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Bodo´s Power Systems®

Electronics in Motion and Conversion

November 2020

WE
WÜRTH ELEKTRONIK

Isolated MagI³C Power Modules Master the 24 V Industry Bus

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Phone +49 (0) 621/7 89 92-0
info@gva-leistungselektronik.de
www.gva-leistungselektronik.de

GvA Power Electronics

CONTENT

Sorry, no room for a cartoon this time. *Little Ohm* will be back soon!

The Gallery

REDEXPERT

WÜRTH ELEKTRONIK

REDEXPERT. Würth Elektronik's online platform for simple component selection and performance simulation.

- The world's most accurate AC loss model
- Filter settings for over 20 electrical and mechanical parameters
- Inductor simulation and selection for DC/DC converters
- Ability to compare inductance/current and temperature rise/DC current using interactive measurement curves
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- Order free samples directly
- Direct access to product datasheets
- Comfortable and clear component selection

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www.bodospower.com

Weeks of Truth

...lie before us. Infections are again increasing, and the virus continues to dominate our lives, both privately and professionally. I do not doubt the truth of these numbers and I am quite sure that all the measures that have been taken to date are correct. It is still necessary to limit the spread, even if some people reject the inconvenience. With our current actions we are laying the foundation for the coming year and whether we will see face-to-face events again in the spring. The recent decisions around embedded world and APEC are no surprise to me. I believe that the longer the situation lasts and the more we get used to holding meetings and events virtually, the harder it will be for us to return to so-called “business as usual”.

It is true that many jobs can be carried out working from home. This is a possibility available at our publishing house. We ourselves are free to decide whether we meet in the office or not. Since we are a pure family business, we have decided that we will work in the office until further notice, knowing that we could switch to "remote working" at any time.

Good news is rare these days, so it is good to hear that the number of vehicles with full or partial electric drives is constantly growing. This trend is just at the beginning and there is a lot of persuasion that will still have to be made to potential buyers. In addition to the range, I see the reliability of these vehicles as an important characteristic. Since both of these issues relate, in part, to Power Electronics and Semiconductors, your focus can help. Wide bandgap power semiconductors will help increase efficiency and high-quality components, such as modules, will help to further promote acceptance. If this sounds familiar to you, do not forget to register at www.power-conference.com for our digital event in December.

Another cornerstone is being laid these days: we are busy negotiating contracts for 2021 with our partners and I am happy to say that most of our supporters have already confirmed. We must not forget that without our advertising partners we would not be able to offer our magazine free of charge to qualified readers. If you are interested in supporting our publication, please download our new 2021 Media Kit. You can find it on our website at “About → Media”.

Bodo’s magazine is delivered by postal service to all places in the world. It is the only magazine that spreads technical information on power electronics globally. We have EETech as a partner serving North America efficiently. If you are using any kind of tablet or smart phone, you will find all our content optimized for mobile devices on the updated website www.bodospower.com. If you speak the language, or just want to have a look, don’t miss our Chinese version: www.bodospowerchina.com

My Green Power Tip for the Month:
The cold season is coming. There are some relatively simple things that can be controlled to save energy. Is my heating technically ok? Are the wool socks ready? Do I have to run these hundreds of outdoor lights?

Best regards

Events

BEVA 2020
Online November 2-3
www.beva-alm-europe.com

electronica 2020
Online November 9-12
www.electronica.de

PCIM Asia 2020
Shanghai, China November 16-18
www.pcimasia-expo.com

sps connect 2020
Online November 24-26
https://sps.mesago.com

Solar & Storage 2020
Online December 2-4
https://ogy.de/solar-storage

E|DPC 2020
Ludwigsburg, Germany December 8-9
www.edpc.eu

Power Electronics Conference 2020
Online December 8-9
www.power-conference.com

IEEE IEDM 2020
Online December 12-16
www.ieee-iedm.org

PEMD 2020
Online December 15-17
https://events2.theiet.org/pemd

The perfect Fit

HLSR

The perfect fit for your design: a cost-effective current sensor that out-performs shunts in every way. The compact package of the HLSR requires only 387 mm², less board area than many shunt solutions. High performance produces accurate measurements across a wide temperature range of -40°C to +105°C. The LEM HLSR – a single compact device that eliminates complexity in your design.

www.lem.com

- **High performance open-loop ASIC based current sensor**
- **$10A_{RMS}$, $20A_{RMS}$, $32A_{RMS}$, $40A_{RMS}$, $50A_{RMS}$, $80A_{RMS}$, $100A_{RMS}$ and $120A_{RMS}$ nominal current versions**
- **Single +5V or +3.3V power supply**
- **Fast response time: 2.5 µs**
- **Full galvanic isolation**
- **8 mm clearance/creepage + CTI 600**
- **Low offset and gain drifts**
- **Through-hole and SMT packages**

LEM

Life Energy Motion

APEC 2021 Announces New Dates

The Applied Power Electronics Conference (APEC) and its sponsors, the IEEE Power Electronics Society (PELS), the IEEE Industry Applications Society (IAS} and the Power Sources Manufacturers Association (PSMA) are pleased to announce that APEC 2021 will now be held from June 9-13, 2021 in Phoenix, AZ. The conference and exposition had previously been scheduled to take place in March. Additionally, the exposition will take place at the start of the conference rather than in the middle as it has been in years past. The location of APEC 2021 will remain, as originally planned, at the Phoenix Arizona Convention Center.

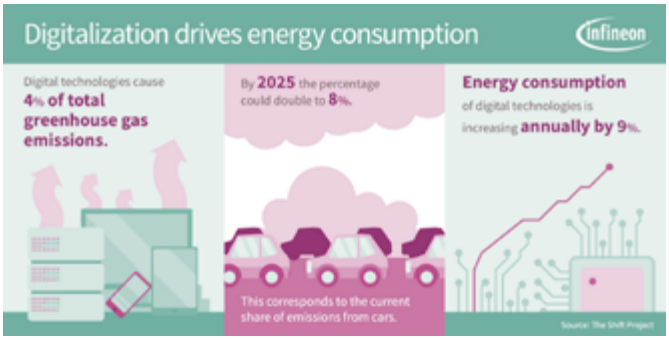
The decision to change the dates of the conference and exposition was made after much consideration between sponsors, the city of Phoenix, and other stakeholders. By moving the global conference for power electronics professionals to June, the organizing committee believes that it will be in a better position to host a safer and more successful in-person event. The committee will continue to assess public health and safety matters in light of the ongoing COVID-19 pandemic, and will make any further adjustments, if necessary, in a timely manner.

With the change of dates, the organizing committee will also re-open the submission process for Technical Papers, Industry Session Presentations, and Professional Education Seminars. More details and timelines will follow in the coming weeks. Those who have already submitted to the conference will not need to re-submit, but may amend or update previously submitted digests.

www.apec-conf.org

Certificate Achieved Thanks to SiC MOSFETS's

Introduced in 2004, the measurement standards defined by the North American 80 PLUS initiative can be used to evaluate and certify the efficiency of switched-mode power supplies (SMPS). A certificate is granted if the SMPS achieves at least 80 percent at defined load conditions. Solutions bearing the 80 PLUS certificate thus help in reducing the power demand of digitalization. To meet the requirements for the highest efficiency 80 PLUS Titanium certification, a 94 percent efficiency at a load of 50 percent is required for 115 V input voltage and 96 percent for 230 V, respectively. Lite-on Technology Corporation has achieved this target with the CoolSiC™ MOSFETs 650 V from Infineon Technologies. Lite-on management is convinced that silicon carbide has become mainstream for applications like solar inverters. Partnering with Infineon, it is their goal to show that it is also relevant for the power supply market for servers. As a perfect fit for this application, CoolSiC technology proves its sweet spots in performance and cost at a system level. Lite-on is very keen on introducing the silicon carbide-based SMPS to the market, which exceeds the requirement of 96 percent efficiency for the Titanium certification.



www.infineon.com

20-Year Partnership

In 2020, Würth Elektronik is honored to celebrate its 20-year partnership with Future Electronics. The longevity of this relationship has proven that it's been strong even in the soft economic electronic component markets. "Our positive partnership with Future Electronics is unlike any other. For us, their attention to detail has been imperative to our business together. Their commitment to our brand has been crucial for our success together throughout the years. We look forward to many more years of strong partnership," says Joe Haukos, Distribution Manager for the Americas for Würth Elektronik. With the help of Future Electronics' strategic partnership, Wurth Elektronik has experienced consistently positive growth in electronic component sales. Future Electronics has also been a sponsor of the Würth Elektronik WE Day Technical Table Top and Seminar events in Mexico. Throughout the last 20 years, the Wurth Elektronik direct sales force has partnered with the Future Electronics field sales to assist customers in their projects from beginning to end. This partnership allows customers to experience exceptional support from conception, through the design cycle, and into production.

