (PSMA), will be held in Perugia, Italy from June 26 to 28, 2024. The event will be hosted by the Noise in Physical Systems (NiPS Lab), Dept. of Physics & Geology of the University of Perugia (UNIPG).

EnerHarv's vision is "to create a focal point for experts and users of energy harvesting and related technologies to share knowledge, best practices, roadmaps, experiences and provide opportunities for collaboration to increase the uptake of such technologies". The workshop is targeted at a broad audience from industry and academia working on materials and devices for energy harvesting and storage, low-power sensors and circuits, micro power management, and their applications in powering IoT devices for health and environmental monitoring, assisted living, and monitoring of equipment and buildings. It will comprise presentations (by invitation only), demos, poster, panels sessions and time for networking activities. There is an open call for demonstrations and posters.

www.EnerHarv.com

1200-V IGBTs on 300 mm Wafers

Hitachi Energy increases its power semiconductor capacity by introducing the 300 mm wafer. The development enables more complex structures in 1200 V insulated gate bipolar transistors. Applications for IGBT include variable frequency drives (VFD), uninterruptible power supply (UPS) systems, electric cars, trains and air conditioners, among others. The larger wafer offers numerous benefits, including the potential to yield over double (2.4 times) the number of functioning integrated circuits per wafer as compared to the existing 200 mm wafer, leading to significant cost savings. It utilizes the latest fine pattern trench IGBT design, resulting in energy-efficient power conversion and control and minimizing power losses during operations. Semiconductor experts at Hitachi Energy achieved this milestone through close collaboration with a cross-functional team, including Product Management, Business Development, Research & Development, and a chip foundry partner.

www.hitachienergy.com

Start-Ups present Energy and Mobility Solutions

In order to demonstrate the impact of start-ups, The smarter E Europe, Europe's largest alliance of exhibitions for the energy industry, provides them a platform of their own: the start-up area. In hall C5, across 2,500 square meters, around 150 start-ups will have the opportunity to present their pioneering energy and mobility solutions to a wide expert audience, and to connect with established companies. The smarter E Europe and its four exhibitions (Intersolar Europe, ees Europe, Power2Drive Europe and EM-Power Europe) will take place from June 19–21, 2024, at the Messe München fairgrounds. More than 2,800 exhibitors and over 115,000 visitors from all around the world are expected to attend. The event will take place across 19 exhibition halls and an outdoor exhibition area.

www.TheSmarterE.de

Going for Mass Production: Funding Round to Support Growth for GaN Solutions

Wise-integration, a French company active in digital control of gallium nitride and GaN ICs for power supplies, has secure financing of 15 million Euros. The Series B round was led by imec.xpand with participation from other investors. The round will fuel mass production and commercial deployment of the company's flagship products, WiseGan and WiseWare, its "disruptive digital-control technology", and its support for clients globally as they adopt these solutions. It included the five investors from the previous funding and three new investors. Since its launch in 2020, the fabless company has been known as an innovator in the power electronics industry, building a portfolio of more than 10 patent families. WiseGan encompasses GaN power integrated circuits designed to maximize the benefits of GaN technology. WiseWare is a 32-bit, MCU- based, AC/DC digital controller optimized for GaN-based power supply architectures, which is said to offer simplified system design, a lower bill of materials and improved power density and efficiency. This combination enables the development of technologies facilitating chargers that are up to 3x smaller, 3x more efficient, and 3x lighter, catering to power requirements from 30 W to 7 kW. The company's target markets include consumer electronics to industrial applications to electric vehicles.

www.wise-integration.com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Application-oriented joint Event: Oscilloscope Days

Rohde & Schwarz has announced that its Oscilloscope Days educational event will return for two days, April 17 to 18, 2024. Experts from Rohde & Schwarz and partner companies will present the latest updates on fundamentals and test features for engineers using next-generation oscilloscopes, covering topics such as power electronics and EMC, as well as signal and power integrity. The Oscilloscope Days event will be hosted online over two days and will deliver insights into the accurate measurement of digital signals and power electronics for purposes including product design, development, debugging and compliance testing. Rohde & Schwarz application engineers, together with experts from long-time event partners Würth Elektronik and PE-Systems, will present measurement challenges and techniques. There will be eight online sessions of up to 30 minutes each over the two mornings, with time for questions and answers after each session. Each session will be presented in English and will include cases based on real applications. Registrants can select the sessions they wish to attend.

www.rohde-schwarz.com

Collaboration to Accelerate Automotive Electrification

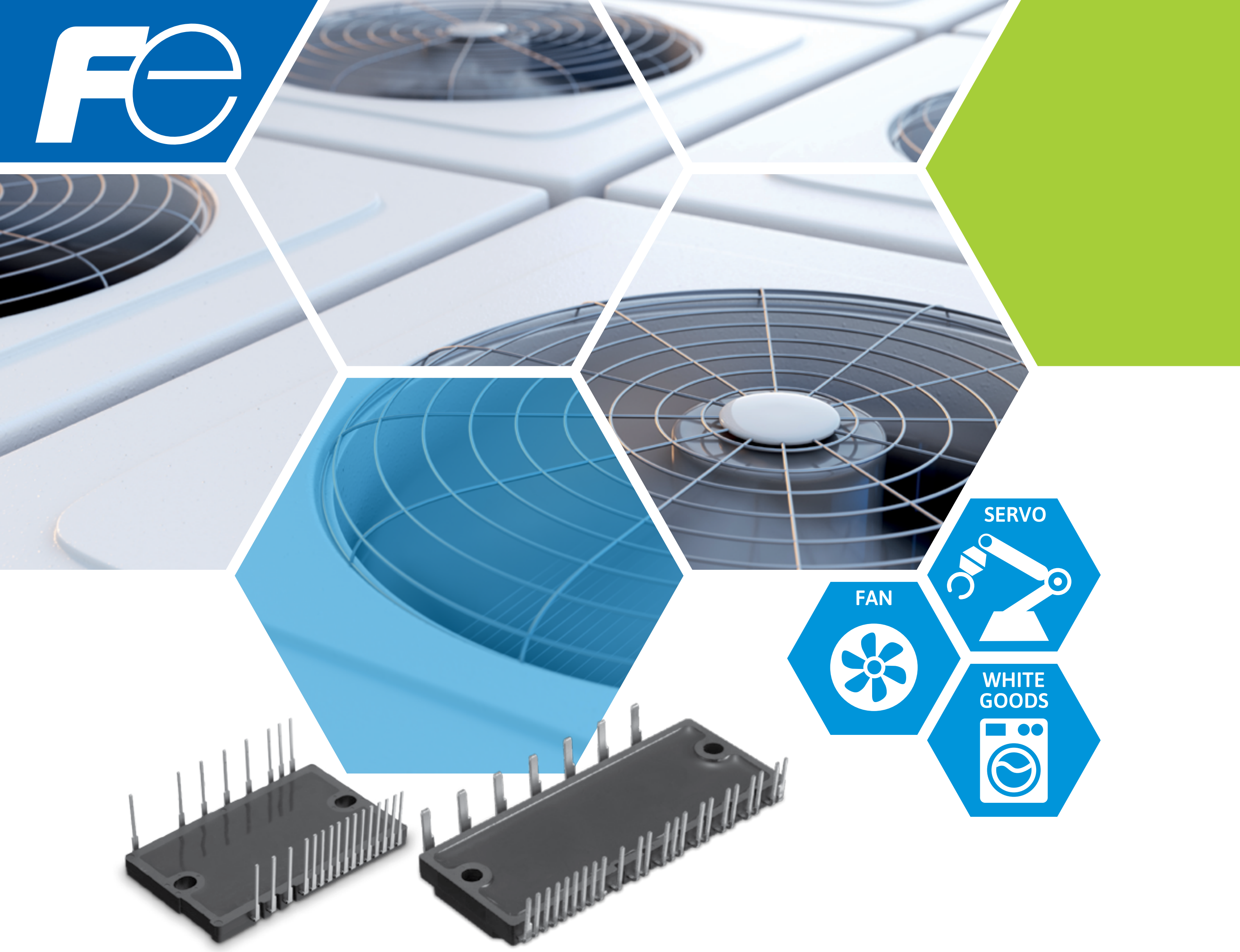
Arrow Electronics and its engineering services company, eInfochips, are working with Infineon Technologies to help eInfochip's customers accelerate the development of electric vehicle (EV) chargers. Development of EV chargers, especially DC "fast chargers," is becoming increasingly challenging to equipment manufacturers due to several factors, such as lack of prior experience, stringent functional safety and reliability requirements, and a fledgling support network. The collaboration between Arrow and Infineon aims to help innovators navigate these challenges while accelerating time-to-market. As part of the collaboration, Arrow's High Power Center of Excellence has developed a 30 kW DC fast charger reference platform. This includes Infineon's 1200V CoolSiC easy power modules and also hardware design, embedded firmware, bi-directional charging support and energy metering functionality.

www.arrow.com

Trade Show expects more international Visitors

The SENSOR+TEST is less than three months away, but preparations for the trade fair taking place in Nuremberg from June 11 to 13, 2024 are in full swing. The innovation dialog is expected to attract 400 exhibitors from Germany and abroad. Interest from international exhibitors in particular has grown once again this year. Following the traditionally strong exhibitor numbers from neighboring Switzerland, especially British and US companies have confirmed their participation. "After the abolition of entry restrictions, we are expecting more exhibitors from China than ever before and, above all, a delegation of more than 40 Chinese visitors who will be spending a week in Germany to exchange ideas," says a delighted Elena Schultz, Managing Director of AMA Service GmbH. "We will be welcoming our exhibitors and visitors back to the exhibition halls at Nürnberg-Messe in June. As things stand at present, we are expecting 400 exhibitors in halls 1 and 2 this year, which will make the exhibition even more attractive, also thanks to the expansion with a lot of highlights," says Elena Schultz. Hall 1 is already fully booked. "There are still places available in hall 2, but interested parties should not take too much longer to register, as more companies are waiting in the wings to present their innovations in Nuremberg," explains Elena Schultz.

www.sensor-test.de



Small-IPM Series – 2nd Generation

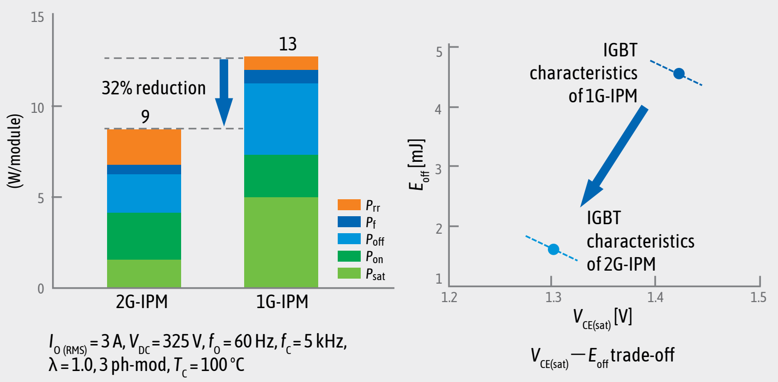
Ideal for Air Conditioners, Inverters and Servo Systems

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

www.fujielectric-europe.com
www.americas.fujielectric.com/semiconductors

Fuji Electric
Innovating Energy Technology

Joint Semiconductor Solution for BLDC Motors

AmberSemi and ST Microelectronics have jointly developed a reference design for brushless motors by using AmberSemi's AC Direct DC Enabler Power Conversion Technology and ST's STM32 MCU devices. The reference design takes a direct AC input through AmberSemi's patented AC Direct DC Enabler technology and powers the ST microcontroller, gate drivers and Hall sensors for brushless motor applications. Compared to typical brushless DC motor-control design, AmberSemi's off-line solution provides up to 5 W of regulated output, which is enough to drive today's requirement of control logic and sensors, with additional headroom for expanded intelligent functionality. The Enabler offers selectable output voltages determined by internal, configurable register settings or with a simple external voltage-divider feedback circuit. Through the integrated SPI communication port and coupled with an SPI-equipped MCU the designer can set alarm bits, protection thresholds, monitor status bits for over-current, over/under voltage, over-temperature and interrupt signals on the Enabler.

www.ambersi.com

90 Years of Materials Science Innovation

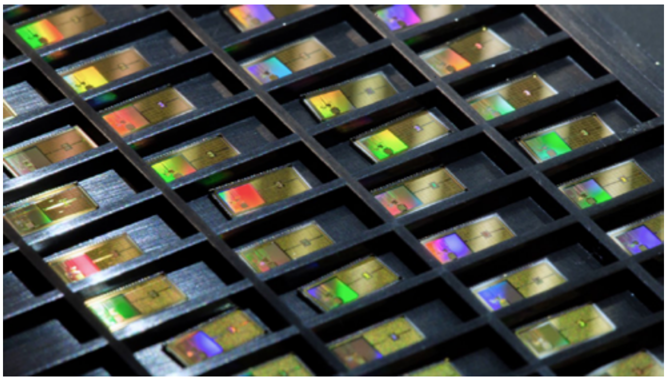
Indium Corporation commemorated its 90th anniversary on March 13. The company was founded in Utica, NY, U.S. in 1934 by Dr. William S. Murray who was instrumental in identifying and enabling the first commercially viable applications for indium metal. Today, the company is a premier materials refiner, smelter, manufacturer, and supplier to the global electronics, semiconductor, thin-film, and thermal management markets with facilities in China, Germany, India, Malaysia, Singapore, South Korea, the United Kingdom, and the U.S.

The company's products include solders and fluxes; brazes; thermal interface materials; sputtering targets; indium, gallium, germanium, and tin metals and inorganic compounds; and NanoFoil®. Currently, over 5 million EVs are on the road with Indium Corporation's proven solder and thermal management solutions for high reliability. Additionally, products such as award-winning Durafuse® LT and the company's Reclaim and Recycle initiative are at the forefront of sustainability within the industry. "This milestone is a testament to the hard work and dedication of our employees, the trust of our customers, and the support of our global partners," said President and COO Ross Berntson. "It also provides a great opportunity to reflect on our achievements, celebrate our present successes, and envision a richer future enabled by Indium Corporation's materials science."

www.indium.com

Power Converters run on Vibrational Energy

University of California San Diego and CEA-Leti (located in Grenoble/France) scientists have developed a piezoelectric-based DC/DC converter that unifies all power switches onto a single chip to increase power density. This power topology, which extends beyond existing topologies, blends the advantages of piezoelectric converters with capacitive-based DC/DC converters. The power converters developed by the team are much smaller than the huge, bulky inductors currently used for this role. The devices could eventually be used for any type of DC/DC conversation, in everything from smart phones, to computers, to server farms and AR/VR headsets.



The results were presented in the paper, "An Integrated Dual-side Series/Parallel Piezoelectric Resonator-based 20-to-2.2V DC/DC Converter Achieving a 310% Loss Reduction", at ISSCC 2024. The paper explains that a hybrid DSPPR converter exploits integrated circuits' ability to offer sophisticated power stages in a small area compared to discrete designs, and enables efficient device operation at voltage conversion ratios (VCR) of less than 0.1.

www.leti-cea.com

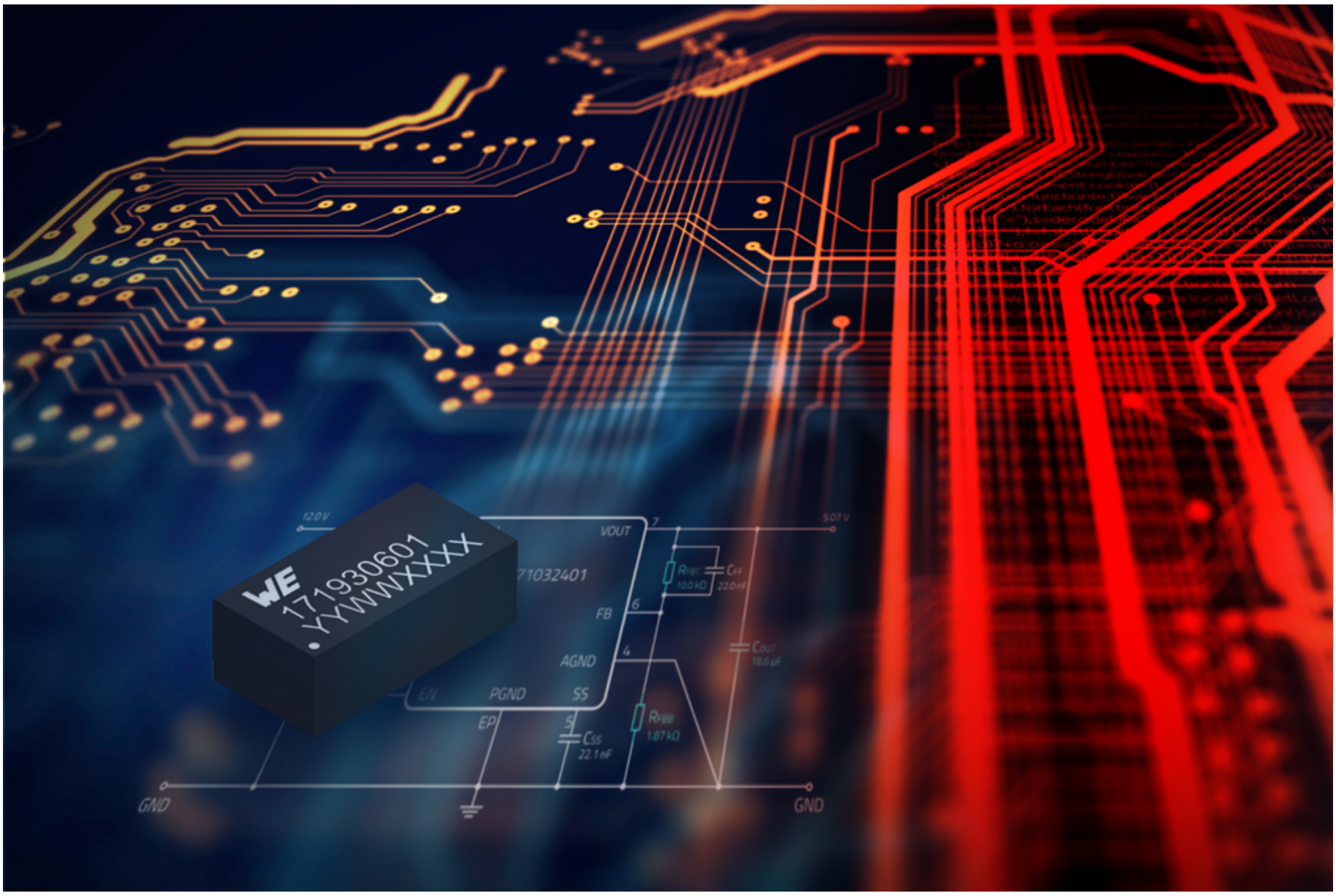
Additional Manufacturing Capacity for wBMS Semiconductors

Analog Devices (ADI) has made a special arrangement with TSMC to supply long-term wafer capacity through Japan Advanced Semiconductor Manufacturing (JASM), TSMC's majority-owned manufacturing subsidiary in Kumamoto Prefecture, Japan. Building on ADI's more than 30-year partnership with TSMC, this adds another option for ADI to secure additional capacity of fine-pitch technology nodes to serve critical platforms across its business, including wireless BMS (wBMS) and Gigabit Multimedia Serial Link (GMSL) applications.

www.analog.com

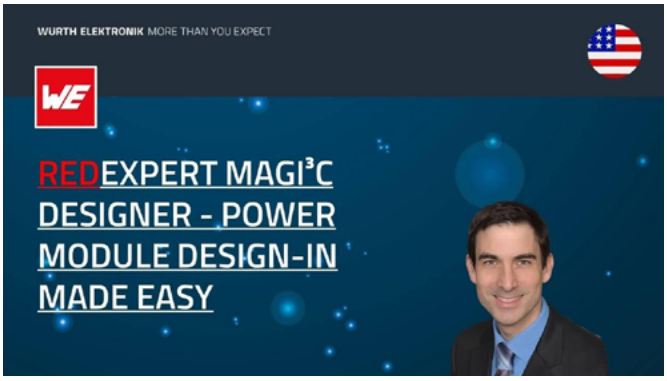
Power Module Design-in Made Easy

Würth Elektronik expands its REDEXPERT online simulation tool with the MagI³C Power Module Designer



REDEXPERT, the online platform for the simple selection, simulation, and design-in of Würth Elektronik components, now features a new function. The MagI³C Power Module Designer enables the swift and hassle-free integration of a power module into an application without requiring special DC/DC converter skills. The tool guides developers step-by-step through the entire selection and configuration process. The automatically created design proposal is rendered as a PDF file, together with a list of the components required. The tool also offers an option for the direct order of samples of selected Würth Elektronik components.