www.we-online.com

SMALLER
STRONGER
FASTER

ROHM SEMICONDUCTOR

REDUCES STANDBY POWER
FOR ALWAYS-ON CONSUMER PRODUCTS

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

KEY FEATURES

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

CONSUMER

www.rohm.com/electronica

electronica 2020

Wolfram Harnack Appointed as Managing Director

Wolfram Harnack is the new Managing Director of ROHM Semiconductor Europe GmbH. He reports directly to the President of the company Toshimitsu Suzuki. The position has been newly created and is of strategic importance for ROHM's growth within Europe. Previously Wolfram Harnack held the position of the President of the European Semiconductor Division at Mitsubishi Electric Europe. For Wolfram Harnack it is in fact a return to ROHM, as he joined ROHM as Sales Director in January 2008. Prior to that he worked for Toshiba Electronics Europe for 12 years. In 2015 Wolfram Harnack left ROHM and joined Mitsubishi, but now he decided to take on a new challenge: He returns with impressive success achieved under a different flag, to now set the course for ROHM´s future in Europe: "Together with Toshimitsu Suzuki, my mission is to further accelerate our growth in the Automotive and Industrial segment, particularly in the Power and Analog domain which is the Company Focus. I'm confident that I can contribute to the success of ROHM Europe with my experiences but more importantly, with my passion", explains Wolfram Harnack: "ROHM's target is to significantly grow sales outside of the Japanese domestic market. The European region will play an important role in accomplishing this objective. Being a technology leader in power semiconductors, I see great growth potential for ROHM in the automotive and industrial sectors."

www.rohm.com

International Workshop on Integrated Power Packaging

IWIPP 2021, a PSMA and IEEE sponsored workshop, will be held April 28th-30th, 2021, on the beautiful campus of Aalborg University, in Aalborg, Denmark. IWIPP is a growing and successful power technology workshop with excellent speakers and networking opportunities. Under the leadership of General Chairman Dr. Francesco Iannuzzo, Professor, Aalborg University, the International Workshop on Integrated Power Packaging (IWIPP) brings together industry, academic and government researchers in the field of power electronics components, electrical insulating materials, and packaging technologies to facilitate and promote the development and commercialization of high-density and high-efficiency power converters. Invited presentations and contributed papers will address a range of topics, including power module design, magnetic and dielectric materials technology, component performance, and application-level impacts of packaging technology. Presenters will address important challenges and present solutions to increase reliability and manufacturability while targeting improved performance with reduced size and system cost.

Packaging and related technologies are the key to creating high-density power sources. Attendance at this important workshop can keep you and your colleagues on the cutting edge. If you have technology advancements or research accomplishments to present to the community, Technical Chairman Nick Baker, Assistant Professor, Aalborg University, invites you to submit a digest for review by the technical committee. The call for papers is available at http://iwipp.org/conference/call-for-papers/. The submission portal of the website http://iwipp.org/conference/abstract-submission-page/ is now open and accepting submissions.

https://iwipp.org

embedded world 2021 Goes Digital

The embedded world Exhibition&Conference will take place next year as a completely digital event. Both the trade fair and accompanying conferences, the embedded world Conference and the electronic displays Conference, will be held as virtual formats under the name embedded world DIGITAL. Participants will have five days at their disposal from March 1-5, 2021. With this decision, NürnbergMesse is reacting to the ongoing conditions caused by the coronavirus pandemic and its effects on the embedded community – while ensuring participants have planning security in good time.
embedded world Exhibition&Conference is the global platform of the embedded community to exchange information and discover the latest trends, products and technologies. "Feedback from the embedded community has shown us that the desire to interact, network and communicate with other professionals and embedded experts remains strong, even throughout this challenging time. With the timely decision to host embedded world 2021 digitally, we are now creating the necessary planning security - for exhibitors and participants. The embedded world Exhibition&Conference DIGITAL at the beginning of March 2021 offers experts from all over the world the ideal opportunity for professional dialogue," says Benedikt Weyerer, Director Exhibition embedded world, NürnbergMesse.

www.embedded-world.eu

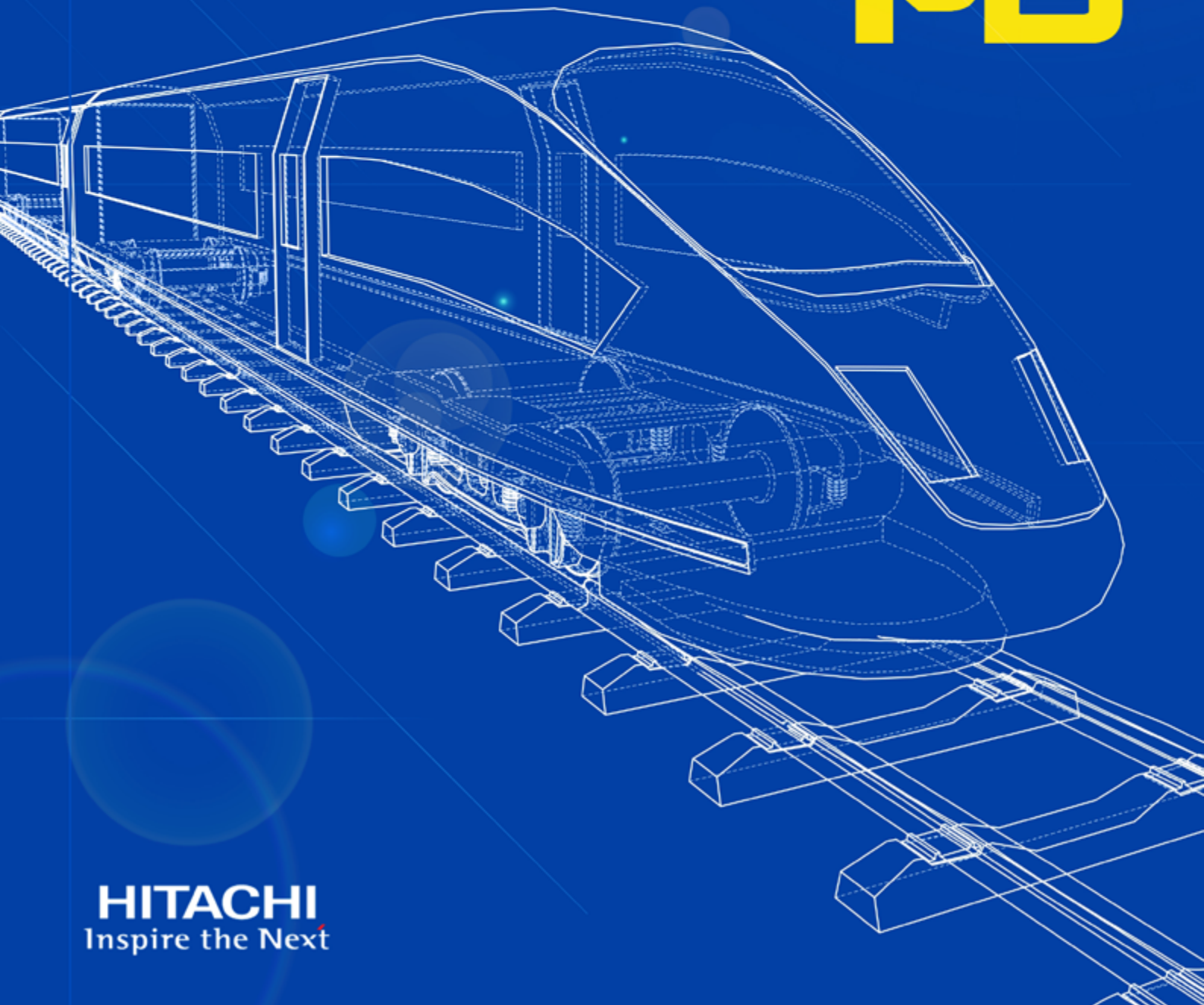
Hitachi Europe Limited, Power Device Division
Email pdd@hitachi-eu.com +44 1628 585151

Shape the Future

Full SiC 3.3kV Power Module in nHPD^2

High Voltage IGBT

nHPD^2



HITACHI
Inspire the Next

Sensor and Measurement Science International 2021

The AMA Association for Sensors and Measurement is opening its Call for Papers to the international conference: Sensor and Measurement Science International (SMSI) 2021. The convention is to take place in the coming year as a hybrid conference parallel to the SENSOR+TEST 2021 trade fair from 3 to 6 May 2021 in Nuremberg. The new final submission date for lectures and poster presentations ends on 30 November 2020. In 2021, the new conference will replace the previous AMA Conferences. The major topics, sensor technology and instrumentation will be complemented in the new format by measuring technology and metrology. The SMSI 2021 links national and international representatives from research, science, and industry. The conference pillar sensors deals primarily with sensor principles, materials, technology, and applications, and integrates the satellite conference IRS² 2021, the conference pillar measuring technology with measuring principles as well as advanced methods, networked systems, and novel AI approaches to measuring. The area of metrology deals with traceability, advanced calibration, and testing methods as well as new regulations and standards in measuring technology. The parallel SENSOR+TEST 2021 trade fair, as an

information platform for sensor, measuring, and testing technology, expands the innovation dialog for the conference participants beyond the SMSI 2021. Interested parties are invited to submit a brief description of their lecture or poster presentation in English no later than 30 November 2020.

www.sensor-test.de

Growing Customer Demand for Test and Measurement Expertise

Keysight Technologies announced it has expanded the company's KeysightCare program to provide a growing customer base with fast, reliable access to priority technical support. KeysightCare is a scalable and comprehensive support model offering test and measurement expertise through a d edicated, proactive single point of contact for instruments, software, application measurements and test. This integrated support model is now available with five tiers to meet the specific hardware, software and technical support needs of customers.

On August 24, 2020, Keysight released the results of a 3rd party survey that showed nearly all companies that design and develop electronic products experience costly and preventable delays related to test equipment configuration, maintenance or training issues. The survey found that 97% of respondents had experienced production delays that directly caused revenue loss to their business, and 90% of respondents said they would value access to testing expertise from outside the organization and that their test teams would work more efficiently with faster access to technical support experts and knowl-

edge resources. The newest offering in the KeysightCare portfolio is KeysightCare Technical Support, tailored to cover all Keysight instruments at a customer site, regardless of performance level, use model, warranty period or discontinuance status. Since November 2018, classic KeysightCare Assured is included with the majority of newly delivered Keysight instruments and software.

www.keysight.com

2020 IEEE International Electron Devices Meeting

The 66th annual IEEE International Electron Devices Meeting (IEDM), to be held virtually December 12-16, 2020, will uphold the conference's tradition as the world's premier forum for the presentation of applied research in transistors and related devices, which are the building blocks of modern electronics technology.

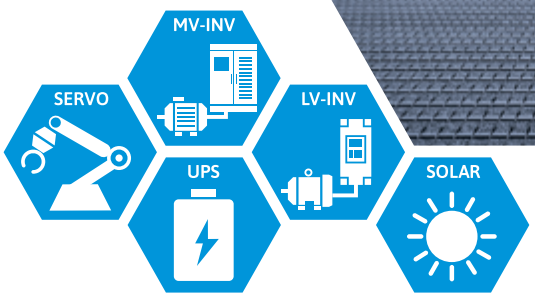
This year's theme is "Innovative Devices for a Better Future," which reflects the fact that, at a time of great global uncertainty, electronics technology is being used much more broadly than ever before to address the world's most pressing challenges.

IEDM 66th International Electron Devices Meeting

"The work to be presented at the IEDM is vital to society, and while we will miss the in-person interactions that normally take place at the conference, the fact it will be virtual this year makes it accessible to a larger worldwide audience," said Dina Triyoso, IEDM 2020 Publicity Chair and Technologist at TEL Technology Center, America, LLC. "People who couldn't attend the IEDM in prior years for any number of reasons such as visa difficulties, limited time or travel funds, and so forth, now have a chance to participate, interact with technology leaders, learn and enjoy the conference."

"The IEDM can be viewed as a leading technology indicator," said Meng-Fan (Marvin) Chang, IEEE Fellow and Distinguished Professor of Electrical Engineering at National Tsing Hua University. "That is because the program will disclose state-of-the-art results from semiconductor manufacturers and research institutions around the world. This combination of scientific research and industrial innovation allows the IEDM to provide an excellent snapshot and forecast of the semiconductor industry."

https://ieee-iedm.org



The 7th Generation Modules

DualXT & Premium DualXT

DualXT – Main features

- 7G IGBT & FWD
- New internal layout
- Higher reliability
- Improved silicone gel
- Solder or mini press-fit pins
- More power, lower losses

Premium DualXT – Additional features

- Advanced bond wire design
- High thermal conductive ceramic substrate
- Package material with CTI > 600
- V_{iso} = 4 kV
- High power density

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

Fuji Electric
Innovating Energy Technology

Laser Test and Trim Systems Distribution in Europe

GS Electronic GmbH & Co. KG will represent PPI Systems throughout Europe distributing its RapiTrim Laser Resistor Trimming Systems.
GS Electronics was founded in 1987 and is located in Fulda, Germany. The compay has established itself with a reputation of excellent sales and service of high quality products. It represents well known manufacturers with succesful installations at well known manufacturers of electric components, PV wafers and solar cells throughout Europe.
PPI System Inc. is seeing tremendous growth in the laser resistor trimming market as they offer innovative systems which enable both quick-turn and volume production resistor trimming for advanced hybrid circuits and electronic components. GS Electronics will ensure that this rapid growth trend continues globally. PPI Systems Inc., located in Ottawa, Canada, is a leading supplier of laser material processing and test systems. The company provides a broad range of turn-key solutions to the interconnect and electronic component market for via drilling, circuit processing, resistor trimming, and high precision micro-machining.

www.gselectronic.de

Agreement Includes Lineup of Power Semiconductor Devices

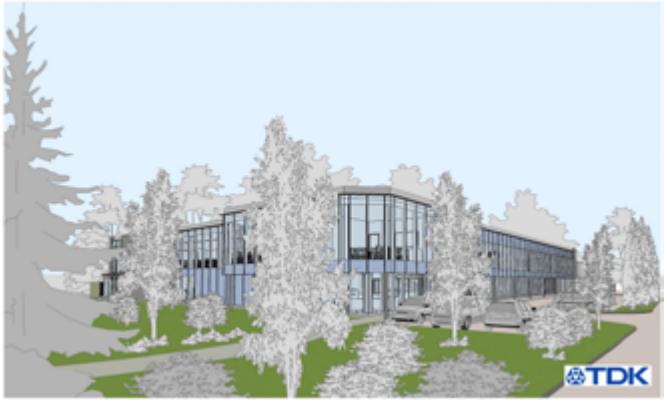
Richardson RFPD announced that it has entered into a global franchise agreement with Hitachi ABB ABB Power Grids, Semiconductors. Hitachi ABB Power Grids is a leading supplier of power semiconductors with production facilities in Lenzburg, Switzerland, and Prague, Czech Republic. The company offers a wide variety of high-power semiconductors using conventional and future-oriented technologies for the traction, industrial and energy transmission market segments. Hitachi ABB Power Grids' power semiconductor business product portfolio includes GTOs, IGBTs, IGCTs, SiC modules, thyristors and diodes in the power range of 150–12000 A and 200–8500 V.
The global agreement includes Hitachi ABB Power Grids' complete lineup of power semiconductor devices. "The addition of Hitachi ABB Power Grids' product portfolio enables Richardson RFPD to service additional high-power applications for energy transmission, traction and industrial applications," said Rafael R. Salmi, Ph.D., Richardson RFPD's president. "We appreciate Hitachi ABB Power Grids recognizing our global reach with local technical support to initiate new design opportunities." "Including Richardson RFPD as a channel partner increases our local presence in additional countries around the world," said Rainer Käsmaier, Hitachi ABB Power Grids' managing director semiconductors. "Their strong knowledge of power semiconductors and the markets we serve offered a natural fit to assist in expanding the visibility of our products and capabilities."

RichardsonRFPD
An Arrow Company

www.richardsonrfpd.com

Investment to Redevelop Manufacturing Facility

TDK Corporation announces an £11.5m investment package to redevelop its TDK-Lambda manufacturing facility in Ilfracombe, UK. The investment, which will be staged over the next three and a half years, will enable the company to increase production capacity by 50%. The original factory was built over 50 years ago with further expansion in the mid-1980s. While the company has invested heavily in new equipment and building upgrades over these years, including the addition of a £1 million EMC Centre in 2019, it is now time to redevelop the site. The redevelopment will increase manufacturing space, expand the R&D facilities, and radically overhaul and automate the end-to-end material flow. According to market research company Omdia, the global power supply market is forecast to reach almost $26bn in 2024, driven by the rapidly expanding digitalisation of economies, increasing healthcare demands and renewable energy trends. Also, noting customers' heightened awareness of the need for trusted, dependable suppliers due to recent events - such as the USA/China tariffs and COVID-19 pandemic - the planned expansion will provide further supply chain robustness within the TDK-Lambda manufacturing network, especially for the European market.



www.emea.lambda.tdk.com

UnitedSiC
Simply More Efficient

UF3SC Series
FAST 650V
& 1200V SiC FETs

Introducing the first SiC FETs with RDS(on) < 10mΩ

New UnitedSiC UF3SC series of FAST 650V and 1200V SiC FETs deliver:

- **Superior efficiency:** Ultra-low RDS(on) of 7mΩ @ 650V; 9mΩ @ 1200V
- **Lower losses:** Conduction loss 2.5X - 4X lower than superjunction silicon MOSFETs
- **Easy, drop-in replacement:** Can be driven with gate voltages compatible with existing SiC MOSFETs, Si MOSFETs or IGBTs
- **Standard packaging:** TO-247 in 4-lead Kelvin source and standard 3-lead

Go to **unitedsic.com/uf3sc** and learn how your power designs can deliver new levels of performance with the industry's best SiC FETs.