Whenever you wish to use a MagI³C power module in the development of an application, the intuitive input mask guides you through the selection process, which asks you to enter the requirements of the application, such as input and output voltage and load current. After answering questions about whether the voltage supply needs to be galvanically isolated, you're presented with an initial proposal for a suitable MagI³C power module. This proposal then forms the basis for the individual configuration of parameters; for example potentiometers for the output voltage, input and output capacitors, or switching frequency. The data for the application are then used to run a simulation of the power module, enabling you to analyse its performance parameters of the power module, such as efficiency, output-voltage ripple, and input-current consumption.



Webinar:
Introduction of MagI³C Power Module Designer in REDEXPERT

https://www.we-online.com/de/support/wissen/video-center?d=redexpert-magic-designer-power-module-design-in-made-easy

The design proposal can then be used to order the required samples directly from Würth Elektronik, which delivers components for pilot and serial production runs directly ex stock without any minimum order quantity.

www.we-online.com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POWER ELECTRONICS EXPERTS

SiC and GaN in huge Quantities

Sanan Semiconductor has moved from a pure foundry to a vertically integrated full-service semiconductor design and production company which also ships automotive-qualified components. Bodo's Power Systems spoke with Michael Sleven, Vice President Sales Europe at Sanan Semiconductor, about the company, production volumes, megafabs, a joint venture and, of course, technical issues.

By Alfred Vollmer, Bodo's Power Systems

Alfred: Sanan Semiconductor is very active in SiC and GaN semiconductors.
Where exactly do you see your core competences?

Michael: Sanan Semiconductor has more than 20 years of experience with compound semiconductors and different materials, especially for automotive applications. We are a reliable partner to deliver huge quantities in very stable quality from our megafabs. In the recent past we have started a tensioned journey to increase our portfolio also with final discrete and module packages in addition to our business as foundry. We have more than 350 patents only with SiC applications on hands, so our degree of innovation is also one of our core competencies.

Several companies offer GaN and SiC semiconductors; what is Sanan Semiconductor's advantage on the market?

We have one of the biggest vertical inline factories for SiC in the world, covering substrate materials, epitaxial growth, chip manufacturing, packaging, testing and other sections. Also, our GaN products are made on our own SiC substrates. So, we have every process step in our own hands. This makes us fast and we are able to offer attractive prices to our customers. The huge production capacities of Sanan allow a stable supply also in this challenging and turbulent times.

Michael Sleven is Vice President Sales Europe at Sanan Semiconductor

What is the advantage of manufacturing your own SiC substrates?

Substrates are the key elements for a fast and flexible delivery and are also dominating the overall costs of SiC devices. Over several years the market was strongly depending on a few companies able to serve SiC substrates. This was combined with very long lead times and high prices. With our 6-inch material we are able to deliver within 8 weeks today. We will increase our capacity again this year with a full 8-inch vertical inline fab in Changsha. I guess that substrates will become more and more important in the 8-inch world for SiC if the market demand is growing so fast.

Why does Sanan Semiconductor control the entire vertical integration from material to packaging?
What is the benefit for the customer?

Besides the mentioned customer advantages, I see a significant reduction of failure potential. We have all processes inline at one place. No transport to other locations or countries during the production is necessary.

What can we expect in terms of technical features when you'll launch the third generation of SiC MOSFETs?

We will launch further MOSFETs in our Gen2 and our new Trench structured SiC MOSFETs (Gen3) from now on in 2024. We will have a complete portfolio fulfilling AEC Q101 standards for industrial and automotive applications. With our matured wafer thinning platform of 120 µm we are using heavily doped n-substrates. The devices show high current density and very low losses. The tradeoff between Ronsp (mΩ/mm2) and Cell pitch (µm) is absolutely competitive. Beside the MOSFETs we have completed our SBD portfolio. In addition to our Gen3 SBDs for general power applications, we have started to serve our Gen4 with very low Vf and Gen5 with an increased surge current capability.

Quite recently, Sanan and STMicroelectronics announced a SiC cooperation. Why did you start this cooperation, what can we expect from it and when will we see the first real quantities?

As part of this joint venture we build another vertical inline megafab combined with an invest of 3.2 billion USD. This plant will start the mass production by the end of 2025 and will serve around 520,000 8-inch wafers exclusively for ST Microelectronics in 2028. This JV is a major step to establish Sanan further as reliable and innovative partner for high quality compound semiconductors.

Talking about volumes, what is Sanan's expected output in SiC and GaN for the next five years?

In addition to the new fab for ST in Chongqing, we have the Mega Fabs in Xiamen and Quanzhou with a monthly production capacity of 30,000 wafers each. Our newest Fab in Changsha has a production capacity of 360,000 6-inch and 400,000 of 8-inch wafers per year. Furthermore, we are prepared to start the production with 8-inch wafers for GaN if needed. So, we are very well prepared to feed the market demand for the next years.

What is the importance of the automotive market for Sanan and how do you expect it to develop?

The compound semiconductor market has changed completely during the last years. In automotive we have a high dynamic combined with strong requirements for higher current densities and costs reductions. Today we are serving most of our SiC parts to OEMs and Tiers, and the growth potential for the next years is incredibly high. For onboard chargers and drive train inverters SiC is the best choice today. To increase our business in Europe, we have established a new experienced team for the European market to support our customers deeply with calculations and simulations to define the right technologies and parts. Our FAEs have a good system knowledge of the applications, and the short response time from our team is also key for our success. The automotive market will be the biggest market in future, and so at Sanan we are following completely the VDA 6.3 process audit methodology and we are fully qualified in regards of IATF16949.

Automotive is by far not the only attractive market for WBG semiconductors. In which applications do you see the highest potential – why?

In addition to automotive the PV market is a main area for Sanan. Energy efficiency programs all over the world, mainly driven by governments, are accelerating factors. We have today only in Asia more than 200 different customers working with photovoltaic. The actual customer requests we see in Europe are showing also good opportunities for us to grow continuously. Especially the high flexibility and expertise of Sanan to develop and produce customized solutions in different housings are highly appreciated.

Do you see any SiC applications shifting towards GaN and vice versa? For which applications and why? And which shifts will we see in the future?

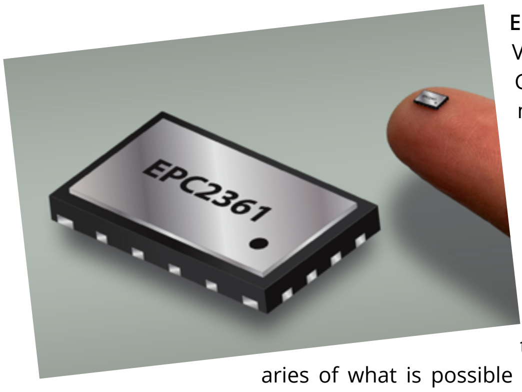
The business development with GaN is also promising. The demand growth is higher than with SiC in percentage, for sure on a different level. I see strong demand for GaN parts for power supplies and server applications, but I guess for higher power applications like inverters for drivetrains SiC will be the best choice.

www.sanan-ic.com

APEC 2024 – Exhibition Highlights

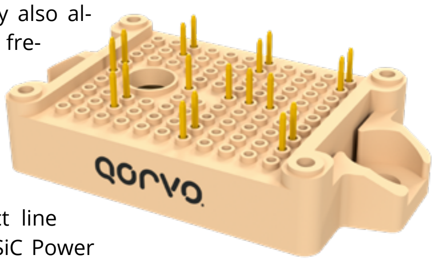
By Holger Moscheik, Bodo's Power Systems

The recent APEC event in Long Beach, CA was a real success. The organizers have reported that a new record in the number of attendees made the trip to the Long Beach Convention Center. Bodo and I attended the event and our days were filled with customer meetings, both in the press room as well as on the floor. On the following pages you will find a pick of the announcements that caught our attention, and we want to schare them with our readers.



EPC introduced the 100 V, 1 mOhm EPC2361 GaN FET in compact 3 mm x 5 mm QFN package, offering higher power density for DC-DC conversion, fast charging, motor drives, and solar MPPTs. "Our 1 mΩ GaN FET continues to push the boundaries of what is possible with GaN technology, empowering our customers to create more efficient, compact, and reliable power electronics systems," commented Alex Lidow, EPC CEO and co-founder.

Qorvo announced four 1200V silicon carbide (SiC) modules - two half-bridge and two full-bridge - in a compact E1B package with RDS(on) starting at 9.4mΩ. These SiC modules are solutions for electric vehicle (EV) charging stations, energy storage, industrial power supplies and solar power applications. "The modules in this family can replace as many as four discrete SiC FETs, thus simplifying thermomechanical design as well as assembly. Our cascode technology also allows higher switching frequency operation, further reducing solution size by using smaller external components" said Ramanan Natarajan, director of product line marketing for Qorvo's SiC Power Products business.



Infineon introduced a product family of Solid-State Isolators to achieve faster and more reliable circuit switching with protection features not available in optical-based solid state relays (SSR). The isolators use coreless transformer technology and support 20 times greater energy transfer with both current and temperature protection contributing to a higher reliability and lower cost of ownership. The solid-state isolators allow driving the gates of Infineon's MOS-controlled power transistors OptiMOS ™ and CoolMOS™ to reduce power dissipation of up to 70 percent of todays' solid-state relays using SCR (silicon-controlled rectifier) and Triac switches.

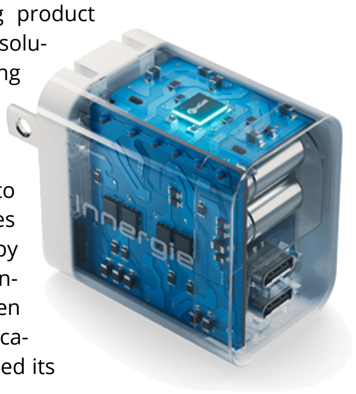
Power Integrations announced the InnoMux™-2 family of single-stage, independently regulated multi-output offline power-supply ICs. InnoMux-2 ICs consolidate AC-DC and downstream DC-DC conversion stages into a single chip, providing up to three independently regulated outputs for use in white goods, industrial systems, displays and other applications requiring multiple voltages. Roland Saint-Pierre, vice president of product development at Power Integrations said: "Most modern electronic systems rely on multiple internal voltages to operate various functions such as computing, communication and actuation function – typically heat, light, sound or motion of some kind. But losses in each conversion stage are compounded, degrading system performance and generating heat. The InnoMux-2 IC overcomes this challenge by providing up to three independently regulated voltage outputs or two voltage output and a constant current output from a single stage, achieving a compact and efficient power sub-system with low component count."

IGCT highest power density for most compact equipment

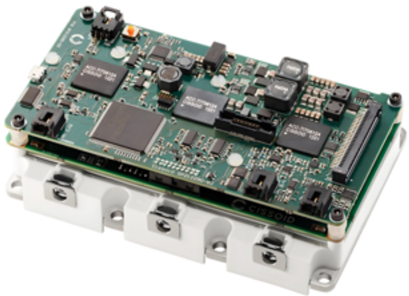
The IGCT is the semiconductor of choice for demanding high-power applications such as wind power converters, medium-voltage drives, pumped hydro, marine drives, co-generation, interties and FACTS. Hitachi Energy's range of 4500 to 6500 V asymmetric and reverse conducting IGCTs deliver highest power density and reliability together with low on-state losses.

Hitachi Energy

ROHM has announced the adoption of its 650V GaN device (EcoGaN™) in the C4 Duo, a 45W output USB-C charger from Innergie, a brand of Delta. Offering GaN-based devices under the brand name EcoGaN, ROHM is advancing product development and providing solutions by focusing on mastering the use of GaN, which has high potential but is difficult to handle. Integrating an ESD protection element into the GNP1150TCA-Z improves ESD breakdown tolerance by approximately 75% over standard GaN HEMTs, and has been evaluated to improve application reliability that ultimately led its adoption.



CISSOID released its series of SiC Inverter Control Modules (ICMs) dedicated to the E-mobility market. The CXT-ICM3SA series offers hardware and software integration of CISSOID's existing line of 3-phase 1200V/340A-550A SiC MOSFET Intelligent Power Modules (IPMs) with an OLEA® T222 Field Programmable Control Unit (FPCU) control board and OLEA® APP INVERTER application software, supplied in partnership with Silicon Mobility.

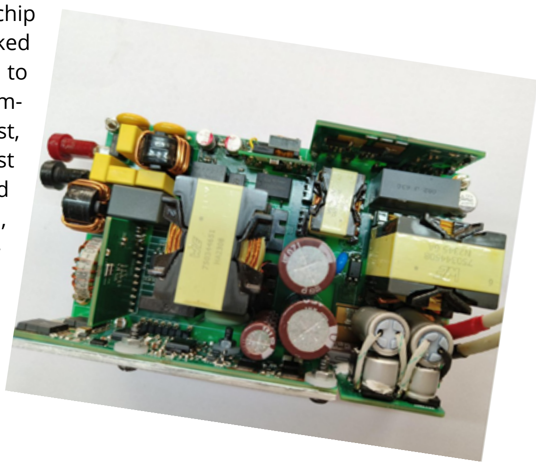


Following the mission to "Electrify our World™", the "Planet **Navitas**" exhibition booth invited visitors to discover how GaN and SiC technology enable the latest solutions for fully-electrified housing, transportation and industry. Examples ranged from TV power to home-appliance motors and compressors, EV charging, solar/micro-grid installations, and on to data center power systems. At the big "GanFast Blast" party on Tuesday night, the team celebrated the 10th anniversary of the company.

With a power density of 23 W/in^3, **Cambridge GaN Devices**' 350 W PFC/LLC reference design has an average efficiency of 93%, and a no-load power consumption of 150 mW. The CrM Totem Pole PFC + Half-Bridge LLC PSU has been realised using CGD's H2 series ICeGaN technology. "We are acutely aware of the increasing power requirements of industrial applications, and the need for high efficiency. For example, as the use of Artificial Intelligence (AI) proliferates, the power demanded by the exponential growth in power demanded by datacentres is growing almost exponentially. Other applications, such as solar inverters, amplifiers, transport and smart mobility, process control and manufacturing are also interested in GaN and the feedback we have received is that they love the simplicity of our 'Drive it Like a MOSFET' approach", said Andrea Bricconi, Chief Commercial Officer.

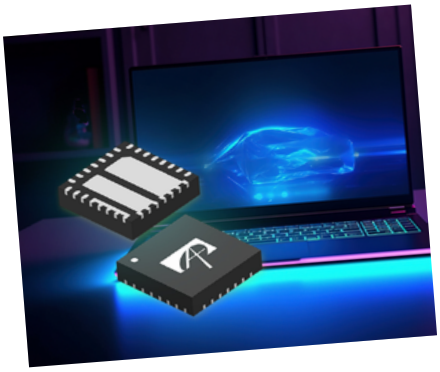
Bourns introduced a single channel basic insulation transformer with a planar structure optimized for Battery Management System (BMS) applications. It is AEC-Q200 compliant and automotive grade, and features a basic insulation layer that complies with IEC 60664-1 and IEC 62368-1 standards. This BMS transformer offers a working voltage of up to 1000 VDC and a Hi-Pot isolation voltage up to 4300 VDC or 2500 VAC with an extended operating temperature range of -40 to +125 °C.

Tagore announced a partnership with Inventchip to introduce a compact 500 W power supply reference design solution with a Totem Pole PFC front-end and an LLC back-end. The reference design uses Tagore's TP44100SG (90mOhm) and Inventchip's CCM Totem Pole controller IC in the front-end PFC section. "Implementation of CCM Totem Pole PFC in a compact footprint is non-trivial. Tagore and Inventchip teams worked collaboratively to develop a compact, robust, and low-cost solution," said Dhaval Dalal, system architect at Tagore Technology.

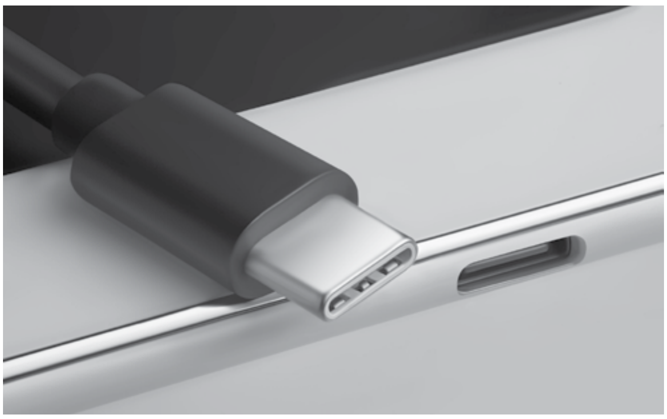


SemiQ unveiled the QSiC 1200V SiC MOSFET modules in full-bridge configuration with a high breakdown voltage exceeding 1400V. The modules withstand high-temperature operation at T_j = 175°C with minimal $R_{ds(On)}$ shift across the entire temperature spectrum. In solar inverter applications, the technology empowers designers to reduce heat loss, improve thermal stability, and enhance reliability, backed by over 54 million hours of HTRB/H3TRB testing.

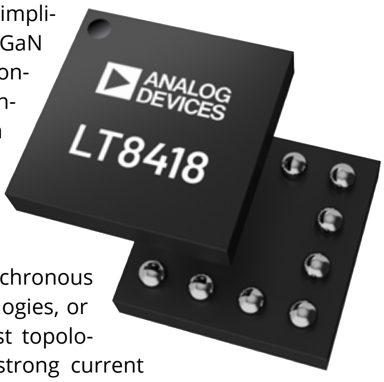
Alpha and Omega Semiconductor presented its application-specific EZBuck™ regulator. The AOZ22559QI and AOZ22539QI Constant On-Time Buck Converters are offered in a QFN 4 x 4 package and feature a PGOOD output, an integrated bootstrap diode, and an integrated soft start. Protection features include cycle-by-cycle current limit, short-circuit protection (SCP), Overvoltage Protection (OVP), and thermal shutdown.

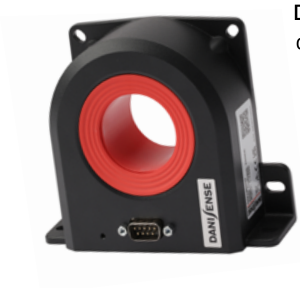


Pulsiv gave a preview to a series of reference designs and assembled modules for USB-C applications, that will deliver an average efficiency of more than 95%. This achievement, which minimises energy waste under all operating conditions, has been developed in collaboration with Innoscience and Frenetic. The front-end of the design utilises Pulsiv OSMIUM technology to efficiently manage the AC to DC conversion process with zero inrush current and no input voltage derating. Using an intelligent active valley fill approach, this patented method also enables the use of smaller system components compared to conventional designs. The DC-DC converter in the 65W variant is based on an industry standard QR flyback. However, when combining a Pulsiv OSMIUM front-end design with optimised magnetics from Frenetic, it is now possible to use an EQ20 core, which provides a 20% reduction in the flyback transformer size.



Analog Devices now offers a 100V half-bridge GaN driver that simplifies the implementation of GaN FETs, proving robust gate control, high frequency switching, and increased system efficiency. Integrating top and bottom driver stages, driver logic control, and protections, the LT8418 can be configured into synchronous half-bridge, full-bridge topologies, or buck, boost, and buck-boost topologies. The device provides strong current sourcing/sinking capability with 0.6Ω pull-up and 0.2Ω pull-down resistance for driving a variety of GaN FETs.