Tony Harris Appointed as Board Member

CUI Devices announced the appointment of Tony Harris as its newest board member. As a highly regarded thought leader, CEO coach, senior executive mentor, and author, Tony brings a wealth of experience in global B2B marketing, eCommerce, corporate communications, and more, thanks to his work with respected brands across a range of industries. During his time at Digi-Key Electronics, including as Chief Marketing Officer, Tony Harris was instrumental in transforming Digi-Key's marketing and online presence with an impressive selection of engineering resources, and was a key contributor to the company's growth during his tenure from 2006 to 2015. Since then, as the Founder and CEO of THINC B2B, Tony works alongside executive teams from around the world to achieve measurable and sustained long-term growth in the digital economy. "I am incredibly honored to be joining CUI Devices as they continue on this unique and exciting journey since spinning off from CUI Inc," commented Tony Harris. "Having developed strong relationships with the executive team from my time at Digi-Key, I truly believe in the company's customer-focused mission and have been a brand advocate of theirs for many years. I look forward to being more closely involved in CUI Devices' global growth moving forward."

www.cuidevices.com

Reliability in Industrial and Utility Applications

In industrial and utility applications, uptime is often one of the most critical aspects of operations – right after safety. ABB is helping to ensure reliable, efficient power in these mission critical industries with its new Integritas* industrial battery charger. The wall-mounted system features switch-mode rectifier technology that provides transformerless, efficient power conversion in a compact footprint – providing true N+1 or N+N redundancy in a single battery charger.

"Ensuring reliable, efficient AC-to-DC power and battery backup is essential in applications such as utility power, oil and gas, and process control – to name a few – where downtime can be critical," said Mark Lloyd, senior product manager with ABB. "Having reliable, efficient backup power in a single charger with high power density helps ensure these critical applications remain up-and-running while also reducing the footprint of the power equipment needed – freeing up valuable floor space."

ABB's versatile industrial battery charger supports the critical DC power and battery charging needs of various rigorous industrial applications – from utilities and manufacturing to pharmaceuticals and petrochemicals. It provides up to 18 kilowatts (kW) of output power at 125 volts DC (VDC) from a direct, three-phase, 480-volt AC (VAC) input feed.

https://electrification.us.abb.com

Cooperation to Develop Surface Coating Solutions

Höganäs and Lincotek Surface Solutions are to cooperate more closely. They announce an agreement to further strengthen their ongoing relationship in product and coating development for thermal spray and surface technology applications. The alliance targets the development of complete surface treatments for aerospace, energy, automotive and other industries. With the combination of the materials expertise of Höganäs and the surface technology expertise of Lincotek Group as an equipment supplier and service provider, both companies intend to offer newly developed solutions to end user industries for various applications. "We are delighted that Lincotek has chosen us as preferred material development partner for the Surface Solutions Division. We believe that the new cooperation agreement will further strengthen the ability of both companies to commonly develop and offer the best materials and coating solutions for the market," said Hans Keller, President Surface and Joining Technologies at Höganäs. "Our long-term fruitful business relationship with our partner Lincotek built an excellent foundation for this cooperation and we are now looking forward to the next chapter of an exciting journey together." Winfried Schaler, Group CEO at Lincotek commented: "To join forces is very exciting for us. We have been cooperating with Höganäs for many years. Today, market dynamics are changing rapidly and we need to provide answers to the latest development needs in the industry."

Höganäs Lincotek Surface Solutions

www.hoganas.com

Global Distribution Agreement

Vicor Corporation announced the expansion of its Europe, Middle East and Africa relationship with Arrow Electronics to a global distribution agreement. "We are looking forward to working closely with Arrow to offer highly differentiated modular power solutions to their extensive customer base," said Rich Begen, vice president of Vicor global distribution and channel strategy. "This agreement comes at a time when many of our customers are asking for smaller and more efficient solutions for their power-delivery networks that are changing to meet ever-increasing system power demands," said David West, senior vice president of global marketing and engineering at Arrow.

www.vicorpower.com

P-DUKE®

P-DUKE POWER

we energize electronics!

RSG®

an Acal BFi brand

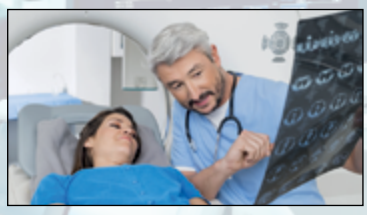
Acal BFi and P-DUKE present:
40 - 65W Multi-Output Medical AC/DC Power Supplies

Top Features:

- MxD40 and MxD65 with 4 case options (incl. DIN-Rail)
- Dual and triple DC outputs in various combinations
- 2xMOPP / 4kVAC Isolation
- Medical Safety & EMC (EN60601-1 3rd & 4th Ed.)
- TxD models for EN62368-1

MAD40 open-frame version:
40 Watt on 2“ x 3.5“ PCB

MED65 encased version:
65 Watt in 2.4“ x 4“ case



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IGBT Module for High Power Industrial and Renewable Applications

LV100-type T-series IGBT Module for Industrial Use will reduce energy consumption and size of renewable-energy power-supply systems, and more

Mitsubishi Electric Corporation has launched the LV100-type T-series IGBT (Insulated-Gate Bipolar Transistor) module for industrial use in September 2020. The common outline LV100 package, which achieves high versatility and high current density, is widely used and established in railway and electric power applications and now has been adapted for industrial and renewable use. The new LV100 T-series IGBT modules for industrial application will be available for 1200V and 1700V blocking voltages and enable the reduction of size and power loss of power converters, especially in the field of renewable energy applications such as photovoltaic and wind-power generation, and also high-power motor drives. The modules are equipped with the latest 7th-generation IGBT, based on Mitsubishi's CSTBT™ (Carrier Store Trench Bipolar Transistor) structure, and the latest RFC (Relax Field of Cathode) diode for achieving low power losses. The RFC diode has an optimized electron mobility at the cathode side. These low power losses in combination with the optimized package structure result in an industry-leading current density of 17.14A/cm². Therefore the module is enabling the miniaturization of power converters and inverterized high power motor drives.

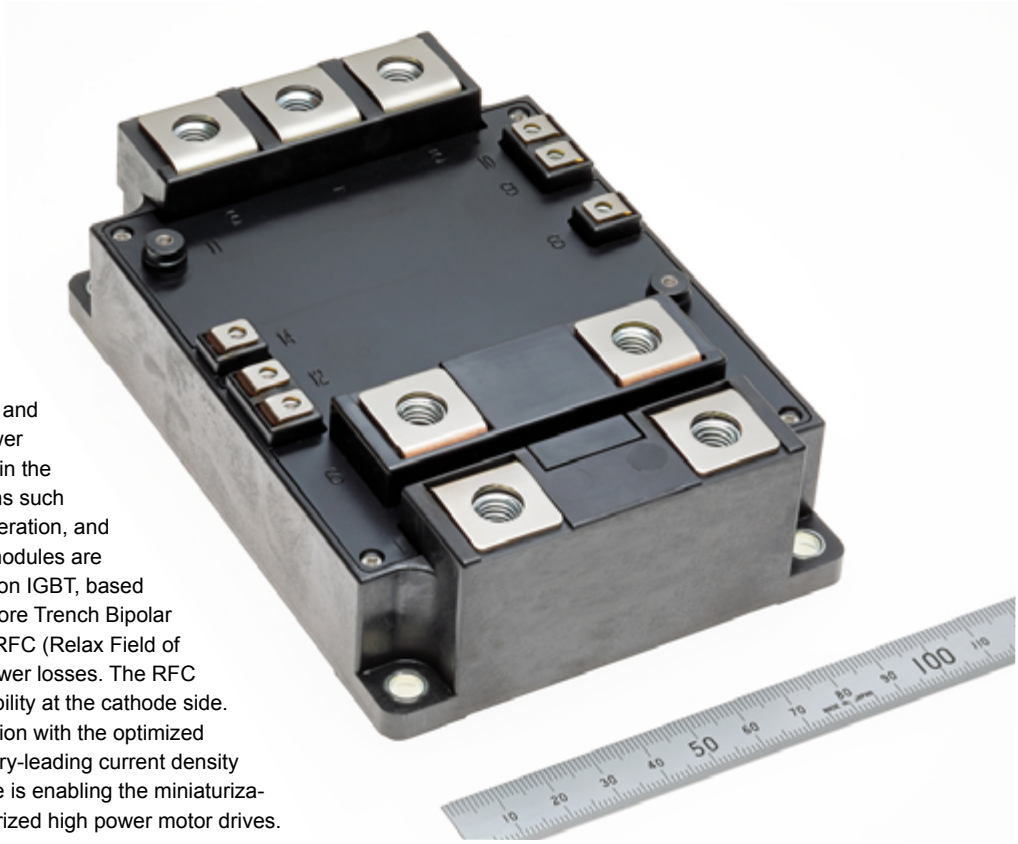

Figure 1: LV100-type IGBT module for industrial and renewable applications

The internal module structure has been optimized for more reliable inverter systems. Both insulation and copper parts have been integrated into a novel baseplate structure thus enabling an optimization of the internal electrode structure and extending the thermal cycling life to highest industry's class. Thermal cycling life is the lifespan due to stress-strain caused by gradual temperature changes which is generated for example by system start and stop load cycles. By this new structure a low package inductance has been realized. As result the optimized internal structure will contribute to the equipment reliability. The terminal layout of the LV100 package is optimized for easy paralleling and flexible inverter configurations and power ratings. The three AC main terminals help to reduce and equalize the terminal current density for achieving an increased inverter power rating.