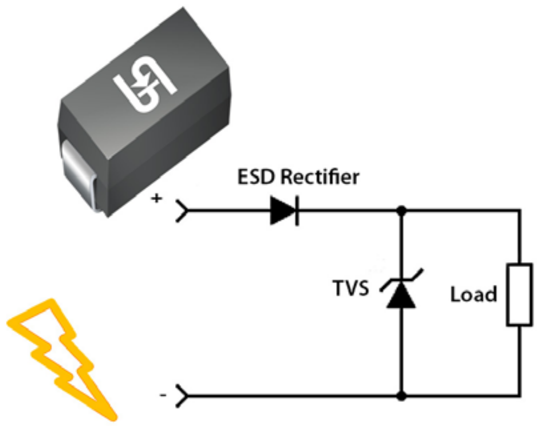




Danisense presented its current transducer mainly aimed for automotive (EV) test benches and battery testing & evaluation systems. Featuring a very large aperture of 41.2mm, the DN1000ID current transducer enables power cables with large power connectors to be easily fitted to EV test benches allowing for quick changeovers.

Vitrek introduced Gary Schafer as the company's new president. Chosen for his record of accomplishment transforming organizations while driving revenue growth, Schafer's goal is to promote the company's unique selection of complementary products offered under its signature brands: Vitrek, MTI Instruments and GaGe. To support this goal, Vitrek has also appointed Michelle Sweetman as head of marketing based on her success in corporate rebranding.

Taiwan Semiconductor announced its line of automotive-qualified rectifiers featuring ESD withstand capability. The TSD Series rectifiers simultaneously provide repetitive peak reverse voltage (VRRM) of up to 600V as well as ESD protection of >10,000V (per IEC-61000-4-2). Devices in the series have optional current ratings of 1A, 2A, and 3A and operating temperature ranges from -40°C to ±175°C. All have a maximum forward voltage drop of 1.1V and feature low-reverse leakage current and fast response time.



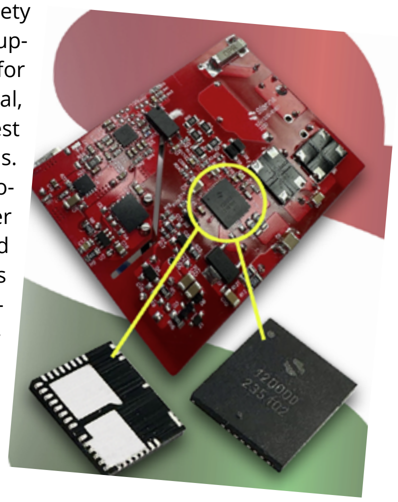
Microchip showcased the 3.3 kV XIFM plug-and-play mSiC™ gate driver with patented Augmented Switching™ technology, which is designed to work out-of-the-box with preconfigured module settings to significantly reduce design and evaluation time. It incorporates 10.2 kV primary-to-secondary reinforced isolation with built-in monitoring and protection functions including temperature and DC link monitoring, Undervoltage Lockout (UVLO), Overvoltage Lockout (OVLO), short-circuit/overcurrent protection (DESAT) and Negative Temperature Coefficient (NTC).

Murata announced the launch of three power product solutions designed to help solve the challenges, constraints, and limitations of the power electronics industry. These include the PE25208, a charge pump IC aimed to fuel the future of portable consumer electronics, including laptops and other USB PD high power applications; and the PE24109 and PE24110, two compact, low-profile, and ultra-high efficiency step-down DC-DC converter solutions for low output voltage applications targeting applications such as high density, optical transceiver modules.

Nexperia announced the release of several MOSFETs to further broaden its range of discrete switching solutions for use in various applications across multiple end markets. This release includes 100 V application specific MOSFETs (ASFETs) for PoE, eFuse and relay replacement in 60% smaller DFN2020 packaging, and 40 V Next-PowerS3 MOSFETs with improved electromagnetic compatibility (EMC) performance.

Silanna has expanded its CO_2 Smart Power Family™ of AC/DC and DC/DC converter technologies with the launch of an active clamp flyback (ACF) controller that integrates adaptive digital PWM control with ultra-high-voltage (UHV) components comprising a 700 V primary GaN FET, X capacitor (X-Cap) discharge circuit, active clamp driver and start-up regulator.

Advanced Energy sowed a variety of AC-DC and DC-DC power supplies and sensing technologies for industrial, semiconductor, medical, IT, telecommunications and test and measurement applications. These included the Artesyn® NeoPower NP08 configurable power supply, which delivers optimized power conversion in form factors up to four times smaller than conventional solutions, ultra-high-efficiency hyperscale data center PSUs, and FlexiCharge FC1500, an all-in-one high-voltage 1.5 kJ capacitor charger and low-voltage power supply.

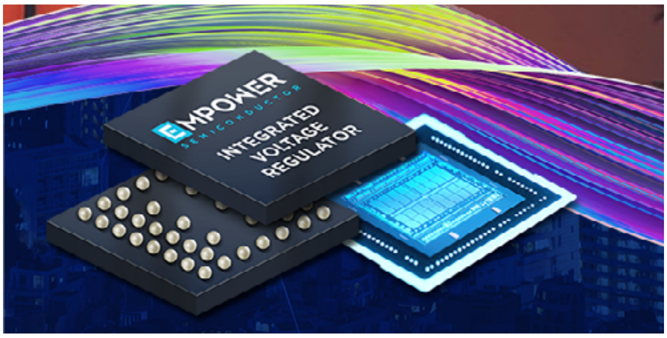


Texas Instruments introduced two power conversion device portfolios to help engineers achieve more power in smaller spaces. TI's 100V integrated gallium nitride (GaN) power stages feature thermally enhanced dual-side cooled package technology to simplify thermal designs and achieve the highest power density in mid-voltage applications at more than 1.5kW/in^3. TI's 1.5W isolated DC/DC modules with integrated transformers are help engineers shrink the isolated bias power-supply size in automotive and industrial systems by over 89%.

ITECH presented its IT2800SMU, which can be used voltage source, power source, 6 ½ digital multi-meter, pulse generator, electronic load, and as a battery simulator. It has wide voltage range up to 3000V, and a resolution of up to 100nV10fA. To accelerate the testing process for engineers, IT2800 offers free program control software PV2800 as well as a professional version of semiconductor parameter testing software.

Tektronix showcased its solutions for Wide Bandgap Double Pulse Test for SiC/GaN, 3-Phase Inverter Motor Drive Analysis, C-V/I-V Measurements of High-Power MOSFETs, and Fully Automated Turnkey Double Pulse Testing.

Empower exhibited its family of multi-rail, multi-phase regulators, which deliver upwards of 20W in 35mm^2, and shrink board space by 3x, to provide a compact solution. Now available on interposers or coupled with off-the-shelf inductors, embedded systems designers have additional choices to further simplify and accelerate the design-in process while raising the bar for efficiency. Combined with its ECAP ultra-low ESL silicon capacitor products, Empower's power management solutions achieve compactness and performance for any space constrained data-intensive applications.



Würth Elektronik released the latest edition of their guidebook; "The Trilogy of Wireless Power Transfer 2nd edition." Also released in Long Beach is Würth Elektronik's comprehensive manual, "DC/DC Handbook." "Our more-than-you-expect service was and is the foundation of Würth Elektronik's corporate success," confirmed Alexander Gerfer, CTO of the Würth Elektronik eiSos Group. "Our DC/DC Converter Handbook, which we presented for the first time at the conference, proves that we are serious about promoting innovation and knowledge transfer. True to our mission "creating together", we will continue to ensure that great ideas get the right power - through functional power supplies as well as targeted development support, especially for start-ups."

Throughout the duration of the exhibition, Würth Elektronik showcased a variety of partner demonstrations on their distinctive booth. Highlighted activities included an interactive 50W WPC Shuffleboard table in collaboration with Infineon Technology, a miniature Ferris Wheel powered by a 24V Brushless DC Motor featuring customizable LED lighting in partnership with Renesas, and an engaging bean bag demonstration game showcasing Texas Instruments Power and Motor Control Solutions.

Next year, the **A**pplied **P**ower **E**lectronics **C**onference will take place March 9 -13 in Atlanta, Georgia. We will be there for sure!

www.apec-conf.org

Noise Optimization of Fan-Based Cooling Solutions

With the advancing electrification and technical progress, e.g. in the automotive industry, active cooling is needed more and more often. If a fan is used in such instances, noise, airborne and structure borne, can quickly become a problem.
What possibilities are there to reduce noise, what must be considered and what questions should be asked, will be explained in the following article.

By Tobias Schult and Karsten Witt, Finepower GmbH

Challenges
In power electronics applications with high power dissipation, small installation space and low permissible noise levels are increasingly common, which pushes active cooling designs (with fans and heat sinks) to the limits of physical feasibility.

To find the optimal solution various factors must be considered. However, any solution will be a compromise between size, speed, sound and cost. Furthermore, the interaction of the fan with the system must be considered.

Theory & Basics
Fans can be as quiet as a mouse when blowing in free air, but as soon as they are installed in a system two issues may occur:

A) Structure-borne noise - vibrations of the fan that are carried on and amplified by the system - like in a violin case
B) Increased airborne noise - due to the air flow in the system, additional turbulence may occur creating sound – similar to how a flute works

What needs to be considered and what adjustments can be made to reduce noise?
First of all, it is necessary to pay attention to the operating point of the fan. Noise does not always increase in a straight line in step with the speed of the fan, i.e. 50% RPM does not equal 50% of the noise's total volume. Furthermore, the volume at maximum speed is also only relevant if the fan is supposed to spin at maximum speed.

The swirl or flow characteristics are different depending on the type of fan as well as on the blade geometry of the rotor, i.e. neither all axial fans nor all centrifugal fans always blow in a straight line, nor do they blow out the same amount of air at each point of their air outlets. This, in turn, affects the system, because if the airflow is disturbed, noise might occur as a result.

Drawing air out of the system can reduce the noise level, but then a fan needs to be able to withstand a higher working temperature, because it is drawing all the hot air in, increasing its own temperature.

If, on the other hand, a fan is blowing air into the system, it can be focused on a hotspot if necessary and disperse the heat or carry it away from the system's main heat source. The position of the fan in the device in relation to the user can also be a deciding factor as to which variant is better.

Using a larger fan and running it at a slower speed can quickly remedy the airborne noise due to a lower rotation speed, as a smaller fan would have to spin faster to achieve a similar result. However, in this case, the respective operating point must also be considered. A smaller fan, in comparison to a larger fan, has at the same operating point on a PQ-curve a steeper characteristic line. Depending on the operating point, this can lead to the smaller fan operating in a more optimal area of its characteristic curve, and therefore it is being quieter than the larger fan after all.

"Bigger" fan, however, does not always mean the same. It can refer to scaling in all directions, or just along the X and Y axes (width and height), or the Z axis (thickness).

The latter case increases the pressure. X and Y scaling leads to both, an increase in pressure and an increase in airflow.

$$\dot{V} \sim n \cdot D^3 \quad Airflow$$
$$\Delta p \sim n^2 \cdot D^2 \cdot \rho \quad Pressure$$
$$P \sim n^3 \cdot D^5 \cdot \rho \quad Power$$
$$n = Speed\ of\ Rotation$$
$$D = Dimension\ (xyz)$$
$$\rho = Density$$

Figure 1: Laws of proportionality to calculate impact on pressure and air flow

An adjustment of the blade geometry can optimize the fan's characteristic curve for the respective operating point and thus reduce noise development.

Changing the number of rotor blades to more or fewer blades can enable the fan to keep its performance values, while spinning slower than before, or it can turn faster, but due to less resistance, the noise's volume does not increase or it may even decrease. It also allows an influence on the frequency spectrum.

The fan's housing geometry can be optimized to reduce or change the flow of air turbulence between fan and fins, finger guard, and air inlet and outlet.

But also, the system itself, which the fan is supposed to cool, can be optimized. By, for example, changing the airflow direction, the spacing of the fan in relation to other components as well as by sealing holes, airborne-noise can be reduced, while vibration dampeners can be used to decrease or avoid structure-borne noise.

Steps of Optimization

What do you need to know about the fan and the system?

- Power consumption
- Heat Map, i.e.
  - where does the cool air need to go to?
  - what is the maximum allowed temperature for each component?
- Available installation space, preferably via a 3D model, or alternatively a sample
- Required lifetime
- Ambient temperature as well as the max. blow-out temperature => determines the necessary measures to achieve the required lifetime

Are there any references?

If possible, information about past projects with similar requirements should be obtained, of which two to three concept ideas will be chosen and then evaluated for feasibility and cost.

As a result, a standard fan, if available, that comes closest to the requirements is selected and tested. These test results are then used as reference and the standard fan may become the basis from which a customized fan will be developed.

What ways are there to avoid the development of noise?

Simulations

They help to reduce airborne noise and optimize the efficiency of the system before prototyping begins. Having said this, simulations should always be carried out by the manufacturer, because only the manufacturer knows the exact blade geometry of its fans. Without knowing that, it is only possible to roughly estimate what the outflow of the fan is. However, the outflow of the fan is often a deciding factor for, to name but a few examples, determining what shape a heatsink should have and which orientation is most efficient, or whether the blade geometry of the fan should be adapted to an existing system.

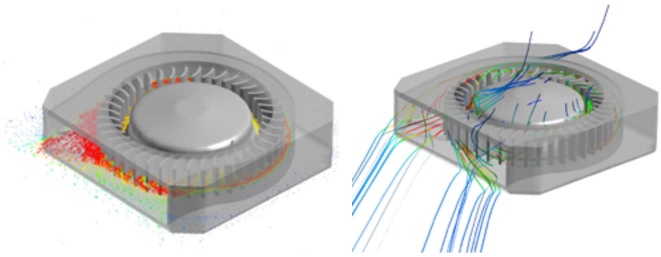


Figure 2: Flow simulation

A simulation could show, among other things:

- where airborne noise will be generated due to the air flow
- if the system has been designed with the interaction of all the thermal management components in mind
- and where material could possibly be saved or replaced if the thermal management was better aligned and tuned to function as one system, rather than individual components.

Single Component Testing

This is where noise optimization begins. It is important to note that a representative number of samples needs to be tested and measured for resonances over the entire range of their speeds, because:

a. Speed and noise do not necessarily increase with each other evenly. Due to certain conditions, noise spikes can occur at certain speeds, which means that, at times, a fan can reach higher noise levels at low speeds than it does, for example, at maximum speed.
b. Unbalance can be a problem not only at maximum speed, but also at lower speeds. It can produce vibrations and noise, as well as lead to a shortened lifetime.
c. Motor cogging torque creates vibrations that can lead to audible resonances.

Based on the results of the vibration tests and the noise spectra, appropriate changes should be made to counteract the problems.

Each adjustment is then tested again at different operating points with the system at the relevant speeds and acoustically measured using 3D printed or CNC machined samples. It should be noted that this is not only about the overall sound pressure level, but also about sound quality.

Example VW82469: no third band may protrude more than 3dB on both sides at the same time.

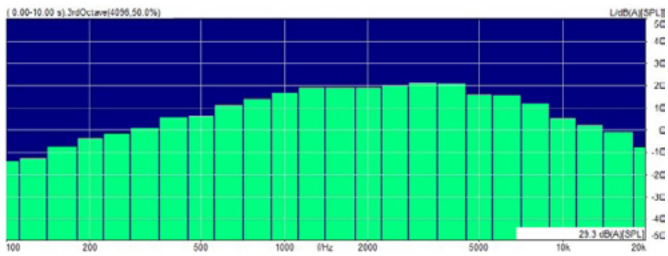


Figure 3: Diagram of Fan alone before system optimization (complies with standard)

Once the desired result has been achieved, it is necessary to condition the fans, depending on the customer's requirements and industry standards, i.e. exposing the fans to various environmental conditions in a controlled environment, such as very high and low temperatures, often alternating, salt water as sprayed mist or immersed in a salt water bath, and by running the fans constantly for a very long time under certain conditions.

After conditioning or at regular intervals during the process, the influence of the conditioning on the fans in terms of noise and other parameters is tested in more detail, in so-called parameter tests. And if necessary, further improvements will be made.

Conducting such test series is often the norm in industries with very high reliability requirements, such as the automotive industry, the energy sector and others. The described tests as well as further tests are carried out in parallel or in sequence to qualify fans for use under difficult conditions.

System Testing

After successful simulations and tests on single components, or in parallel with these, in-system tests are carried out, based on various industry standards, e.g. VW82469, which has been specifically developed for sound quality characterization, or the corresponding standards of other manufacturers. Physical tests are necessary, for several reasons, to name but one, a spectral survey like the VW82469 cannot yet be simulated reliably enough.

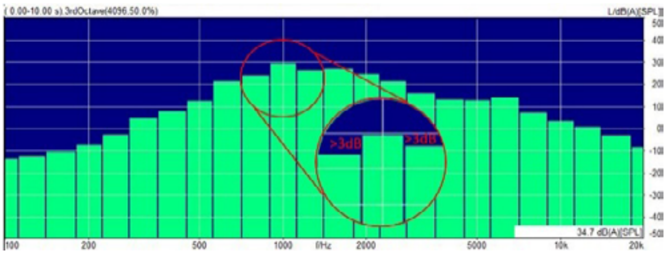


Figure 4: Diagram of Fan in the system (does not comply with standard)

These tests are part of the most important and final steps to virtually eliminate the risk of having to re-design the fan or the system shortly before the start of series production.

In this context, particular attention should be paid to vibration tests, to ensure there is no transmission nor amplification of structure-borne noise, because vibrations in the system can be much more pronounced than that of a single fan.

In existing systems where only the fan is replaced, system tests are often just another part of the parameter tests during the B-Sample and C-Sample phases of each individual component, i.e. during the noise optimization that was outlined in the "Single Components Testing" paragraph.

If a system is developed in parallel with the fan, and thermal management and system are supposed to be properly aligned, then fan manufacturers need samples of their customer's system, preferably from after design freeze, because any deviation from the final design could potentially contribute to less accurate results and prolong the optimization.

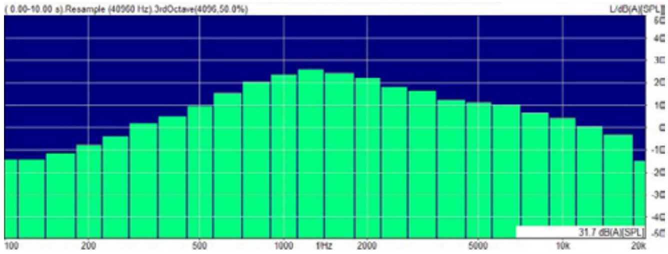


Figure 5: Diagram Fan after optimization in the system (complies with standard)

The conditioned fans, as well as new fans, are installed in the system and parameter tests are carried out again, i.e. during the B-Sample phase, the system together with the fan is tested, usually in several runs, as previously mentioned in the paragraph "Single Components Testing" and then both, the fan and the system are optimized. This could be modifications to the fan, or other system components, such as a heatsink that is being reworked to eliminate air resistance, or openings that are responsible for noise or other drawbacks to the system. Once the optimization with the B-Samples is complete, the so-called design validation tests (DVT) begin, for which C-Samples will be used, i.e. tooled parts based on the final design resulting from the B-Sample phase. Normally, there should be no more surprises in the C-Sample Phase and at most fine-tuning should take place. In cases where an exception occurs, and there are issues, another cycle of optimization and testing would follow. Otherwise, at the end of the DVT, the C-Samples would be transferred to series production.