Product	Model	Rating
LV100-type T-series IGBT module for industrial use	CM800DW-24T	1200V / 800A
	CM1200DW-24T	1200V / 1200A
	CM800DW-34T	1700V / 800A
	CM800DW-34TA*	1700V / 800A
	CM1200DW-34T	1700V / 1200A

*) CM800DW-34TA uses enlarged free-wheeling diode

Table 1: Ratings of LV100-type IGBT module for industrial and renewable applications

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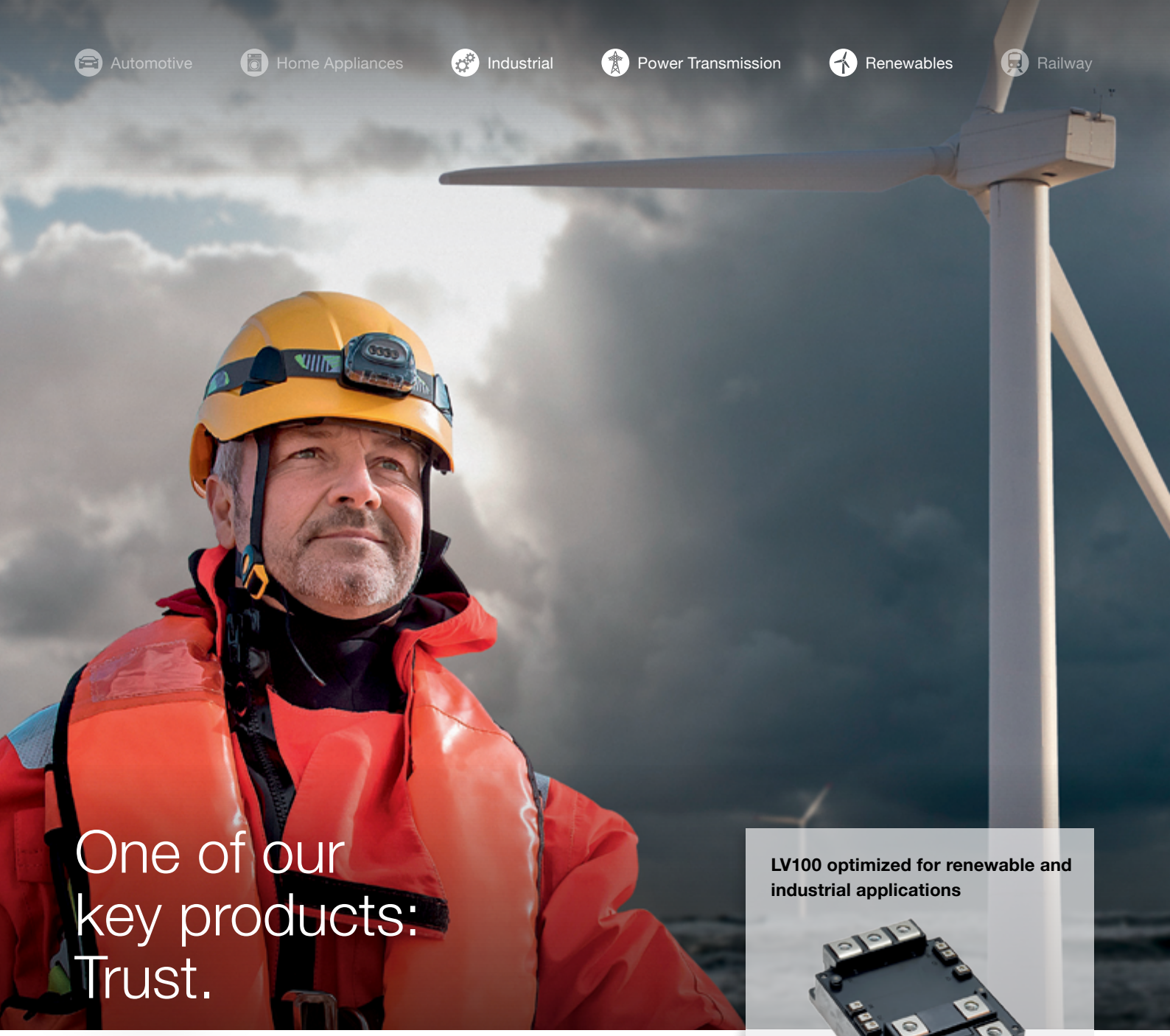
Automotive | Home Appliances | Industrial | Power Transmission | Renewables | Railway



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LV100 optimized for renewable and industrial applications

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A 25 Year-Long Success Story

Proton-Electrotex is about to celebrate its 25th anniversary. We asked the head of Marketing Department Alexey Cherkasov about the milestones achieved in these years and the company's plans for the future.

By Bodo Arlt, Publishing Editor, Bodo's Power Systems

Bodo: The company will celebrate its 25th anniversary in 2021. Tell us about the key milestones in its history.

Alexey: Correct. Next February the company will celebrate its 25th anniversary, a landmark event for both the Russian power electronics industry and our company itself. Proton-Electrotex was founded in 1996, at a very unstable time for the Russian state. The founders at the origins of the company, including the General Director Alexander Semenov, strived hard to put the company on sustainable track.
The initial projects mainly involved development and production of power thyristors for a number of projects in Russia. From the very beginning, the company set itself a goal to provide top-quality solutions, paving the road to further success. In a few years it allowed us to enter the European market, where competitors from Germany, Great Britain, the Czech Republic and Japan had been present for decades. Twenty years ago the global market was new and unknown for us, the mentality and approach to doing business were very different from those in Russia. But Proton-Electrotex managed to adapt to requirements of foreign clients. Within a few years, our company has earned both trust of large industry-forming customers and respect of our competitors. Today Proton-Electrotex is a well-known and respected brand not only in Europe, but in the entire global market of power semiconductor devices.

Alexey Cherkasov, Head of Marketing Department

Bodo: Can you name some special achievements of the company on the Russian and global markets?

Alexey: The company got lots of achievements under its belt in this quarter of a century. Year after year the company kept launching new products and modifying existing models for use in multiple industries. Every day our employees keep working to conquer new heights.
To be specific, I think that our participation in the Vyborg DC link project was one of the most significant international projects. This is the only DC link in Russia built to export electricity from Russia to Finland.
Besides, our company participated in restoration of the Sayano-Shushenskaya hydroelectric power station. We provided our semiconductors for repairs of the power machines after the 2009 accident.
Speaking about recent achievements, I want to highlight entering the prestigious rating Techup-2019. This is the Russian national ranking of the fastest growing companies in the tech industry. Proton-Electrotex took first place in the "Export potential" category among all Russian enterprises.

Bodo: Which products in the company's existing product line look the most promising in the Russian and global markets today?

Alexey: Many semiconductors look promising, including thyristors, diodes and IGBT modules. It all depends on their end use and application. But speaking about general trends in the world of power semiconductors, then of course the future belongs to IGBT modules. These products have been on the market for a long time, and yet they still continue to evolve. IGBT modules have standardized electrical parameters and overall dimensions making them an obvious choice for projects in many industries. Engineers around the world work hard to improve existing form factors and design new ones. Researchers of Proton-Electrotex follow this trend too.
Many companies pay special attention to our MIDA-type modules now. These are IGBT modules in a low-inductance housing used in new designs for electric drives, renewable energy and electric vehicles.
Besides, lots of manufacturers are now closely tracking products based on silicon carbide since this material allows end devices to operate at higher frequencies while keeping the same compact size. Dimensions are critical for many manufacturers of electrical equipment. However, there are still some nuances in this technology that prevent SiC devices from fully competing with silicon IGBTs, but this work is underway, and surely the moment will come when SiC will "bite off" the Si devices' "pie".

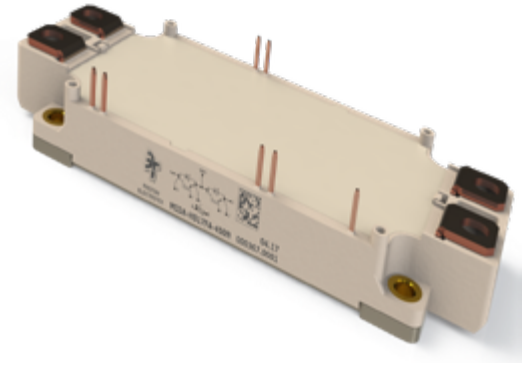
Bodo: What solutions allow the company successfully compete in foreign markets? Any new R&D projects in progress?