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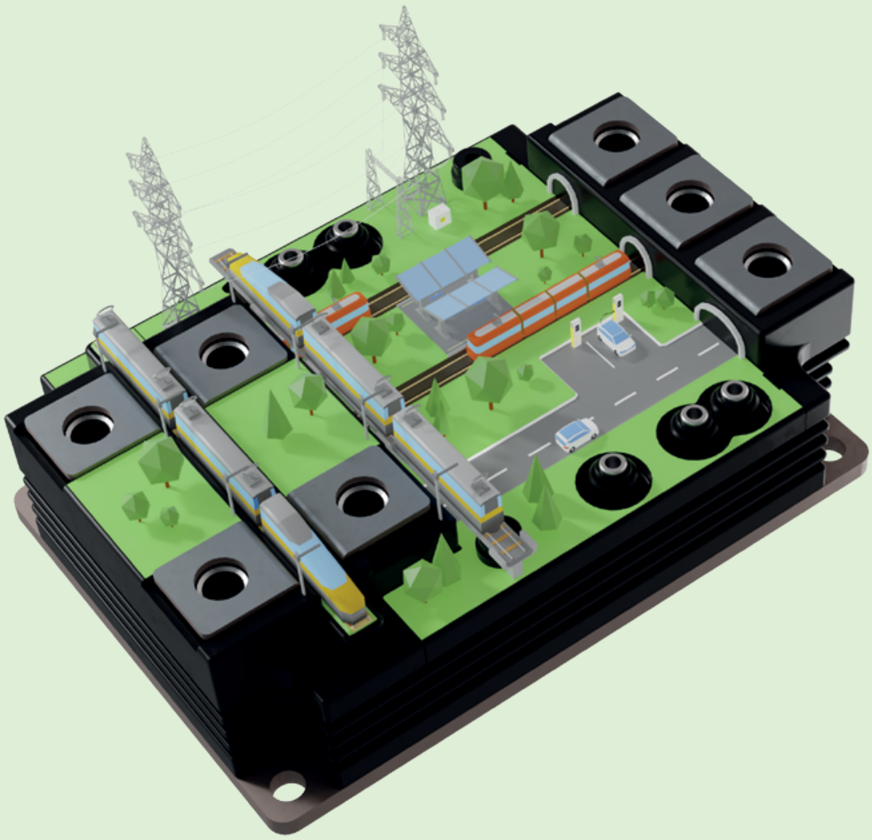

Cost- and Energy-efficient Bridgeless Totem-pole PFC with SiC Hybrid Discrete IGBT

Industrial power supply applications, such as telecom and servers, require cost-effective and highly efficient solutions. This article presents a price-performance analysis of the totem-pole (TP) power factor correction (PFC) topology as compared to other topologies, such as interleaved boost topology or TP-PFC with SiC MOSFET and synchronous rectification, using the 650 V CoolSiC™ hybrid discrete IGBT, which incorporates TRENCHSTOP™ 5 IGBTs co-packed with 6th generation CoolSiC Schottky diodes in the same package.

By Syeda Qurat ul ain Akbar and Jaeeul Yeon, Infineon Technologies Austria AG

Motivation

Efficiency and power density are critical considerations in industrial power supplies. Particularly in telecommunication and server applications that operate 24/7 continuously [1-2]. This has motivated power converter designers to develop topologies and use semiconductor technologies that enable smaller, lighter, and more powerful systems with lower costs of ownership. The newer regulatory and energy labeling requirements have also set higher efficiency standards. The 80 Plus® efficiency rating is fast becoming a widely accepted benchmark for power supplies [3]. However, to meet the regulatory requirements for harmonics standards, a PFC stage is essential. This may cause additional losses and increase system costs. To address this, PFC circuits have to utilize converter topologies that provide optimal efficiency, performance, and cost effectiveness. This paper demonstrates that the CoolSiC Hybrid discrete IGBT in a bridgeless TP-PFC topology can meet the requirements of the 80 Plus Titanium grade, enabling power supply manufacturers to achieve higher efficiency while meeting regulatory requirements at a lower cost.

Efficiency, power density, and cost effectiveness in industrial power supplies

Power supply units, typically, use a two-stage design consisting of an AC-DC PFC stage and a DC-DC converter stage implemented in various configurations. Infineon's EVAL_3KW_2LLC_CFD7 evaluation board includes a DC-DC converter stage utilizing a two-phase LLC configuration. It offers 98 percent efficiency over the entire load range and enables reliable use of the half-bridge (HB) LLC topology with significant thermal benefits [4]. The AC-DC PFC stage commonly uses the classic boost topology that requires only a single active power switch. However, the full-bridge diode rectifier stage preceding the boost PFC stage accounts for a significant portion of the total loss in the PFC stage [5]. At higher power levels, interleaved boost PFC stage is employed to improve the efficiency of the power supply, but it requires more components, including multiple inductors and power switches, that increase system cost. To overcome the limitation of the boost topology, the bridgeless TP topology can be adopted. The utilization of CoolSiC Hybrid discrete in this topology offers a highly efficient, cost-effective solution for high power switched mode power supply (SMPS) applications.

650 V CoolSiC Hybrid discrete

CoolSiC Hybrid discretes offer two significant advantages over conventional IGBTs equipped with silicon-based, co-packed diodes:

- Significantly lower the switching losses
- Improve the electromagnetic compatibility (EMC)

The CoolSiC Hybrid discrete doesn't experience diode's reverse recovery, reducing losses in both the IGBT and diode. Its turn-on energy and switching slopes are almost independent of temperature. Measured data in Figure 1 indicates that the total switching energy can be halved compared to conventional IGBT co-packed with Si-diode [6].

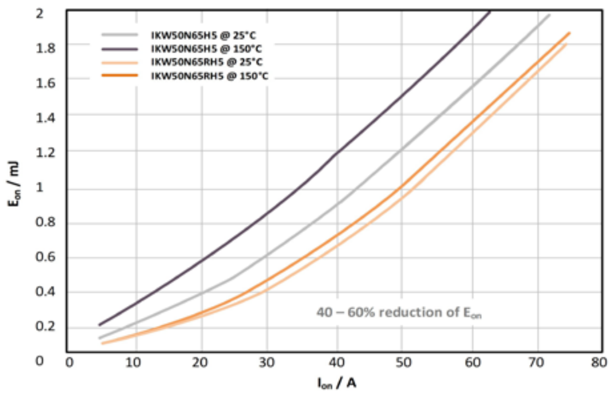

Figure 1: Comparison between the turn-on energy loss of the CoolSiC Hybrid discrete (IKW50N65RH5) and a conventional TRENCHSTOP 5 (IKW50N65H5)

Totem-pole PFC with CoolSiC Hybrid discretes

A bridgeless TP-PFC typically uses wide bandgap (WBG) devices in the high frequency (HF) leg and synchronous rectification, using silicon (Si) MOSFETs with very low RDS(on), in the low frequency (LF) leg to achieve higher efficiency. This results in a significant increase in the system cost. The continuous conduction mode (CCM) bridgeless TP-PFC requires low loss diode operation with fast reverse recovery performance of the switching device employed in the HF leg.

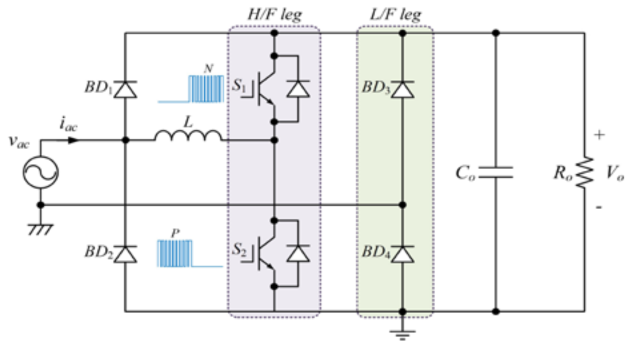

Figure 2: Bridgeless TP PFC with hybrid discrete devices and conventional rectifier diodes in the LF leg


RT Box 3

The CoolSiC Hybrid discrete IGBT combines the advantage of a SiC diode and a fast-switching silicon IGBT, offering significant switching performance improvement. It maintains the higher switching frequency required for smaller form factors and provides lower system costs compared to WBG device solutions. Moreover, as the IGBT in the CoolSiC Hybrid discrete is a unidirectional device, the reverse current flows through the SiC Schottky diode of the duopack, simplifying the drive scheme, unlike a bridgeless TP-PFC that uses WBG devices and a synchronous rectifier with low $RDS_{(on)}$ Si MOSFET.

System evaluation and results

A PLECS [7] simulation was performed to verify the performance of the CoolSiC Hybrid discrete in TP-PFC. The simulation results were as follows:

- Interleaved boost with fast-switching Si-IGBT and SiC diode: Higher power losses compared to the CoolSiC Hybrid discrete in a bridgeless TP-PFC
- TP-PFC with synchronous rectification using an 18 mΩ Si MOSFET in the LF leg and 48 mΩ SiC MOSFET in the HF leg: Significantly lower power losses, especially for light to medium loads
- Bridgeless TP-PFC with the CoolSiC Hybrid discrete in the HF leg and a 25 A conventional bridge rectifier (BR) in the LF leg: Lower total power losses in the semiconductor devices compared to conventional interleaved boost PFC. This was due to lower conduction loss in the rectifier diodes.

Figure 3 shows a comparison between the three different scenarios.

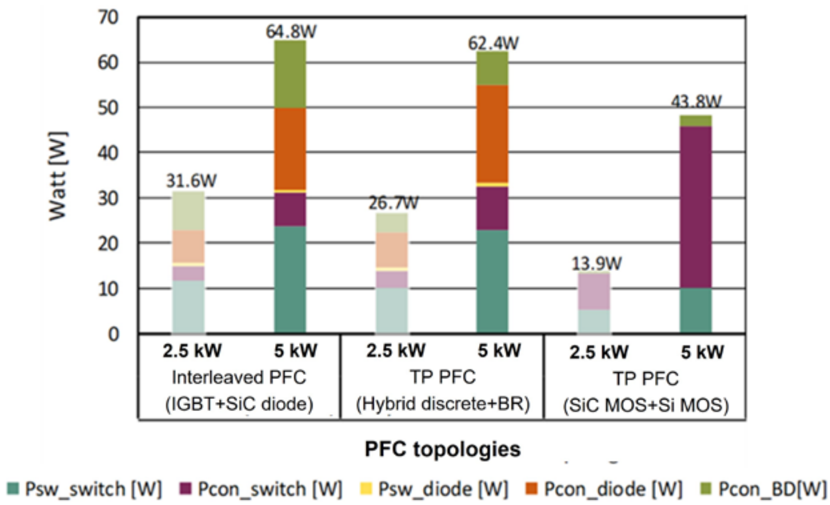

Figure 3: PLECS simulation of power losses in the semiconductor devices

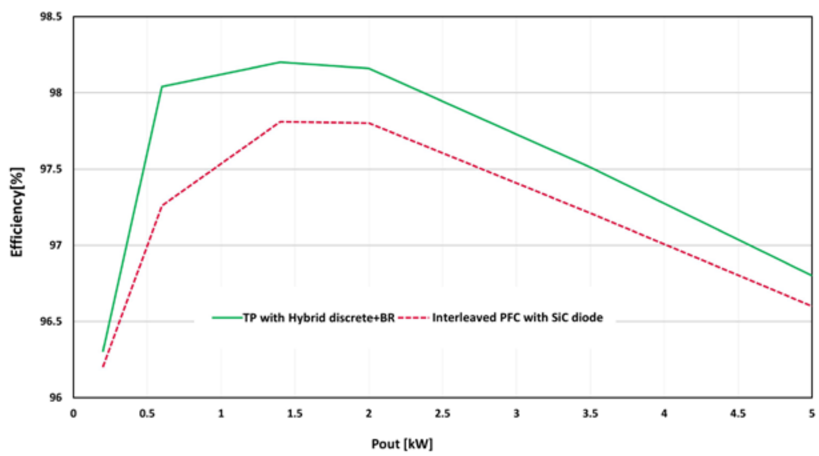

Figure 4: Efficiency of TP with CoolSiC Hybrid discrete

The simulation results were verified through experimental measurement that are presented in Figure 4. Efficiency curves tested at a switching frequency of 65 kHz revealed that the bridgeless TP-PFC with CoolSiC Hybrid discrete offered improved efficiency over the entire load range compared to the conventional interleaved PFC, with the peak efficiency exceeding 98 percent.

Furthermore, a cost analysis indicated that the cost of a TP-PFC implemented with the CoolSiC Hybrid discrete might be 12 percent lower than that of a conventional interleaved PFC. It is because, in this case, the TP-PFC requires only a single inductor and two hybrid devices instead of two inductors, two SiC Schottky diodes, and two main switches required by the interleaved boost PFC. The system costs of TP-PFC with a WBG solution are considerably higher due to the costly components.

Finally, an experimental analysis was performed on a complete system comprising a TP-PFC and a two-phase LLC connected in series. The measurements indicated the efficiency at 10 percent, 20 percent, 50 percent, and 100 percent load to be 93 percent, 94.28 percent, 96.02 percent, and 95.6 percent, respectively. This overall system efficiency measurement confirms that the TP-PFC solution meets the 80 Plus Titanium grade with a peak efficiency of over 96 percent, and that its efficiency at full and light loads is well above the specifications for the 80 Plus Titanium grade.

Conclusion

To summarize, this article evaluated and validated the efficiency and cost benefits of a bridgeless TP-PFC topology using 650 V CoolSiC Hybrid discrete IGBTs. The results showed that the TP-PFC with CoolSiC Hybrid discretes and rectifier diodes offers better efficiency and lower system bill of materials (BoM) cost compared to conventional interleaved boost PFC. It meets the 80 Plus Titanium grade with a peak efficiency of over 96 percent, thereby, providing the best price-performance ratio for industrial power supplies that operate continuously over an extended period.

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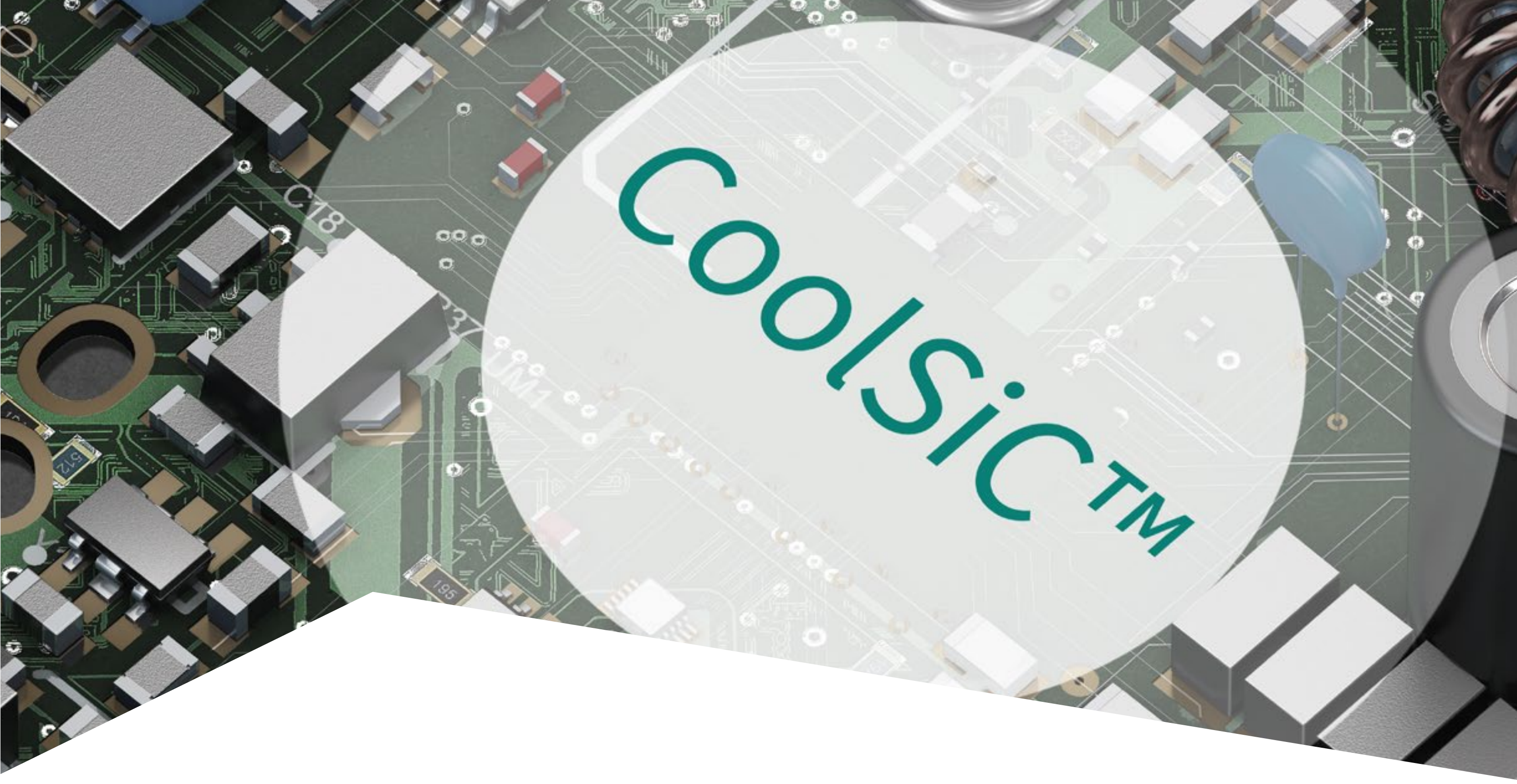

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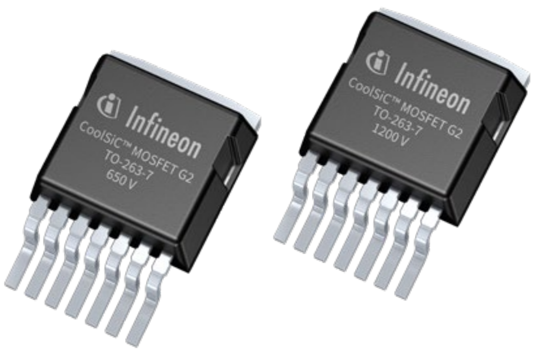


More information here

Wireless Power Transfer (WPT)

We are all familiar with the rechargeable toothbrush or the phone charging pad that use low power wireless power transfer, but what challenges lie ahead for high power wireless charging, for example, for an electric vehicle (EV)?

By Steve Roberts, Innovation Manager, RECOM Power

Almost all owners of plug-in electric cars rely on a heavy and expensive cable to connect the vehicle to the electric vehicle charger. The cable is expensive because it must be thick enough to carry the required peak charging current (typically from 11kW up to 100kW or more), tough enough to withstand being carelessly thrown in the back of the car or used in inclement weather and be robust enough to withstand repeated plugging and unplugging operations. Even so, the cable and connectors have a limited lifetime and will eventually become unsafe, worn or damaged by daily use. A better solution would be to dispense with the cable and connectors completely.

Figure 1 shows a concept for a wireless electric car charger. The vehicle would be simply parked over a charging coil and power would be transferred by inductive wireless power transfer to recharge its batteries. Wireless communication would ensure that power was only transferred when it is safe to do so, much as a modern mobile phone communicates with a Qi-enabled charger pad to ensure that no foreign objects are present in the charging field before power is applied.

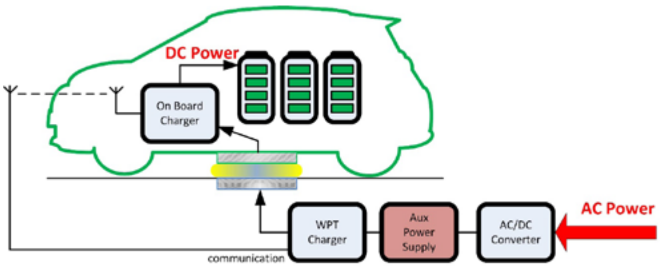


Figure 1: EV wireless charging concept

The main difference between a mobile phone and EV wireless power charger is the power levels used. For a high-power wireless charger, efficiency must be maximized, whereas phone chargers are typically only 70% efficient, according to the Wireless Power Consortium. This figure is acceptable for a low-cost commodity product, but would be wasteful for an EV wireless charger, where a system efficiency figure of closer to 85% is required (AC power to DC power)

There are three ways in which the power transfer efficiency can be improved: more tightly coupled magnetic circuits, higher frequency operation and better matching, but first let us look at the basics of wireless power transfer technology.