Alexey: Indeed, our company successfully competes in foreign markets. Today the share of exports in the total sales of the company exceeds 60%. Our facility is equipped with advanced equipment, technologies are constantly being updated, staff join various trainings and internships. Big customers are invited to carry out their own audits that also help us to improve existing production processes.
For us, an audit is a great opportunity to show off our achievements, share experience and learn something new. The company created project teams working on updating almost the entire product portfolio. This process is continuous. This is where our success lies.
The world market could confirm the quality of the Proton-Electrotex brand by now, so we are trusted not only by small and medium-sized enterprises but also market giants – ABB, Schneider Electric, Siemens, General Electric.

Bodo: You have announced the launch of a web application to calculate thermal parameters of IGBT. Tell us about this application: what are its tasks, capabilities and what is the benefit for the customer?

Alexey: Yes, we started this project last year and opened access to the app last month. This is our in-house solution, which we are especially proud of. All participants of this project have put their souls into it.
One of the main tasks of the web application is to make it easier for designers to create converters based on IGBT modules manufactured

by Proton-Electrotex. This software is designed to calculate heat losses in specified operating modes. A user can select one of the IGBT modules manufactured by our company, specify the circuit type and input data for the voltage, output frequency, phase load and other parameters.



At the moment, calculations support five possible topologies, but we intend to keep developing this application so its functionality will increase in the future.

Bodo: Did your industry encounter any new problems related to the situation on the global financial markets and the pandemic?

Alexey: Though customers from Europe and Asia are already returning to a normal life, one should not expect the same from the economy. The global economy has suffered massive damage over the past few months, and it will take more than one year to recover. Speaking about the electrical engineering market, it is hard to say when it will return to the pre-crisis levels. Now we are positive that the consequences will be there, and the electrical engineering market will begin to feel the consequences of the spread of the virus to a greater extent as soon as in the second half of this year. Major market players have already reduced their forecasts for the next 6-12 months, so a quick recovery is not expected.

Bodo: Recently the company was included in the list of systemically important organizations of the Oryol region. Such a large organization is surely familiar with the problem of staff shortage. How do you solve it?

Alexey: Yes, according to the decree of the Oryol region government Proton-Electrotex is a company of regional significance with a high impact on employment and social stability of the Oryol region. Our company employs about 500 employees now. Each of them makes an invaluable contribution to the development and prosperity of the company.

Understaffing is a known problem in our industry. It is very difficult to find professionals meeting all our requirements. This is why our company has a number of programs aimed at handling this problem. We have been closely working with the Oryol State University for many years now. Starting from early courses we start to supervise promising students, provide them part-time involvement in our projects, give them hands-on experience in research and production. So students become part of our team throughout their studies, and after graduating they join us for full-time employment.
In addition to this program our company holds trainings and seminars, our employees attend all kinds of industry events. There are many ways to improve your skills and gain new knowledge. Heads of departments have an opportunity to improve their qualifications under MBA and EMBA programs.
Professional workforce has tremendous importance in our industry as it directly affects the success of the company, both nationally and internationally. That is why we will always be focused on this issue.

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Isolated MagI³C Power Module Masters the 24V Industry Bus

Challenges for an electronic design engineer for industry control in terms of supply voltage from the 24V bus, with the use of isolated DC/DC converter modules.

By Timur Uludag, Product Manager Power Module MagI³C EMC & Inductive Solutions, Würth Elektronik eiSos

Introduction

Every industry control circuit needs a supply voltage. But as the industry control circuit is only a small part in a bigger electrical environment, a lot of specification parameters have to be considered to choose the proper supply device. During the design in of a DC/DC converter, the ever-present questions from the designer are:

- What is the input voltage range?
- What is the output voltage (range)?
- How much power do I need?

The following overview provides a brief summary of the essential facts that explain the story behind key parameters.

What kind of isolated power module do we need?

The following applications are typical for an industrial environment such as bottling plants, rolling mills, conveyor belts and printing presses:

- Interface/Bus Isolation – RS232, RS485, CAN, Interbus, Profibus
- Isolation of Digital circuits
- Sourcing isolated amplifier, analog-to-digital converter
- Measurement and data acquisition

All these applications have one thing in common, which is the input supply voltage is isolated from the bus voltage. But why should you galvanically isolate a supply from a bus or switching components in general? Galvanic isolation prevents faults that can propagate from the supply voltage into the bus and disturb its operation. The following schematic (figure 1) shows a typical application for an isolated power module. It shows the set-up for isolated RS485 communication with the essential functional units.

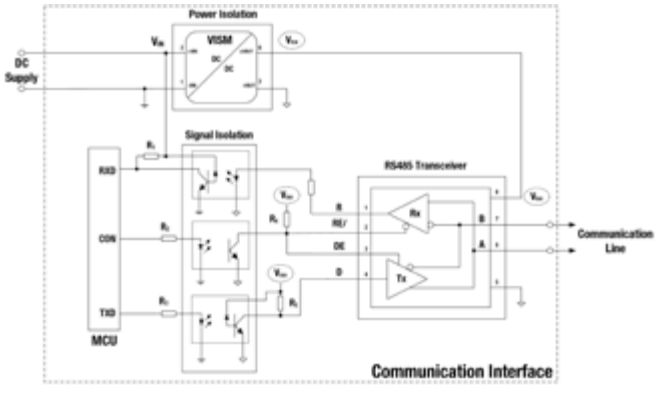

Figure 1: Typical application for an isolated power module.

The following functional units are necessary to set up isolated communication:

The Micro Controller Unit (MCU) provides the data for the RS485 transceiver and receives data from it. The signal isolation unit implements galvanic isolation of the signals using optocouplers. Galvanic isolation of the grounds between the signal isolation unit and the transceiver unit is achieved with a power isolation unit - a DC/DC converter power module.

Wide voltage range – Enhanced application area

In terms of input voltage range, 8V to 42V has been set as the typical industry range for decades. This voltage range has been selected for two reasons. First, it is inspired from existing relevant standards such as IEC61131-2 for programmable logic controllers (PLC). Second, field experience with electrical supply and installation conditions confirmed and agreed with this voltage range. It should be noted that the most commonly used rail voltages of 12V and 24V can be covered with this classical voltage range.

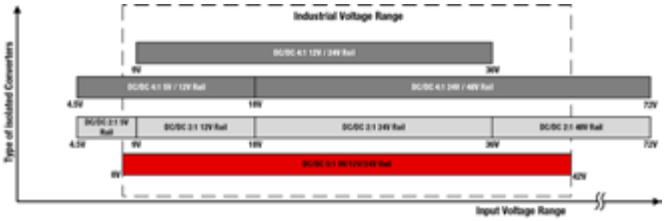

Figure 2: Industrial voltage range versus converter types.

Typically, industry uses 2:1 and 4:1 isolated converters to cover the wide input voltage range of 8V to 42V as shown in figure 1.
As an explanation to the terminology, the first number of a 2:1 or 4:1 converter indicates the multiplication factor. And this value is multiplied by a minimum input voltage value to get the maximum voltage range value. This means for a 2:1 converter with a minimum input voltage value of 4.5V, the input voltage ranges only from 4.5V to 9V. If another voltage range is needed, a different type of module needs to be chosen. But none of the commonly available 2:1 and 4:1 modules cover the industrial voltage range in total. The 5:1 SIP-8 module from Würth Elektronik cover with one type the complete industrial range of 8V to 42V. If we also take into account the adjustable output voltage (3.3V to 6V) of the SIP-8 module the added value is even more obvious. It can address common applications like CAN or RS485 for isolated converter with 1W need a supply voltage of 3.3V or 5V.

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To supply an application with 3.3V and 5V, two types of power modules are needed instead of one with adjustable output voltage like the SIP-8.

The 5:1 SIP-8 with wide input/output voltage range – reduces the type of different converters as well as the number of designs that have to be conceived, configured, tested, EMI conformity proven, built and logistically handled.

Wide voltage range – Input Voltage limits
Basic considerations
For further considerations, it is helpful to have a common understanding of the structure of an industrial application, such as which voltages are present and why.

Industrial applications are known for long connecting lines between the separated parts of the application. Due to the spatial extensions the length of these connecting lines can be in the range of tens of meters.

Figure 3 shows the basic structure of an industry plant. Nowadays, the electrical supply is realized through cabinets with switched mode power supplies or transformer power supplies. Transformer power supplies are still common for higher power application supply. The separated parts of the applications are supplied through a dc bus. On site, every separated electrical load is connected via a sub distribution with 24V. It is easier to generate the 24V in a centralized cabinet and distribute them through a dc bus than to distribute the hazardous 230Vac / 400Vac. This also reduces the number of separated power supplies.