Wireless Power Transfer Basics

WPT technology dates back to the late 1800's when Heinrich Hertz demonstrated high frequency spark gap wireless power transfer using two parabolic reflectors to focus RF radiation. Nikola Tesla also experimented with coupled electromagnetic resonance circuits just before the turn of the century, but there is no evidence that he succeeded in transferring meaningful amounts of electrical power. The earliest successful demonstration of Inductive power transfer was in 1910 to illuminate a light bulb held over an open transformer, but again this was not turned into a practical wireless electricity product. Despite the lack of commercial success, these early pioneers laid the groundwork for some of the main wireless power transmission technologies used today:

WPT Method	Range	Frequency	Uses
Inductive	short	kHz-MHz	Electric toothbrushes
Magnetic Resonant Coupling	mid	kHz-GHz	Phone Chargers, EV chargers
Capacitive Coupling	short	kHz-MHz	Biomedical implants
Microwave	long	GHz	Satellites
Laser	long	THz	Drones

For capacitive and magnetic WPT systems, the energy stored in a unit volume of air between the transmitter and receiver is given respectively by:

$$W_e(electric\ field) = \frac{1}{2}\varepsilon_0 E^2$$

$$W_m(magnetic\ field) = \frac{1}{2}\mu_0 H^2$$

Where E and H are the intensity of the electric and magnetic fields respectively and and are the permittivity and permeability values for free space. As is higher than , about a thousand times more energy can be transferred in a coupled magnetic field than a capacitively coupled field when practical voltage and current limitations are considered. Therefore, inductive and magnetic resonance coupling lend themselves to the highest power transfer.

Essentially, inductive charging systems use a transmitter coil to generate a localized magnetic field which is coupled into a receiving coil via mutual inductance (Figure 2):

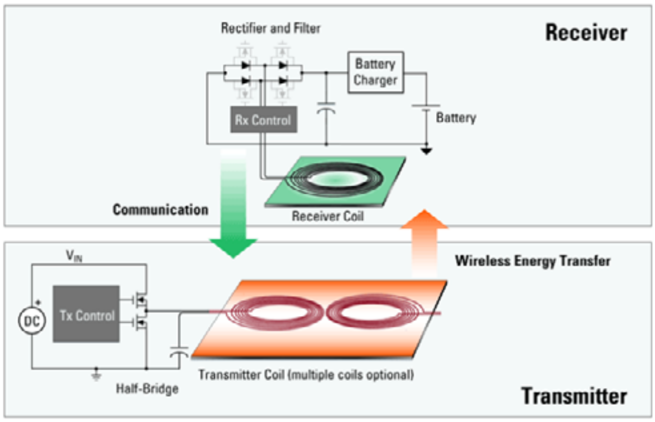


Figure 2: Inductive wireless power transfer schematic (Figures 2, 3 and 4 are from the RECOM AC/DC Book of Knowledge, Chapter 10.)

The mutual inductance, M, between the transmitter and receiver coils is given by the deceptively simple equation:

$$Mutual\ Inductance, M = k\sqrt{L_t L_r}$$

Where L_t and L_r are the winding inductances of the transmitting coil and receiving coil respectively and k is a coupling coefficient, which is dependent on the dimensions, number of turns and alignment (orientation and separation) of the coils (Figure 3):

EV STATION

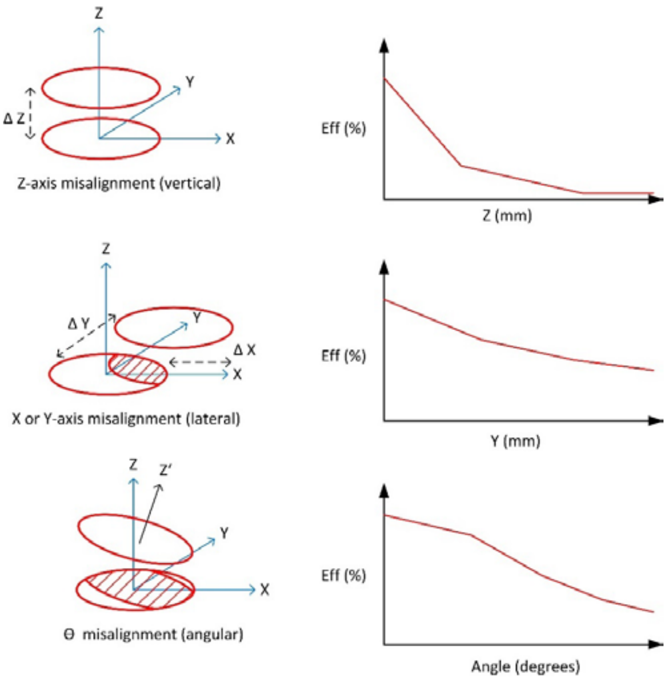


Figure 3: Effect of various flat coil misalignments on inductive power transfer efficiency

The coupling coefficient can be enhanced by inserting intermediary coils which act as 'magnetic lenses' to focus the magnetic flux (Figure 4). Higher power resonant inductive coupling systems may use three or more of these coils. These intermediary coils are resonant tank circuits with a capacitor in parallel with the winding which resonates at the frequency of the alternating magnetic field (Figure 5). The resonators boost the effective magnetic field strength from the transmitting coil and concentrate the effective received field into the receiving coil, increasing the coupling efficiency significantly. Additionally, even if only part of the projected magnetic flux is intercepted by the intermediary circuits, they will still resonate, so separation distance and alignment are not so critical as with two simple flat coils.

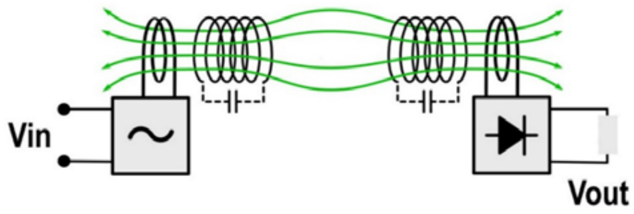


Figure 4: Resonant inductive coupling using intermediary resonators

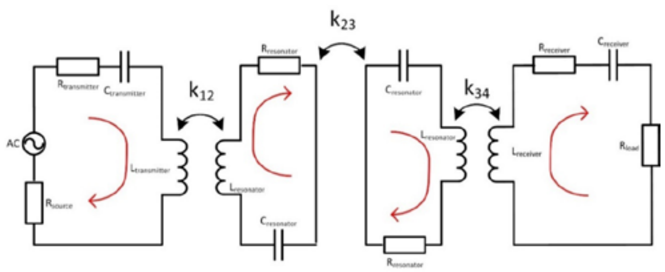


Figure 5: Equivalent circuit model of a WPT with intermediary resonators

The intermediary resonators do not have to be placed symmetrically as shown in Figure 4 – if the limiting factor for power transfer is sufficient magnetic flux, then paired resonators placed close to the transmitter coil will magnify the local magnetic field through the coupling factors k_{12} and k_{23} for a stronger coupling factor k_{34} to the more distant receiver coil.

Such intermediary coils are essential for WPT applications where the distance and alignment between the transmitting and receiving coils is not fixed, for example in an electric road that recharges a moving vehicle driving over it. Tesla, amongst other companies, have built prototype in-road charging systems where the vehicle has underbody spring-loaded metal power connectors to recharge while on-the-go, but Detroit in the USA is the first city in the US that has implemented a contactless in-road charging system based on wireless power transfer[1]. The system successfully demonstrated a charging rate of up to 19kW.

High Frequency Wireless Power Transfer

It would be possible to carry out charging by induction by using the low frequency 50/60 Hz alternating current available from the mains supply, but this would be inefficient for higher powers.

The higher the transmission frequency, the more power can be transferred according to:

$$P_{out} = \omega_0 M I_t I_r$$

Where the output power, P_{out}, is equal to the angular frequency at resonance, ω_o, multiplied by the mutual inductance, M, the current in the transmitting coil and the resulting induced current in the receiving coil, I_r. Thus, the transmitted power is directly proportional to the frequency of the alternating magnetic field. However, core eddy current and switching losses increase with higher frequency, so there is an optimum WPT operating frequency which is dependent on other system parameters for peak inductive power transfer efficiency.

With existing high power switching technology, a resonant frequency of between 20kHz and 150kHz achieves the best results.

The final significant factor affecting the system efficiency is the matching of the supply, coil and load resistances. The maximum power transfer efficiency (PTE_{max}) can be derived from the following relationship (at resonance):

$$PTE_{max} = \frac{\omega_0{}^2 M^2 R_L}{R_t(R_r + R_L)^2 + \omega_0{}^2 M^2 (R_r + R_L)}$$

Where R_L, R_t and R_r are the load, transmitter and receiver ohmic resistances respectively.

For best performance, the resistance of the load, receiving coil and transmitting coil should all be the same.

This creates some practical problems in the design of the WPT system. The high current power supply front end and inverter for the transmitter has a very low internal impedance, so a high frequency impedance matching transformer may be needed to get the highest coupled transmission power to the coil. Similarly, the load is a battery pack with a non-linear internal resistance characteristic which is dependent on its state of charge, so a DC/DC on board charging (OBC) unit will be required which can be impedance-tuned for optimum power reception, much like the maximum power point tracking (MPPT) circuits used in photovoltaic DC/DC converters (Figure 6).

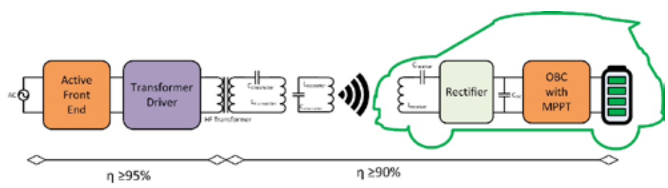
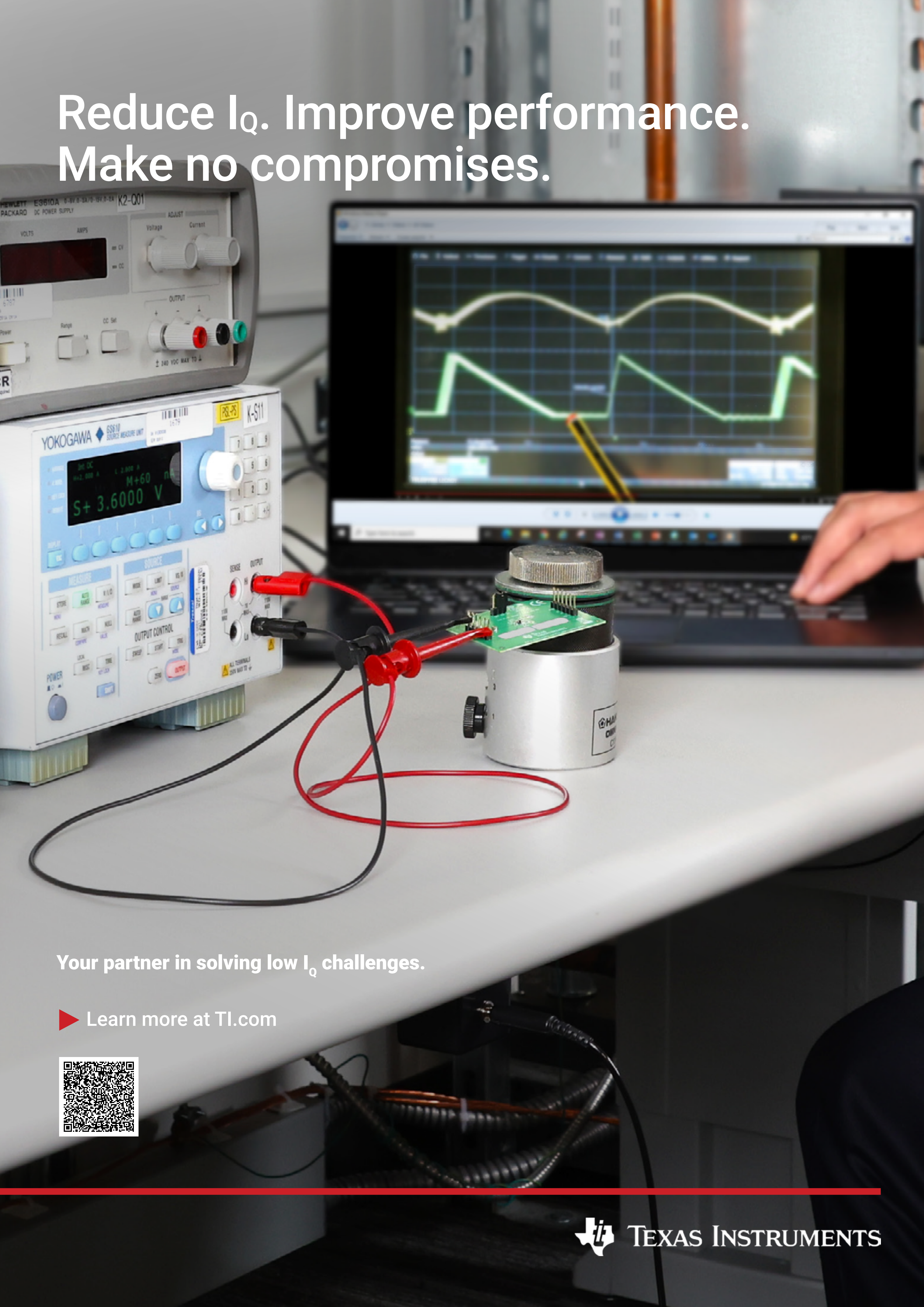


Figure 6: WPT power stages with anticipated conversion efficiencies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To meet the efficiency targets, the active front end (AC to DC conversion and power factor correction) will need to use a bridgeless totem pole configuration or similar (Figure 7) and the inverter will need to use a full bridge or variant of an LLC topology. Both designs will need to use several isolated transistor gate drivers, which is where RECOM can support WPT designs with standard and programmable isolated gate driver DC/DC power supplies:

With high power switching designs, it is often difficult to balance out the power ground stray inductances in each leg, which can lead to asymmetric performance and switching instability. Isolating both the high-side and low-side gate drivers eliminates this problem (Figure 8).

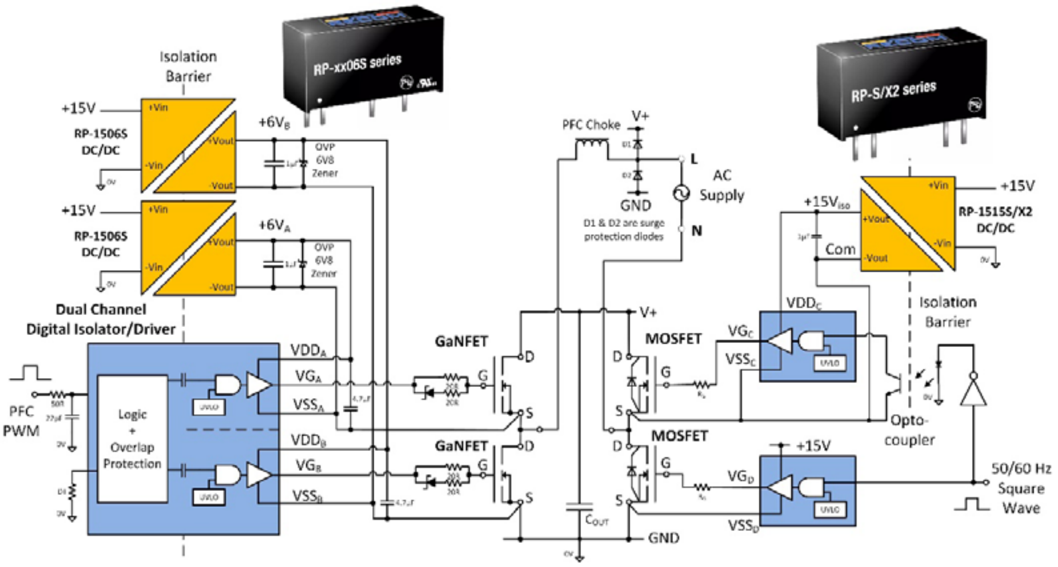

Figure 7: GaN Totem pole bridgeless rectifier example circuit

RECOM offers a range of compact gate driver power supply modules with high isolation, asymmetric output voltages for optimal power transistor switching and a wide operating temperature range, making them ideal for such high-power designs, including bidirectional circuits.

In the electric vehicle itself, another active rectifier circuit will convert the AC from the receiving coil to charge an intermediary bus capacitor, C_{DC}. This unregulated DC bus voltage can be used to supply a high-power digital DC/DC converter unit such as RECOM's 15kW OBC design (Figure 9).

This 15kW converter design will accept a wide DC input voltage range of 25VDC up to 280VDC and boost the output voltage up to a programmable 200V-800VDC to charge a high voltage EV battery stack, with an efficiency exceeding 97%. The built-in MPPT circuit optimises the power transfer efficiency during the entire charging cycle. The CAN-bus interface allows communication with standard battery management system controllers and permits active load sharing between paralleled units.

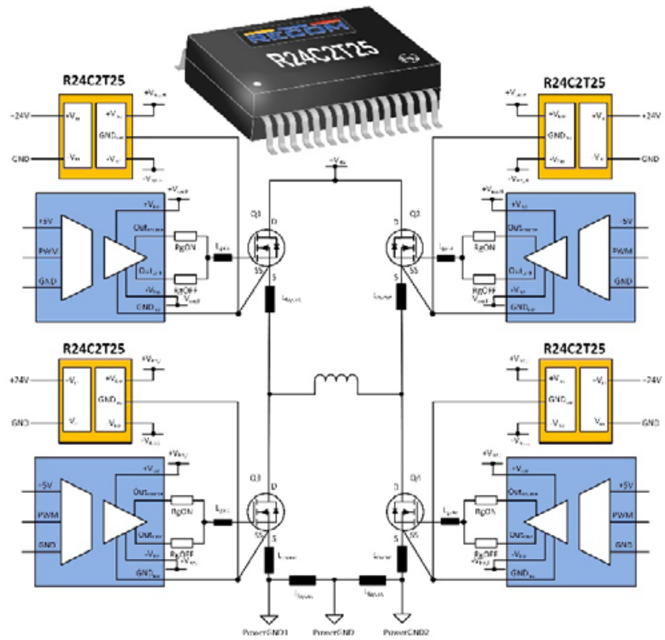

Figure 8: Full bridge gate driver example circuit

Conclusion

Wireless power transfer is a viable alternative to wired electric vehicle charging systems in terms of technology, even if it is not mainstream yet due to the higher cost. As EVs become the norm rather than the exception, the ease-of-use and convenience of simply driving up to a parking slot and starting to charge the battery wirelessly will make WPT more attractive, especially as the technology already exists for the vehicle to move and park itself. Ultimately, on-the-go WPT charging using electric roads will eliminate the "range anxiety" of using EVs, enabling the battery to be fully charged at the end of the journey, not just at the start.

RECOM already offers products that will allow high voltage power supplies and systems for wireless charging for electric vehicles to be built, evaluated and tested.

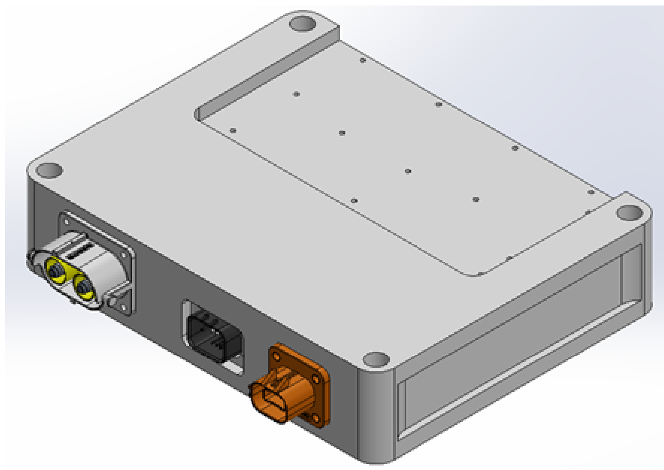

Figure 9: RECOM's 15kW (parallelable up to 75kW) high voltage on-board charger

Reference

1 https://eu.freep.com/story/money/cars/2023/11/29/detroit-wireless-charging-road-project-electric-vehicles/71728454007/

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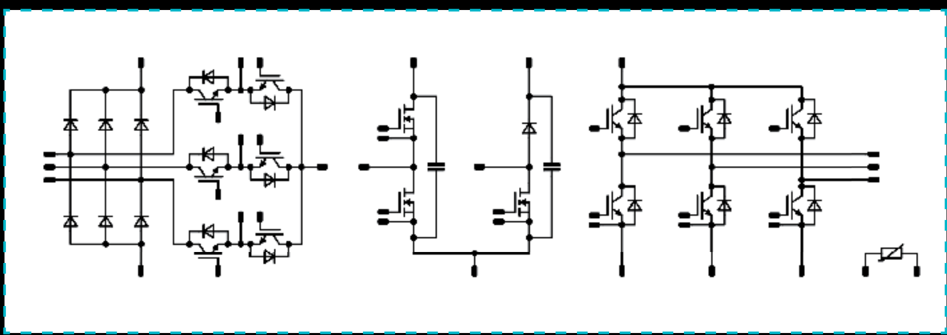

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Modular dv/dt Pulse Generator Testbench for Insulation Endurance Assessment – Part 1

Power electronics technology is advancing continuously. However, this also results in new requirements. The insulation systems of rotating machines, transformers, cables, or bearings experience significantly higher stress due to the steep du/dt voltage pulses generated by the inverter. In particular, the rapid progress in fast-switching devices presents new challenges that must be addressed by insulation material manufacturers and system integrators.