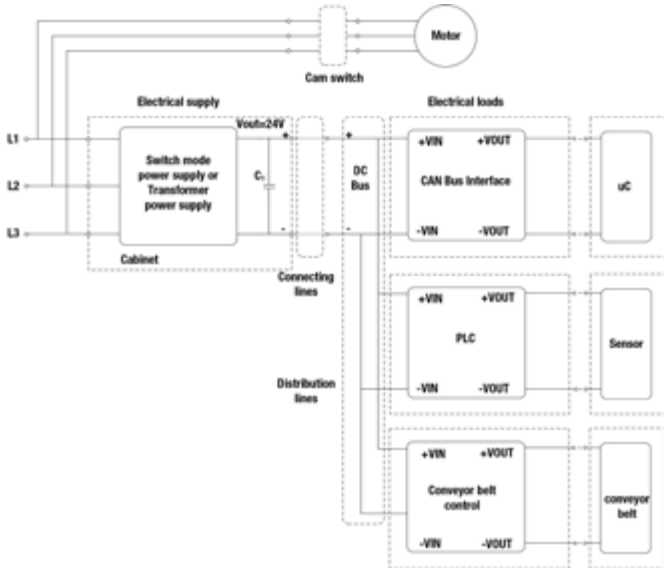

Figure 3: Basic structure industrial plant

Based on that structure there are three main influencing phenomena to the dc bus voltage:

- The voltage from the electrical supply
- Disturbances to the dc-bus from running cables that are placed in parallel
- Voltage drops due to current flow

In order to explain the lower voltage limit the voltage drop due to current will be considered:

Minimum input voltage – Lower limit
Usually the cable cross-sections for the DC-Bus is selected based on experience, rough estimation or with the use of tables. It should be noted that the commonly used design constraint for cable sizing is to avoid overheating. This means the voltage drop of the connecting line is mostly overlooked and therefore not considered. This voltage drop in turn means a difference in the voltage levels between output of the electrical supply (Vout) and the input of the application (+VIN).

For a better clarification a numerical example calculation is shown with real values that could be found in an industrial plant:

24V bus voltage 4A rated current Connecting line length l= 60m Cross sectional area A=0.75mm^2 Copper cable with specific resistance $\varrho=0.0172\,\frac{\Omega mm^2}{m}$	$R=\varrho*\frac{l}{A}$ **(1)** $R=0.0172\,\frac{\Omega mm^2}{m}*\frac{60m}{0.75mm^2}=1.376\Omega$ Voltage drop (V)= current flow through dc Bus (I)*cable resistance (R) **(2)** V=4A*1.376Ω=5.504V **(2)**

Based on the cable cross sectional area, A, cable length, l, and the specific resistance the electrical resistance, R, can be calculated as 1.376Ω using equation (1). If we consider a 100W supply, a rated current of 4A flows through the 24V DC bus. Based on equation (2) we will get a voltage drop across the connecting lines. That means, at the supply input of the application, e.g. PLC, the nominal 24V cannot be provided as it is only 24V-5.5V=18.5V. If we take a closer look at the PLC standard IEC 61131-2, the input voltage range for the supply voltage is defined to 19.2V to 30V. With a supply voltage of 18.5V, the undervoltage shut down of the PLC will be tripped and it will stop its operation.

The lower operating voltage limit of 8V of the SIP-8 enables a placement in an application far away from the supply cabinet.

In addition, an undervoltage detection circuit can be installed to protect against input voltage drop below 9V, in a typical 9V application.

Maximum Input Voltage – Upper limit
For the derivation of the maximum input voltage, the industrial plant (figure 3) has to be decomposed to its functional units which are the electrical supply, the DC-bus and the electrical loads. The electrical supply itself, e.g. transformer power supply without post regulation, is going to be supplied with 3x380Vac -15% / +20% whereby it is possible that the dc bus voltage differs from the nominal 24V. Furthermore voltage fluctuations of the ac input voltage due to relieved ac motors that are connected in parallel change the output voltage of a transformer power supply.

As already mentioned, the supply and the loads are connected through a dc bus, with some 10 meters cable connections. These cables can act as an antenna and receive disturbances from neighboring pulse loads such as frequency converters. These disturbances can then be distributed to the entire dc bus and every connected application. In addition, the input side physical connection of the different applications itself through the dc bus could lead to interactions. These include e.g. voltage spikes due to inductive induced switching transients and back feeding overvoltage from dc motors. As a basis for the explanation of the maximum input voltage value two parameters are relevant:

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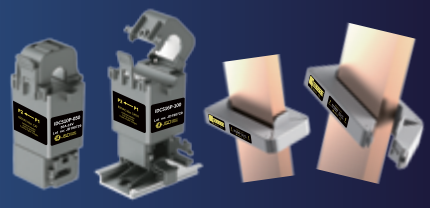

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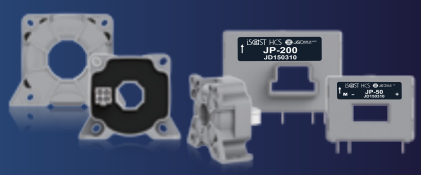

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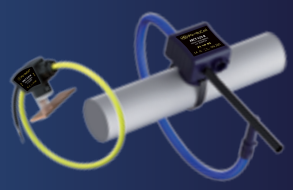

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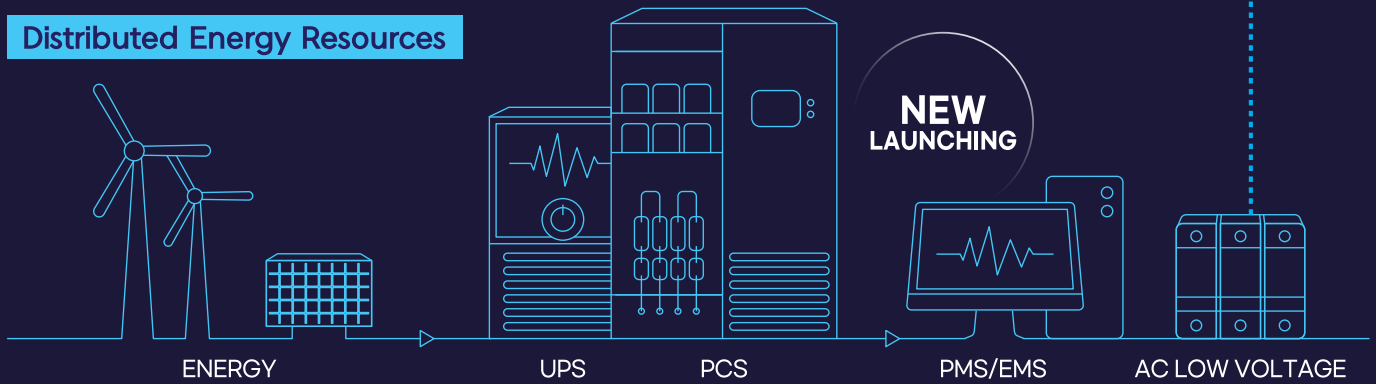

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First, the value of the maximum output voltage of the electrical power supply that is technically possible. Second, the maximum peak value of an input protection element for a nominal 24V application.
Every switched mode power supply or transformer power supply has one or more output electrolytic capacitors for stabilization and filtering the output voltage, see figure 3. These capacitors have a voltage rating of 35V for a 24V nominal output voltage. The IEC 60384-4, chapter 4.14 defines peak voltages and their frequency for the lifetime of an electrolytic capacitor that can be applied without visible damages of the capacitor or a capacitance change of less than 15%. The bearable peak voltage is set to the 1.15 times of the rated voltage. This leads to 40.25V for a 35V capacitor.
To protect the input of the application against transient over voltages, Transient Voltage Suppressor Diodes (TVS) are commonly used. The diode conducts if the breakdown voltage VBR is reached and the energy of the impulse is bypassed through the diode and thus protects the load. No destructive voltage greater than the clamping voltage VClamp of the TVS can be present.

To protect a 24V application against transients, following basic guideline is a suitable reference point:
The diode starts conducting at the maximum reverse voltage (VRMW) and the current is negligible with only few µA. Therefore, the nominal operating voltage of the load and its tolerances has to be above VRMW. For a nominal 24V rail, a TVS diode from Würth Elektronik with 26V VRMW is a common value. When the transient voltage reaches VBR the diode conducts and a current of 1mA flows. Due to the technology of a TVS diode, the breakdown voltage has a tolerance between a minimum and maximum value. Therefore a precise tripping point cannot be defined. For our 26V VRMW example we have the region between 28.9V and 31.9V. The diode is able to clamp the maximum voltage VClamp while conducting the maximum allowable current of IPeak. For a TVS diode with a 26V reverse voltage VRMW the clamping voltage VClamp is typically 42.1V. If you compare TVS diodes from various suppliers the characteristic values are all nearly in the same range.
The TVS diode protects a DC/DC power module in the 24V system against overshoots above the absolute maximum ratings VINMAX. In general the higher this value is specified the easier it is to design the right TVS diode and the input filter. That means that it is more difficult to find the right diode if the nominal operating input voltage is close to the maximum input voltage VINMAX of the module.
In conclusion, a specification of the maximum operating input voltage VIN of the SIP-8 isolated power module, 42V is a proper value to withstand the 40.25V and 42.1V transients as shown above.