By Prof. Dr. Benjamin Sahan, Prof. Dr.-Ing. Christian Staubach, B. Eng. Kevin Kaczmarek, B. Eng. Stefan Reddig (Hannover University of Applied Sciences), and Dipl. Ing. Konrad Domes, M.Sc. Philipp Berkemeier, M.Sc. Felix Schönlebe (SAXOGY POWER ELECTRONICS GmbH)

This trend is further amplified by the increasing system voltage in many applications, as observed in electric vehicles (400 ➜ 800V) and PV systems (1000 ➜ 1500 V). The application of steep inverter d*v*/d*t* slopes leads to increased stress compared to the traditional 50 Hz sinusoidal voltage for some of the following reasons:

- Reduced partial discharge inception voltage (PDIV) and increased partial discharge activity
- Inhomogeneous voltage distribution within the windings [1]
- Polarization effects and dielectric heating due to displacement currents

Figure 1a. illustrates a twisted wire test specimen undergoing stress during inverter operation. Strong corona discharge activity is clearly visible to the naked eye.

In Figure 1c, a conventional enamel wire insulation, also configured as a twisted pair, underwent testing with pulsed voltages, revealing distinct indications of partial discharge erosion.

Lastly, Figure 1b shows an example of a destroyed motor as a result of failed insulation.

Under these challenging operating conditions, precise knowledge of the aging process and the ability to estimate the remaining lifespan of the insulation system are crucial.

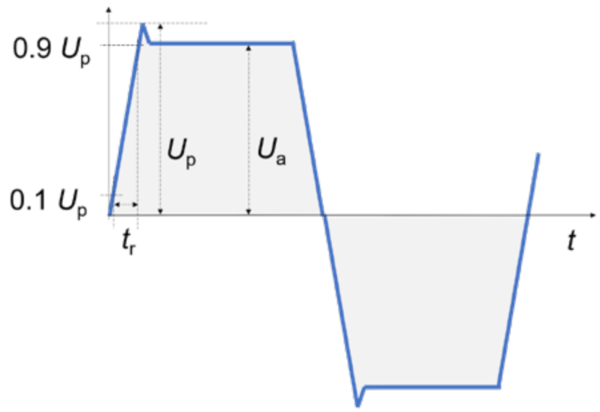


Figure 2: Specification of the voltage waveform over one period

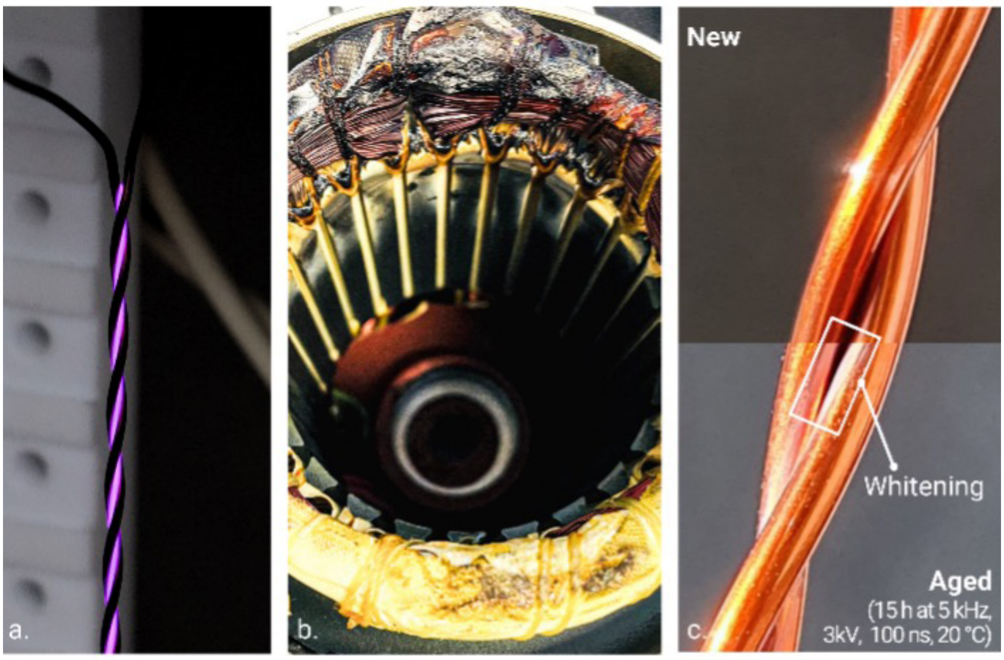


Figure 1a. test specimens with strong corona discharge; Figure 1b. motor example; Figure 1c. twisted pair wire after endurance testing (tested at Hannover lab)

SAXOGY® and Hannover University of Applied Sciences have taken on the task of developing a test bench that realistically simulates the stresses of inverter operation and can be used for accelerated insulation endurance assessment. The corresponding project "ISODyn" was supported by the German ZIM research funding.

Which requirements are used for testing?

Currently, there is no unified international standard for endurance testing under high-frequency voltage impulses for winding wires. Therefore, we refer to the existing chinese standard GB/T 4074.21-2018 and incorporate feedback from manufacturers to derive the following requirements according to figure 2 that the dv/dt pulse generator must meet.

- Voltage waveform: Bipolar square wave
- Peak voltage: 1,5 kV (should be modular extendable)
- Rise time t_r > 25 ns (10-90%) – adjustable
- Max. voltage slope d*v*/d*t*: 60 kV/µs
- Pulse frequency: 20 kHz
- Test temperature >180 °C
- Voltage overshoot $(1\text{-}U_p/U_a)$ < 2%
- Grounding of the device under test

The breakdown of motor windings due to insulation failure occurs when the insulation degrades over time under the influence of steep d*v*/d*t* voltage pulses. This degradation can lead to arcing, ultimately reducing the insulation resistance and resulting in a breakdown. Reliable detection of this breakdown is necessary to prevent damage to the test bench and accurately define the resulting lifetime.

Factors influencing insulation lifetime
Various measurements are carried out in endurance tests. The ensuing results were subjected to statistical analysis. The test samples consists of twisted pair copper wires that met the specifications of the IEC 60851 standard.

First, the influence of the pulse frequency f_p on the resulting electric lifetime of conventional copper wire enamels without additives is investigated (see Figure 3). The samples failed after about 4 min (for 11 kHz) to about 55 min (for 1 kHz) in average. It can be summarized as follows:
- the electric lifetime decreases almost lineary with increasing frequency f_p

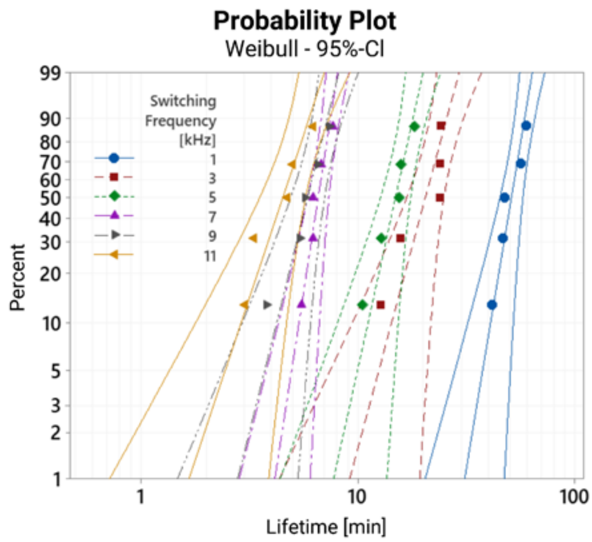


Figure 3: Probability plot of the electric lifetime depending on the switching frequency

Additionally, the effects of slew rate, temperature, and insulation material on the resulting lifetime has been investigated, examining different combinations of rise time (tr) and oven temperatures [2].
- variations in rise time have a noticeable impact on lifetime (see Figure 4)
- increasing the temperature reduces the electric lifespan (see Figure 4)

Furthermore, the choice of insulation material and its structural composition were found to significantly influence the overall lifetime [2].

Unique modular dv/dt pulse generator test bench for lifetime testing
SAXOGY POWER ELECTRONICS and Hannover University of Applied Sciences have jointly developed a modular high-voltage pulse generator, as shown in figure 5.

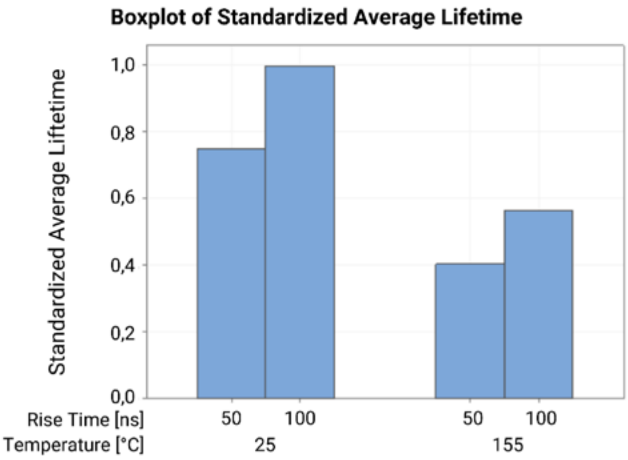


Figure 4: Impact of rise time and temperature on lifetime for conventional copper wire enamels

This generator consists of state-of-the-art SiC MOSFET technology. It is designed to be adaptable allowing for expansion to fulfill the specific test requirements for lifetime testing and upcoming standards in terms of insulation testing.

The concept is scalable and can be expanded to meet specific application needs. The bipolar voltage waveform is adjustable across a broad voltage range, from 0,4 kV_{pp} to 12 kV_{pp}, depending on the configuration and the generator can achieve voltage slopes up to 200 kV/µs.

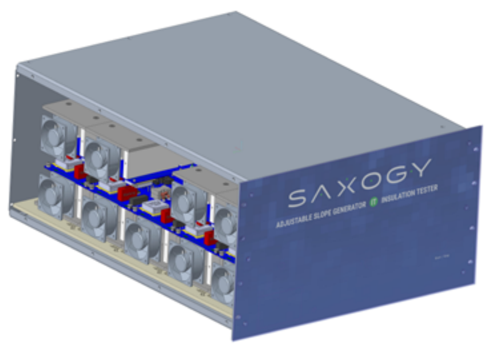


Figure 5: SAXOGY's sketch of the power unit of the dv/dt pulse generator

Adjustable load settings
A precise gate driver circuit has been developed to ensure that the overshoot of the SiC inverter remains below 2%.

Furthermore, an almost linear voltage gradient was achieved during the switching time, ensuring a consistent stress in every rising and falling edge. To adjust the stress level, there are 16 steps to fine-tune the voltage slope based on the requirements of the individual insulation testing standard. To vary the test time for accelerated endurance tests, the generators square wave frequency can be set between 2 kHz and 20 kHz.

In addition to the electrical key figures for insulation testing, the development focused on two essential requirements for an insulation endurance test bench:
1. the generator must never exceed its own insulation limits and cause stress to itself
2. Most insulation tests end with an insulation breakdown, which from the generator's point of view represents a low impedance short-circuit. This short-circuit current must be detected and handled within microseconds. This process is repeated beyond the device's lifetime.

Further details regarding the development of the pulse generator and its various configurations will be elaborated upon in part 2 of this article.

Research and development in accelerated insulation endurance testing

The collaborative effort between SAXOGY and Hannover University of Applied Sciences has resulted in the development of an advanced modular d*v*/d*t* pulse generator. This innovative testbench represents a significant leap forward in accelerated insulation endurance testing. It offers a valuable tool for validating existing and developing new insulation systems, thereby contributing to the enhancement of future power electronic systems.

Outlook: Given the importance of the topic, a subsequent article will be published next month. Part 2 will dive into the design and challenges of the novel dv/dt generator test bench.

www.saxogy.de

References

[1] WEG technical guide "Induction motors fed by PWM frequency inverters" https://static.weg.net/medias/downloadcenter/hcb/h20/WEG-induction-motors-fed-by-pwm-frequency-inverters-50029350-brochure-english-web.pdf

[2] C. Staubach et al. "Inverter voltage endurance testing of twisted pairs acc. IEC 60851 with a self-developed, adjustable generator" IEEE Electrical Insulation Conference (EIC), 2024 (accepted for publication)

SAXOGY POWER ELECTRONICS GmbH and the Hannover University of Applied Sciences

Since 2020, SAXOGY has been actively collaborating with Hannover University in the form of research and business projects. The project "ISODyn – dynamic, modular testing device for modern insulation systems in electric motors" described in the article was funded as part of the BMWi's Central Innovation Program for SMEs (ZIM).

The result was:

- functional prototype test generators
- a complete test bench for examining the influence of highly dynamic voltage pulses on insulated wires, including evaluation software
- new measurement data and insights into aging mechanisms of insulation
- market-ready testing device for testing insulation systems
- further developments to increase safety when dealing with high voltages (e.g. SAXOGY's safety measuring box)

Konrad Domes

Benjamin Sahan

How a tiny isolated DC/DC Module is enabling higher Power Density

One way to optimize an automotive or industrial design is to reduce the size of the power-supply unit, which can result in system-level cost savings by requiring less physical material and of course fewer discrete components.

By Bethlehem Defar, Product Marketing Engineer, and German Aguirre, Product Marketing Engineer, Texas Instruments

Isolated bias-supply solutions such as push-pull and flyback converters have traditionally required heavy, bulky transformers that are prone to vibrations, necessitating a complicated design layout. The design of isolated bias- supply solutions with external transformers also affects performance efficiency and can lead to high radiated electromagnetic interference (EMI).

Breakthroughs in transformer design have allowed integrated circuit designers to fully integrate a transformer and silicon into one package, reducing the isolated DC/DC power supply height and size significantly. The end user obtains a tiny, lightweight isolated power module enabling high power density without having to design a transformer or compromise system performance.

In this article, we'll describe the basic functionality of three automotive and industrial applications, the importance of the isolated DC/DC power supply to this functionality, and how the new UCC33420-Q1 power module from Texas Instruments can help you to design an effective isolated DC/DC power supply.

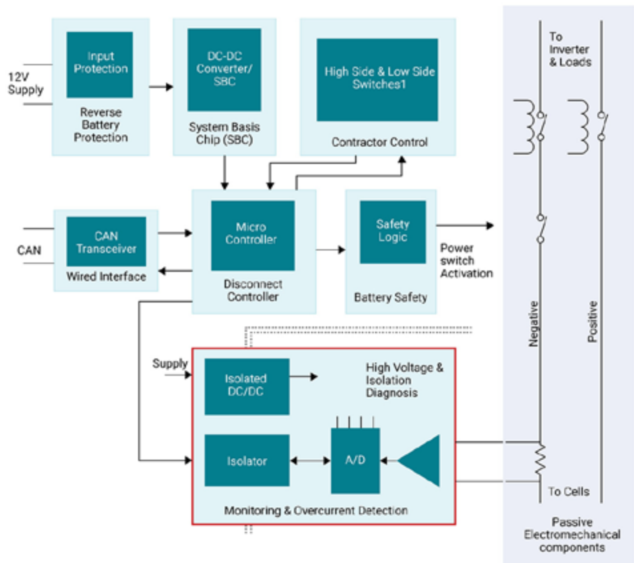


Figure 1: Battery disconnect unit system block diagram

Isolated DC/DC power supply in BMS
The main function of a battery management system (BMS) is to monitor pack voltage, pack current and cell voltage. Monitoring high-voltage battery (>60V) leakage current and isolation resistance between the bus and chassis ground is required to comply with safety standards. An isolated DC/DC power supply is present in the high-voltage and isolation diagnosis subsystem within the BMS, providing isolated power to digital isolators and current sensors.

The isolated DC/DC power-supply input gets a 5V supply from the safety power-management integrated circuit and provides 5V of output power to digital isolators, voltage/current sensors or analog-to-digital converters on the high-voltage side in a battery disconnect unit application, as illustrated in Figure 1.

In an intelligent battery junction box using a single voltage, current and insulation resistance monitor, the isolated DC/DC power supply provides an output voltage of 5V to the battery monitor. Advancements in integrated transformer technology occupy less printed circuit board area compared to other push-pull discrete solutions, optimizing power density, reducing system bill-of-materials (BOM) count, and accelerating time to market.

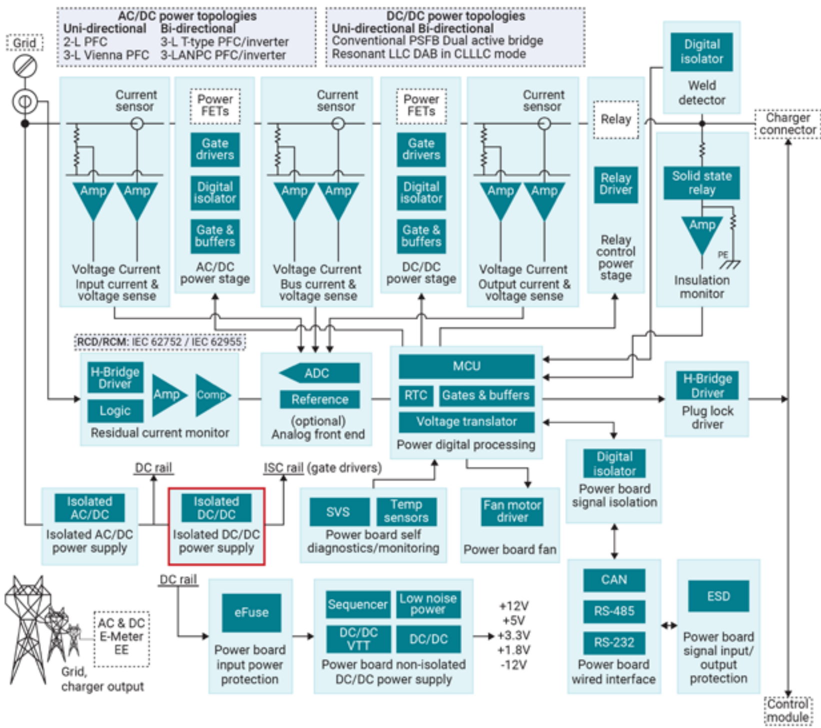


Figure 2: EV charging station system block diagram

EV charging
As the move toward vehicle electrification grows, the need for affordability and reduced charging time increases. Reducing the size of electric vehicle (EV) charging power modules can provide efficiency and reduce overall system cost.

As shown in Figure 2, an EV charging station includes data communication interfaces such as Controller Area Network, RS-485 and isolated amplifiers for voltage and current sensing, which all require isolated DC/DC power. To decrease charging times, there has to be an increase in power output, which can increase overall system size. The UCC33420-Q1's small footprint and high efficiency can help you design a more efficient isolated power-supply system while reducing overall board space. It is possible to eliminate the number of external components by as much as 50% while supporting the high voltages from AC input lines.

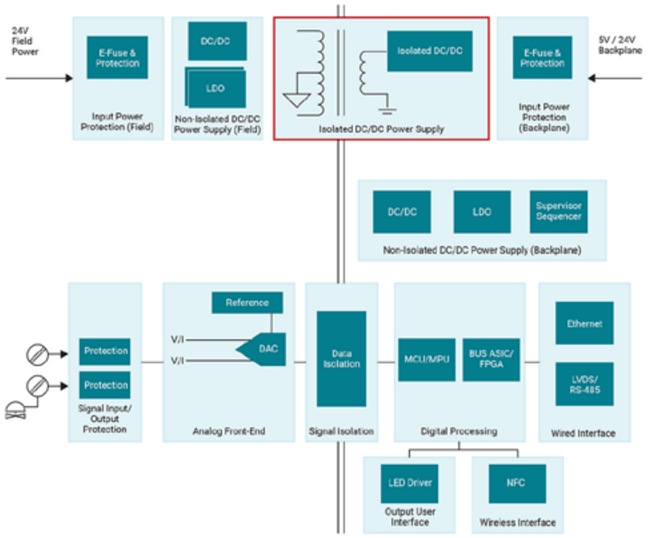


Figure 3: PLC voltage and current output module block diagram

PLC I/O modules
As shown in Figure 3, high-performance programmable logic controller (PLC) systems include several modules in a small space. These PLC systems use centralized input/output (I/O) modules to communicate with sensors, solenoids and valves. The isolated bias supply in a PLC system must be small in size, have tight output-voltage regulation, and be able to mitigate EMI and electromagnetic compatibility. High power density and output-voltage accuracy are also typical requirements.

The UCC33420-Q1's ability to deliver 1.5W of output power in a 4mm-by-5mm very small outline no-lead package enables this device to power multiple integrated circuits. The UCC33420-Q1 can provide 5V and 3.3V output voltages with accuracy <±3% at VIN 3V to 3.6V and 4.5V to 5.5V, without the need for a post regulator or low-dropout regulator.

Conclusion
Within the realm of transformer design, the UCC33420-Q1 delivers over 8.5 times higher power density than discrete transformer solutions with the same output power levels. Other innovations over discrete transformer solutions include a reduction in solution size by >89%, a reduction in height by >75%, and a reduction in BOM count by half. Figure 4 compares the size of the UCC33420-Q1 to a push-pull converter.

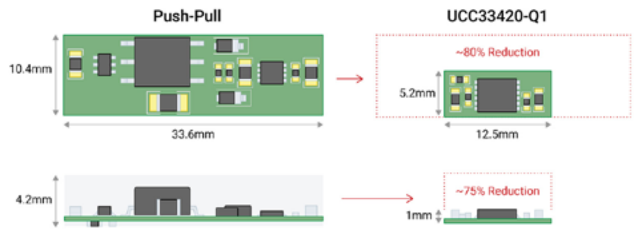


Figure 4: UCC33420-Q1 isolated DC/DC module vs. a traditional push-pull converter

The UCC33420-Q1 integrates an isolation power transformer, primary- and secondary-side bridges, and control logic into one package, enabling you to meet the demand for smaller and lighter automotive and industrial applications.

The UCC33420-Q1 is designed with an EMI-optimized transformer with 3pF of primary-to-secondary capacitance that can meet Comité International Spécial des Perturbations Radioélectriques (CISPR) 32 compliance without the use of an EMI filter. The device can also meet the CISPR 25 standard with fewer components and a simpler filter design.

www.ti.com

How to Select a Transformer When Designing an Isolated Buck Converter

This article explains how an isolated buck converter works and how to select a transformer, a pivotal step in designing an isolated buck converter. It discusses which parameters to consider, the mathematics that should be followed when choosing a transformer, and how these parameters influence the overall circuit.

By Yaxian Li, Applications Engineer, Analog Devices

How Does an Isolated Buck Converter Work?

An isolated buck topology, as shown in Figure 1, is similar to a generic buck converter. By replacing the inductor in a buck circuit using a transformer, we can get an isolated buck converter. The transformer's secondary side has an independent ground.

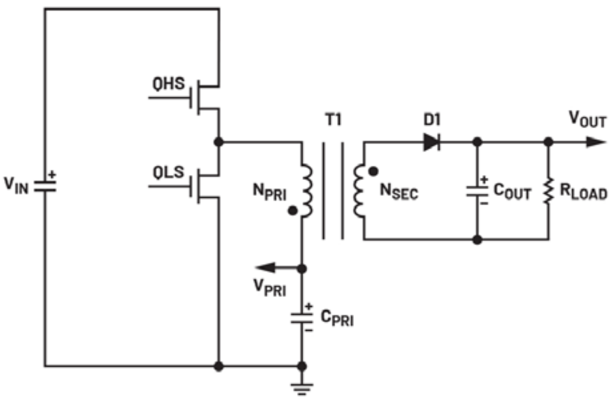


Figure 1: An isolated buck topology.

During on-time, the high-side switch (QHS) is on and the low-side switch (QLS) is off. The transformer's magnetizing inductance (LPRI) is charged up. The arrows in Figure 2 show the current flow direction. The primary current increases linearly. The current ramping slope depends on (VIN – VPRI) and LPRI. The secondary side diode, D1, is reverse biased during this time interval and loads current flow from COUT to load.

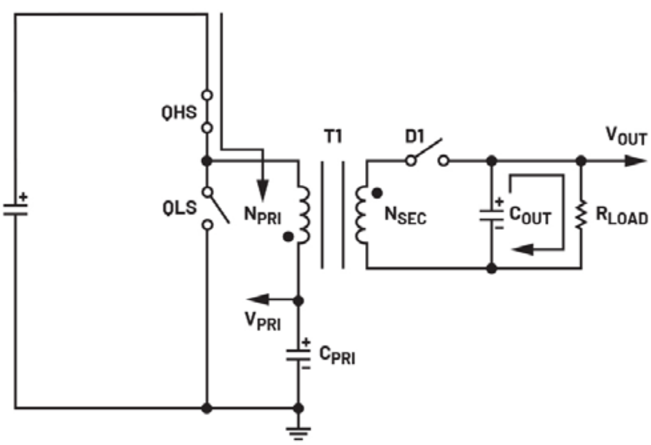


Figure 2: On period equivalent circuit.

During off-time, QHS is off and QLS is on. The primary inductor is discharged. The primary current flows from QLS to ground, D1 is forward biased, and the secondary current flows from the second side coil to COUT and to load. COUT is charged up in this time period. (Turning off QHS and turning on QLS cannot change current direction; it can only change the current slope. The positive current decreases until 0 A, then the negative current increases.)

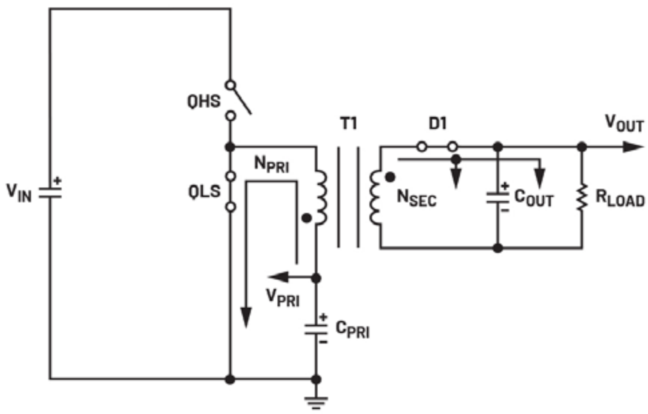


Figure 3: Off period equivalent circuit.

Which Specifications Will Influence the Transformer?

When designing a converter, some specifications should be declared and cleared. It will determine which component will be used especially when choosing a transformer.

- Input voltage range
- Output voltage
- Maximum duty cycle
- Switch frequency
- Output voltage ripple
- Output current
- Output power

Maximum duty cycle (D) is usually assigned in the range of 0.4 to 0.6. The minimum input voltage (VIN_MIN) and maximum duty cycle will determine the primary output voltage (VPRI). Then, the primary output voltage (VPRI) and secondary output voltage (VOUT) will determine the transformer turns ratio.

Output current (IOUT) and output power (POUT) are key parameters that influence transformer selection. Output current determines the thickness of the copper wire, while output power determines which transformer bobbin should be used. The permeability of the bobbin shows how much energy it can store and how much power it can put out. Generally, the DC output current multiplied by a coefficient is assigned to the inductor's (transformer's) ripple current. Duty cycle and switch frequency are used to calculate TON time, while VIN, VPRI, and ripple current determine the primary inductance. The assigned coefficient must not be too large or too small since a large coefficient can lead to a large ripple current. A large ripple current may reach half of the H-bridge current limit

and damage the MOSFET. This will lead to a large ripple voltage on the output capacitor due to its ESR and ESL. On the contrary, when an extremely small ripple current is needed, we need to use a high inductance value inductor (transformer). If the coil has many turns, this will require a bulky bobbin. The large inductance will limit loop bandwidth and reduce the dynamic response index.

Choosing a Transformer

Energy is transmitted to secondary coil only in TOFF time. The turns ratio can be determined by Equation 1:

$$\frac{V_{OUT}+V_D}{V_{PRI}}=\frac{N_{SEC}}{N_{PRI}} \quad (1)$$

Where V_D is the secondary diode forward bias voltage. For V_{PRI}, we usually assign a maximum duty cycle in the range of 0.4 to 0.6. The V_{PRI} can be calculated using Equation 2:

$$V_{PRI}=D\times V_{IN\_MIN} \quad (2)$$

Where D is the maximum duty cycle and V_{IN_MIN} is the minimum input voltage. From Equation 2, we can calculate the turns ratio. In a non-isolated buck converter, the ripple current is the same on both sides of the inductor. Easily, we can calculate the inductance required using Equation 3.

$$L=\frac{(V_{IN\_MIN}-V_{OUT})\times D}{f\times\Delta I} \quad (3)$$

Where f is the switching frequency and ΔI is the ripple current. As discussed previously, ripple current equals the DC output current multiplied by a coefficient:

$$\Delta I=I_{OUT}\times K \quad (4)$$

Where K is the coefficient. But in an isolated buck converter topology, there is a transformer and not an inductor. How do we deal with it when the component is a transformer rather than a inductor? As we know, the current ratio equals the inverse of the turns ratio:

$$IPRI_{TOFF}=I_{SEC}\times\frac{N_{SEC}}{N_{PRI}} \quad (5)$$

Where $IPRI_{TOFF}$ is the secondary current that is converted to a primary current in T_{OFF} time. We should add a transformer's two-coil current as an equivalent inductor current.

$$ILeq=I_{PRI}+I_{SEC}\times\frac{N_{SEC}}{N_{PRI}} \quad (6)$$

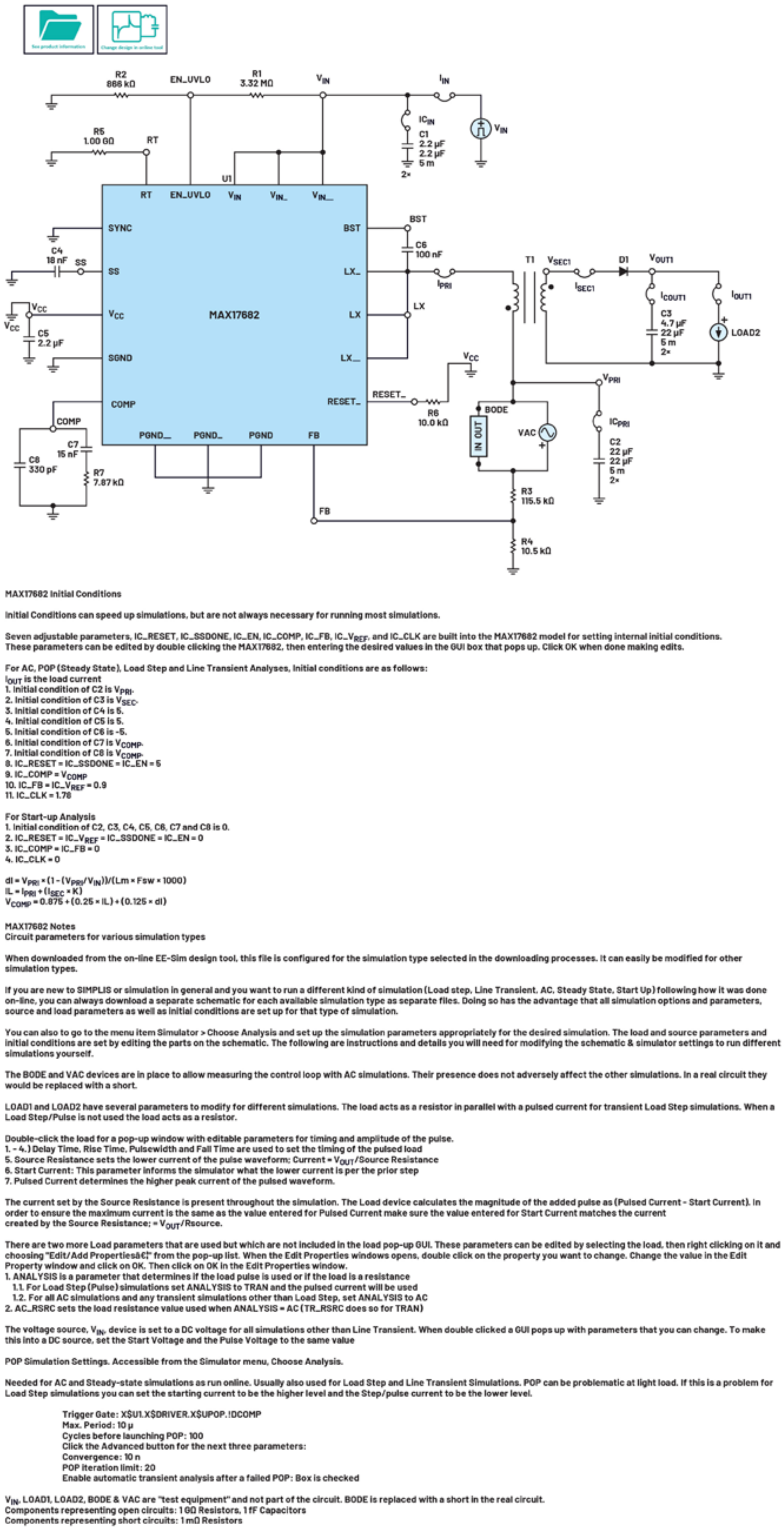


Figure 4: A MAX17682 typical circuit in EE-Sim OASIS, powered by SIMetrix/SIMPLIS.

Where ILeq is the equivalent inductor current. If the transformer has three more windings, then

$$ILeq = I_{PRI} + I_{SEC} \times \frac{N_{SEC}}{N_{PRI}} + I_{THI} \times \frac{N_{THI}}{N_{PRI}} + \cdots \quad (7)$$

Is this correct? Let's see a simulation result based on the MAX17682. Figure 4 shows a MAX17682 circuit, which was drawn in EE-Sim® OASIS, powered by SIMetrix/SIMPLIS. Current probes, labeled I_{PRI} and ISEC1, have been placed at both sides of the transformer.

Figure 5 shows a transient simulation result from the two probes. The two current waveforms were added utilizing Equation 6.

The added current results (red) in a triangle wave and behaves just like the inductor in a non-isolated buck converter.
So the transformer's primary ΔI can be easily calculated:

$$\Delta I = \left(I_{PRI} + I_{SEC} \times \frac{N_{SEC}}{N_{PRI}}\right) \times K \quad (8)$$

Usually, we assign a load ripple current that is 0.2 times the DC output current. So K can be assigned to 0.2 times NSEC/NPRI. At the same time, the primary peak current should be designed less than the switch current limitation, where IPK is:

$$I_{PK} = ILeq_{DC} + \frac{\Delta I}{2} \quad (9)$$

Then the transformer's primary inductance can be easily calculated:

$$L_{PRI} = \frac{(V_{IN\_MIN} - V_{PRI}) \times D}{f \times \Delta I} \quad (10)$$

By using the turns ratio, primary inductance, output power, output current, and isolation voltage, we can decide which inductor will be used or designed.

Why a Simplified Equation Can Work
Let's see how we can better understand and apply the equation shown in the MAX17682 data sheet (see Figure 6).

According to the previous discussion, Equation 10 can be rewritten to follow Equation 11 for TOFF time.

$$L_{PRI} = \frac{V_{PRI} \times (1 - D)}{f \times \Delta I} \quad (11)$$

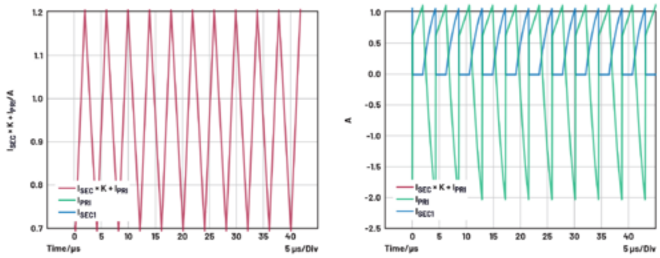


Figure 5: A MAX17682 typical circuit simulated current waveform.

Primary Inductance Selection
Primary inductance value determines ripple current in the transformer. Calculate required primary inductance using the equation:

$$L_{PRI} = \frac{V_{PRI}}{f_{SW}}$$

where V_{PRI} and f_{SW} are nominal values.

Figure 6: A screenshot of the MAX17682 data sheet.

Assuming D is 0.6, if and only if ΔI were 0.4 A, the polynomial (1 – D) and ΔI can be reduced. Then Equation 11 and the equation from Figure 6 are the same. The equation in the data sheet already selects the primary ripple current. If we assign D as 0.6, the primary ripple current is 0.4 A. In quantity, TOFF duty cycle equals the primary ripple current.

$$\Delta I = 1 - D \quad (12)$$

Conclusion
By using the simplified equation shown in Figure 6, the user ensures a faster design with a primary ripple current that equals the TOFF duty cycle. If you want to modify primary ripple current or use another parameter, you can follow this tutorial.

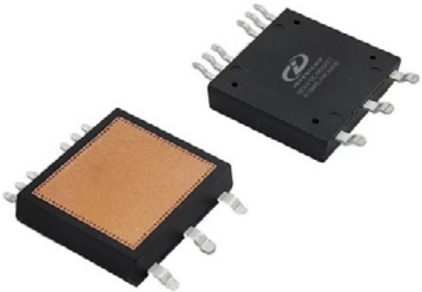
Low Power High Voltage Diodes

Dean Technology (DTI) has introduced a series of high voltage diodes. This so-called VDRM Series is an axial-leaded, high voltage diode line that offers industry standard performance and high reliability. VDRM units range from 2.5 to 16 kV, 50 to 125 mA, and have a maximum reverse recovery time of 200 ns. These diodes are best suited for low to medium power, small form-factor applications. Further, VDRM diodes offer a miniature package size and are compliant to the RoHS directive. In addition to the new VDRM Series, DTI also offers a large catalog of diodes for many different high voltage needs.

www.deantechnology.com

Automotive-Grade SiC MOSFET Half Bridge SMPD Modules

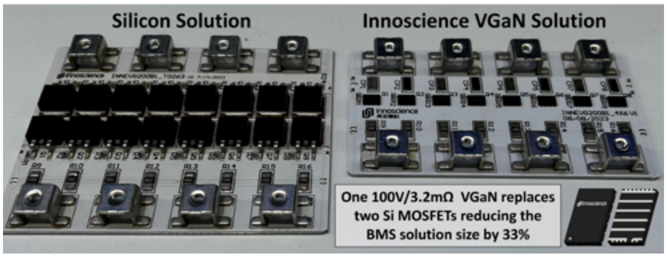
Inventchip Technology has added two automotive-grade SiC MOSFET half bridge SMPD modules named IVSM12080HA2Z and IVSM06025HA2Z. The modules are specified 1200 V/80 mΩ and 650 V/25 mΩ. SMPD is a compact, topside-cooling surface-mounted package with a plastic surface size of 25 mm x 23 mm. Compared with TO-247, the SMPD saves over 25 % PCB space, and the more important thing is that the SMPD reduces the half-bridge stray-inductance of power loop by around 40 %. The reduction of the stray inductance reduces MOSFET VDS overshoot, VGS ringing, switching loss and EMI noise. It helps engineers to solve the critical design issues and achieve a high density and reliable power conversion design. Compared with TO-247 with external electrical isolation assembly, SMPD with traditional AL2O3 and SiN lowers junction-to-heatsink thermal resistance by over 20 % and 50 % respectively for the same 25 mΩ/1200 V SiC MOSFET die. It eases the thermal design and increases the power handling potential. A NTC is also integrated in the SMPD package. It senses the DBC temperature directly and offers more accurate module temperature sensing for reliable thermal protection. The SMPD package has a minimum 4 mm creepage from terminals to the package's heatsink mounting surface, which can safely work for both 400 V and 800 V systems without isolation reinforce. Both modules are AEC Q101 and AQG 324 certified.



www.inventchip.com.cn

100 V bi-directional GaN IC for 48 V/60 V BMS Applications

Innoscience Technology has launched another 100 V bi-directional member of the company's VGaN IC family. The first family of VGaN devices rated 40 V with an on-resistance range between 1.2 mOhm and 12 mOhm have been successfully deployed in the USB OVP of several mobile phones. The 100 V VGaN (INV100FQ030A) can be employed to achieve high efficiency in 48 V or 60 V battery management systems (BMS), as well as for high-side load switch applications in bidirectional converters, switching circuits in power systems, and other fields. Such device it is usable in applications such as home batteries, portable charging stations, e-scooters, e-bikes etc. One VGaN replaces two back-to-back Si MOSFETs; they are connected with a common drain to achieve bidirectional switching of battery charging and discharging, further reducing on-resistance and loss significantly with respect to traditional Silicon solution. BOM count, PCB space and costs are also reduced accordingly. The INV100FQ030A 100V VGaN IC supports two-way pass-through, two-way cut-off and no-reverse-recovery modes of operation. Devices feature a low gate charge of 90 nC, a dynamic on-resistance of 3.2 mOhm and a package size of 4 mm x 6 mm. These 100 V GaN series products are in mass production in En-FCQFN (exposed top side cooling) and FCQFN packaging.



www.innoscience.com

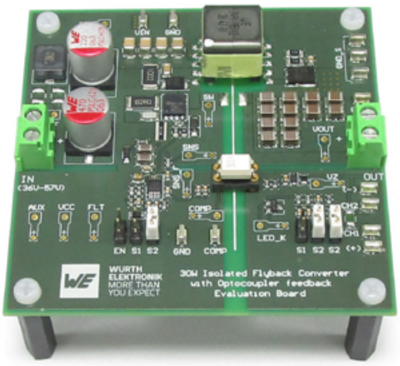
Joint Efforts for Magnetic Component Solutions

ITG Electronics has collaborated with STMicroelectronics (ST) in developing magnetic component solutions for 54 V/48 V to 12 V converter applications. ST's patented 54 V/48 V to 12 V stacked buck converter features an on-board solution with a quarter brick space using the PM6780 dual digital multiphase controller, the STPRDC02A high-voltage full-bridge driver, and ITG's L101353A-3R6MHF non-coupling dual inductors. This magnetics design collaboration is named Stacked buck converter with unified coupled inductor. Combined with ST's PM6780 and STPRDC02A, ITG's L101456A-1R4MHF can elevate the overall power rating of ST's 48 V solution to 1500 W. This product combination is claimed to "provide the industry's highest power density rating for 48 V solutions". The on-board stacked buck converter 48 V conversion system offers cost savings, form factor flexibility, and a customizable design compared to power-module designs.

www.itg-electronics.com

How to Design the Compensation Circuit for a Flyback Converter

Würth Elektronik has published its Application Note “Compensating the feedback loop of a current-controlled flyback converter with optocoupler”. The guide is aimed at developers looking to use a DC/DC flyback converter to achieve greater stability and reliability in power supply design. It might also be useful for those who use optocouplers for galvanic isolation of the feedback path. Applications include primary and auxiliary power supplies for home appliances, battery chargers for smartphones and tablets, as well as LED lighting. This Application Note also provides assistance with power supplies for desktop and laptop computers, industrial power supplies and auxiliary supplies in motor drives, or for Power-over-Ethernet (PoE). AppNote ANP113 explains in detail how the feedback loop can be compensated using a current-controlled flyback converter with optocoupler, and which aspects require special attention. The CTR (current transfer ratio) influences the control loop of the compensation circuit and therefore must be carefully considered in the design stage. ANP113 places particular emphasis on design constraints imposed by the optocoupler parameters and on the related solutions. The validation results of a 30 W flyback converter prototype are also included in the AppNote.



www.we-online.com

Electrolytic Polymer Hybrid Performance

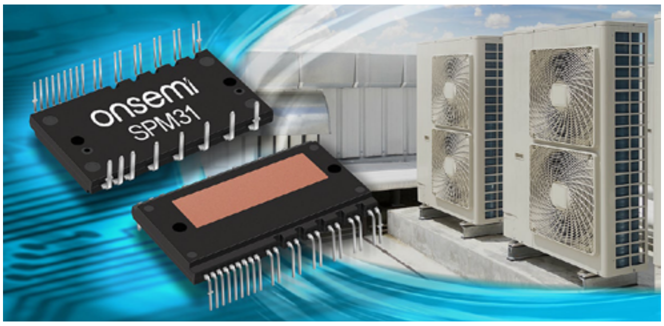
Panasonic introduces the ZV Series Electrolytic Polymer Hybrid capacitor. Achieving a maximum Ripple Current (3.3~4.6 Arms) approximately 50% higher than comparable case-sizes from competitors, the ZV Series ensures performance in demanding applications. While comparable capacitors usually come up with a ESR of around 16 mΩ at 35V, the ZV series has a significantly lower ESR of 12 mΩ at this voltage – and thus enhances efficiency and reliability in electronic systems. This capacitor is AEC-Q200 compliant, enforcing stringent quality control standards, particularly crucial for the automotive industry. It boasts high-temperature endurance, one of the industry's highest ratings at 4000 hours at 135°C and 125°C. With a focus on durability, the ZV Series offers vibration-proof variants capable of withstanding shocks up to 30G, making it a reliable choice.

The ZV Series finds its applications in various "under the hood" scenarios, including water pumps, oil pumps, cooling fans, high-current DC to DC converters, and ADAS applications. It is also suitable for use in inverter power supplies for robotics, cooling fans, solar power systems, and more, covering the DC side of both inverter and rectifier circuits.

http://industry.panasonic.eu

IGBT based Intelligent Power Modules

onsemi announced the availability of its 1200V SPM31 Intelligent Power Modules (IPMs) featuring the latest generation Field Stop 7 (FS7) Insulated Gate Bipolar Transistor (IGBT) technology. The SPM31 IPMs deliver higher efficiency, smaller footprint and higher power density resulting in lower total system cost. Given the greater efficiency realized using optimized IGBTs, these IPMs are ideal for three-phase inverter drive applications such as heat pumps, commercial HVAC systems, servo motors, and industrial pumps and fans.



The SPM31 IPMs control the power flow to the inverter compressor and fans in heat pumps and air conditioning systems by adjusting the frequency and voltage of the power supplied to three-phase motors for maximum efficiency. For example, onsemi's 25A-rated SPM31 using FS7 IGBT technology can decrease power losses by up to 10% and increase in power density up to 9%, compared to our previous generation products. With the transition to electrification and heightened efficiency mandates, these modules help manufacturers drastically improve system design while increasing efficiency in heating and cooling applications. With the improved performance, our SPM31 IPM family featuring FS7 enables high efficiency with reduced energy losses, further reducing harmful emissions globally.

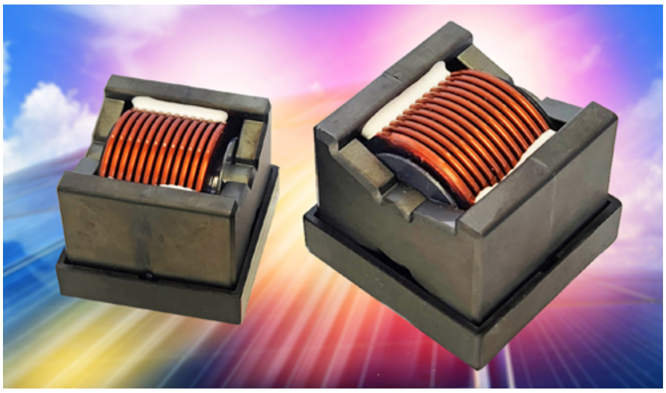
www.onsemi.com

Magnetically Shielded Flat Wire Power Inductors

Sumida introduced two series of AEC-Q200 qualified power inductors, the DPQ3535/T150 and DPQ5050/T150. These inductors are magnetically shielded and have a pin-type base for surface mounting on printed circuit boards. High surface area flat-wire windings minimize internal resistance at high frequencies and allow space savings and higher current ratings.

The DPQ3535/T150 series offers a range of inductance values from 3.3 µH to 22 µH. Maximum saturation current ranges from 28 to 152 amps at 150°C. The larger DPQ5050/T150 is of similar design, with an inductance value of 10 µH and a saturation current of 112 amps at 20 °C. The absolute maximum voltage across the inductor is 500Vdc for each. Operating temperature is -40 °C to +150 °C (including the device's self-temperature rise).

The flat-wire inductor is encased in ferrite and mounted on an insulating base. Circuit connectivity is by two robust flat, tinned copper pins. Two additional pins provide additional mounting stability. Size for the DPQ3535/T150 is (HWD) 33x38.7x38.2 mm. The DPQ5050/T150 measures 44x53.5x53.3 mm.

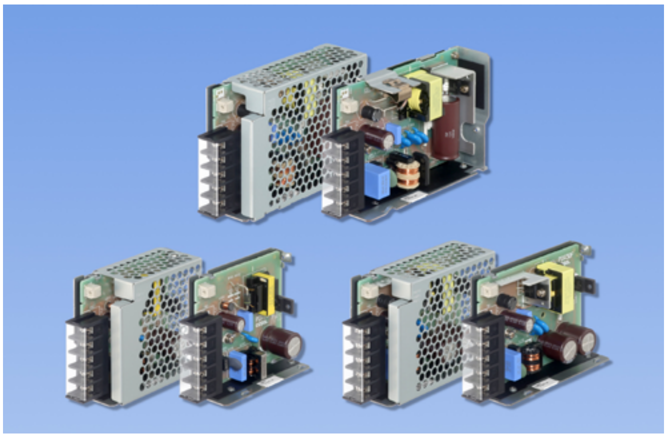


Applications include use as a buck/boost inductor for Onboard Chargers (OBC) in electric vehicles (xEV), DC-DC converters, point-of-load converters, LED drivers, class D audio amplifiers, and other general high-performance power applications.

www.sumida.com

Power Supplies for Industrial Applications

COSEL has announced the launch of the PDA series of AC/DC power supplies with further enhanced reliability for industrial applications. The PDA series uses a quasi-resonant topology with a limited number of components, resulting in higher reliability. It is 100% form, fit and function backwards compatible with the PBA series, which is retiring after 20 years of powering high volume applications worldwide. The first models introduced are the 15W PDA15F, the 30W PDA30F and the 50W PDA50F, with other versions to follow. The PDA series is designed for use in a wide range of applications and can operate over a wide temperature range from -20 to +70 degrees C. The power supplies are UL/EN62368-1 certified. Designed for worldwide applications, the PDA series has an input voltage range of 85VAC to 264VAC single phase and meets safety standards with an input voltage range of 100-240VAC (50/60Hz). The 15W PDA15F, the 30W PDA30F and the 50W PDA50F are available in three output voltages, 5V, 12V and 24V with corresponding output currents. The output voltage can be adjusted by a built-in potentiometer.



www.coseleurope.eu

GaN and SiC Technologies to Enable Next-Gen AI Power Delivery

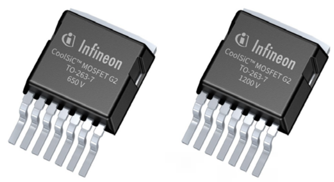
Navitas Semiconductor has announced their AI data center technology roadmap for up to 3x power increase to support similar exponential growth in AI power demands expected in just the next 12-18 months. To meet this exponential power increase, Navitas is developing server power platforms which rapidly increase from 3kW to up to 10kW. In August 2023, Navitas introduced a 3.2kW data center power platform utilizing latest GaN technology enabling over 1638.7W/cm^3 and over 96.5% efficiency. Now, Navitas is releasing a 4.5kW platform enabled by a combination of GaN and SiC to push densities over 2131.1W/cm^3 and efficiencies over 97%.

Navitas also announces its plans to introduce an 8-10kW power platform by the end of 2024 to support 2025 AI power requirements. The platform will utilize newer GaN and SiC technologies and further advances in architecture to set all-new industry standards in power density, efficiency and time-to-market. Navitas is already engaged with major data-center customers, with full platform launch anticipated in Q4 '24, completing this 3x increase in power demands in only 12-18 months.

www.navitassemi.com

Silicon Carbide Technology drives Decarbonization

The Infineon CoolSiC™ MOSFET 650 V and 1200 V Generation 2 improve MOSFET key performance figures such as stored energies and charges by up to 20 percent compared to the previous generation without compromising quality and reliability levels leading to higher overall energy efficiency and further contributing to decarbonization.



CoolSiC MOSFET Generation 2 (G2) technology continues to leverage performance capabilities of silicon carbide by enabling lower energy loss that turns into higher efficiency during power conversion. This provides strong benefits to customers for various power semiconductor applications such as photovoltaics, energy storage, DC EV charging, motor drives and industrial power supplies. A DC fast charging station for electric vehicles which is equipped with CoolSiC G2 allows for up to 10 percent less power loss compared to previous generations, while enabling higher charging capacity without compromising form factors. Traction inverters based on CoolSiC G2 devices can further increase electric vehicle ranges. In the area of renewable energies, solar inverters designed with CoolSiC G2 make smaller sizes possible while maintaining a high power output, resulting in a lower cost per watt.

www.infineon.com

DC/DC Converter Designed for the 'NewSpace' Market

VPT announces the addition of the VSC100-2800S to the VSC Series of space COTS DC/DC converters. Designed for the "NewSpace" market, the VSC Series complements VPT's hermetic hybrid SV / SVL Series of rad hard products available on DLA SMDs. The VSC Series is intended for use in commercial rad tolerant satellite applications and NASA Class D missions where the balance of cost and guaranteed performance is critical.

The VSC100-2800S features output voltages of +3.3 V / 66W, +5 V / 100W, +12 V / 100W, and +15 V / 100W, as well as a wide input voltage range. Sensitive semiconductors are RLAT to 40 krad (Si) per MIL-STD-883 Method 1019 and guaranteed to 30 krad (Si) TID. Converters are characterized to LET > 42 MeV/mg/cm^2 for catastrophic events and LET > to 30 MeV/mg/cm^2 for SET and SEFI. Our proprietary packaging creates a dual-side heatsinking option with very low outgassing.

VPT's Vice President of Engineering, Leonard Leslie, stated, "We are pleased to introduce the VSC100-2800S as the newest addition to our VSC Series. Drawing on VPT's extensive expertise in the development of radiation-hardened DC/DC converters, the VSC Series ensures the optimal level of radiation performance for low Earth orbit (LEO) applications, all while maintaining an exceptionally competitive cost."

www.vptpower.com

Series of Supercapacitor Modules

With the Supercapacitor modules of the SCM series from KYOCERA AVX, Rutronik offers robust components for industrial applications that require high peak performance. The SCM series is suitable for high-current or industrial applications, including renewable energy generation, grid-connected storage, or the buffering of power peaks.

Thanks to active balancing, the capacitor modules have a stable voltage level in the individual cells installed in the module. They operate individually or in combination with batteries or accumulators. Either they supply energy as a backup or support providing power peaks together with batteries or accumulators. In this case, they often have a positive effect on the service life of the battery or accumulator. Due to the convincing characteristics of the individual capacitors used, the SCM modules achieve their special pulse load capacity. The combination of very high capacitance and very low internal resistance (ESR) enables a high power density and high efficiency.

The modules are also characterized by a high mechanical load capacity and can withstand high currents, frequent charging and discharging cycles, and strong vibrations. They are designed for operating temperatures from -40 °C to +65 °C and can handle several million cycles, depending on the application. In addition, the modules are lead-free, RoHS-compliant, and meet the UL 810A standard.

www.rutronik24.com

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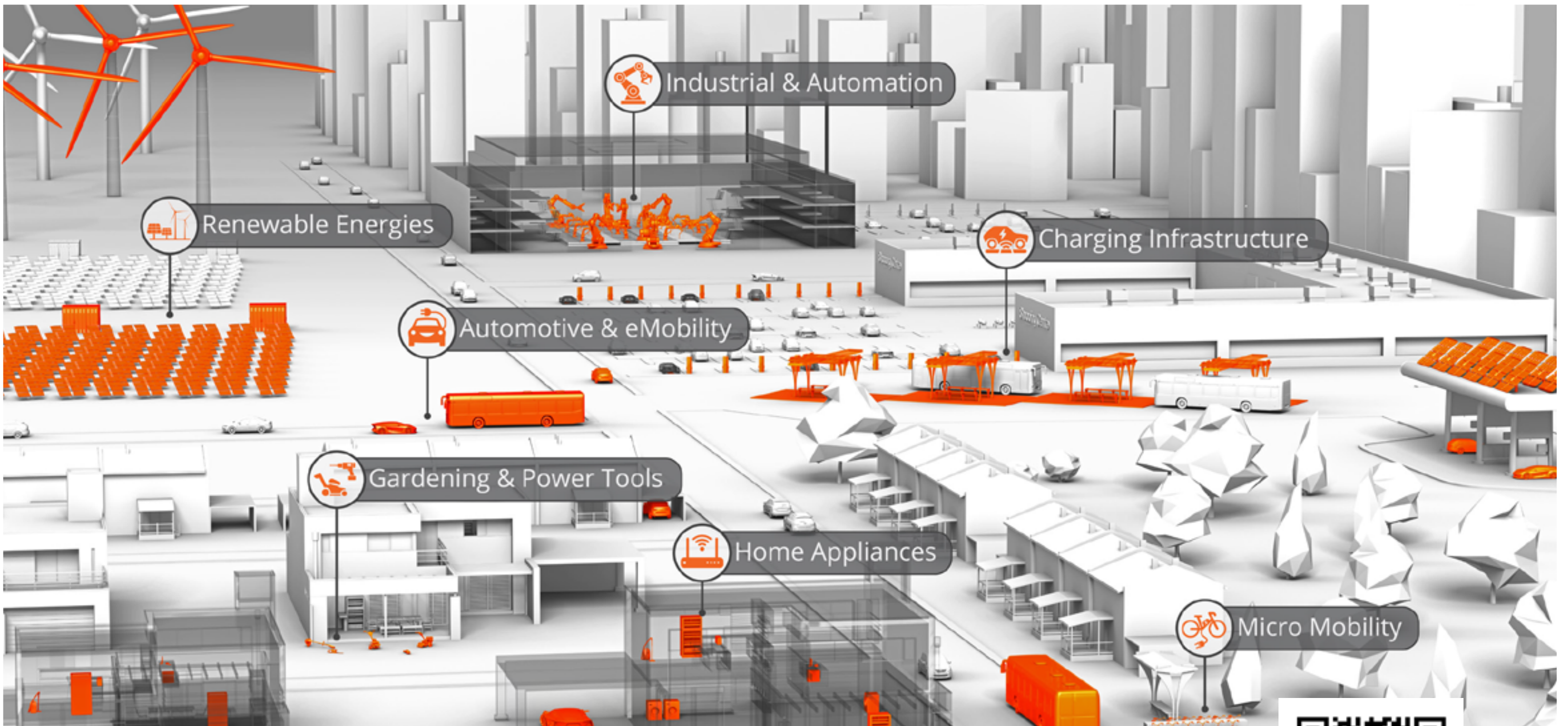

www.finepower.com