Wide voltage range – Output voltage limits
3.3V and 5V are the common IC supply voltages in industrial control applications like:

- Interface/Bus Isolation – RS232, RS485, CAN, Interbus, Profibus.
- Isolation of digital circuits.
- Sourcing isolated amplifier, analog-to-digital converter.
- Measurement and data acquisition.

Figure 5: SIP-8

Common isolated power modules on the market provide a fixed output voltage. The SIP-8 isolated dc/dc module provides an adjustable voltage range because in some cases it is helpful to set the output voltage a little bit higher than the nominal operating voltage value of the load so that it is more robust against, e.g. voltage dips. Therefore the bulk capacitor of the load can also be reduced in its capacitance value because the undershoot at the module output is less.

Power Boost – "Power more than you expect"
In an industrial plant with its variety of applications, a lot of interaction between the supply, the loads and interference takes place. Many parameters are hard to calculate and hence can change during the implementation
One important point is the power that is needed to supply a load. Therefore, it is useful to have some kind of flexibility without changing the design.
A power boost feature is the ability of a power module to provide more than the nominal output power. There are two possible kinds of Power Boosts: static and dynamic. The static power boost provides a durable extra power. The dynamic Power Boost even provides a multiple of the nominal power at a limited time. It needs periodic cool down cycles. During the power boost event, the maximum ambient temperature rating is lower. This is related to the increased power dissipation of the power module.

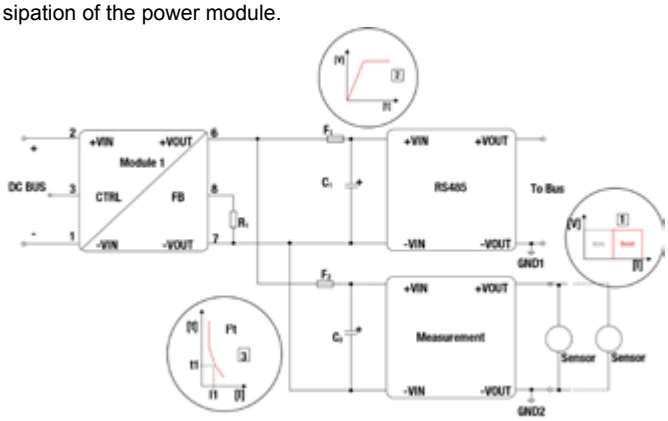

Figure 4: Power boost abilities

Thanks to the ability to deliver more than the nominal power, the following additional positive aspects enhance the applications of the power module:

- Unforecasted increases in load demands are supported – see figure 4 [1].
- Monotonic charging of capacitive loads is provided without voltage dips – see figure 4 [2].
- Backup power for momentarily higher energy demands of the application.
- Tripping input fuses of downstream applications in case of an overload (ensures higher current for safe tripping) – see fuse tripping characteristic see figure 4 [3].

To fulfill all of these requirements the VISM 17791063215 SIP-8 from the "Fusion" series was developed.
This new MagI³C module can work with 9V / 12V / 24V and 36V-bus voltages with its ultra wide input voltage range from 8V to 42V. The module is a functionally isolated DC/DC converter that includes the PWM control IC, power stage, transformer, input and output capacitors. The precisely regulated output voltage can be adjusted from 3.3V to 6.0V. The output is continuously short circuit protected. The 1W power module can offer triple of the rated power capability with Power Boost. Therefore, applications with a peak power consumption of up to 3W can be supplied. An ON/OFF Pin turns the module into a remote controlled power source. By virtue of its unique features, the module is suitable for applications like supplying interfaces, microcontrollers, industrial control and test & measurement equipment.

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Keeping Harmonics in Check with Electronic Voltage Sensors

From wind turbines to railway traction systems, the protection of critical motors against abnormal situations has always been vital. With increasing amounts of energy supplied by renewable sources such as wind power, it is also vital to ensure that motors receive a high quality power supply.

By Damien Leterrier, Global Product Manager, LEM

One of the key considerations is to ensure the reliability and safety of the system when converting the primary voltage from a DC to an AC system, and to do so in all environmental conditions and temperatures.

The increasing demand for green energy is one of the drivers of the adoption of wind power. Wind turbines commonly use a variable speed controller that works with the power electric converter to connect the generated power to the grid. However, a common problem of power electronics is the generation and emission of harmonic currents, which dramatically reduce the quality of the injected current.

The table below summarizes the requirements of IEEE 519, showing the allowable harmonics limit for both voltage and current at various bus voltages.

Bus voltage V at PCC	Individual harmonic (%)	Total harmonic distortion (THD) (%)
V≤1.0 kV	5.0	8.0
1 kV<V≤69 kV	3.0	5.0
69 kV<V≤161 kV	1.5	2.5
161 kV<V	1.0	1.5[a]

[a] High-voltage systems can have up to 2.0% THD where the cause is an HVDC terminal whose effects will have attenuated at points in the network where future users may be connected.

Source: Modified from IEEE Std. 1159-2009, IEEE Recommended Practice for Monitoring Electric Power Quality, IEEE Power and Energy Society, 2009.

Figure 1: Allowable harmonics limits for current and voltages at different bus voltages

Various types of filters are used to reduce the harmonic distortions to acceptable levels. These filters can compensate for the harmonics of non-linear loads and are usually installed close to the point of distortion. One of the more common techniques is to use an Active Power Filter, which repairs the distorted waveform by injecting an anti-harmonic waveform. A typical circuit schematic is shown below.

An anti-harmonic signal waveform is then generated using the p-q theory as a reference signal for APF switching. Clarke transformation is used to transform the three-phase coordinates into equivalent two-phase α-β coordinates for voltage and current.

In a high current/high voltage system, the demands on the sensor are relatively high, with a requirement to bring the measured voltage to the controller in a safe and insulated manner.

The DVC 1000 family of electronic based voltage sensors from LEM offers this high level of insulation, up to 4.2kV. Its modular design also allows it to be installed as close as possible to the load, ensuring it can fit into restricted spaces.

In railway applications, the auxiliary converter which brings power to loads such as fans, blowers, lighting or battery chargers needs to perform stringent monitoring of the harmonics. In particular, it is very important not to re-inject any signal back to the tracks at a 50Hz frequency, which could result in disturbances to track equipment and a consequent risk to safety. This is why the converters are often coupled with a voltage sensor which monitors the signal and plays an important role within the safety loop.

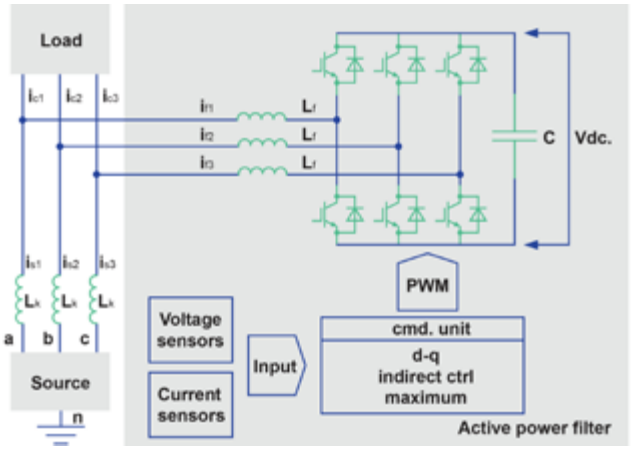

Figure 2: An Active Power Filter can be used to repair distorted waveforms

As previously mentioned, protecting the motor is a permanent requirement. In particular, most electric drives incorporate an inverter circuit which rectifies AC into a high-voltage DC signal. Called a DC-link, this serves as a power supply for circuitry that generates drive signals to power the motor. The DC-link voltage must be continuously controlled. Under certain operating conditions, a motor can act as a generator and deliver a high voltage back into the DC-link through the inverter's power device and/or the recovery diodes. This high voltage adds to the DC-link voltage, and the IGBTs (insulated-gate-bipolar transistors) driving the motor can be stressed by a high (and potentially damaging) surge voltage. An isolated voltage sensor is then necessary to monitor voltage back to the control application, which will shut down the whole application safely in the event of an overvoltage.

As well as overvoltage conditions, under voltages can be just as dangerous. If we consider a 600V rated drive, the overvoltage should be around 1000V while undervoltage would be around 400V. The same sensor should be capable of being used between these two limits.

There are several conditions that could lead to a voltage drop, but the most common one is the loss of one phase. Having said that, the volt-

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age sensor can be located at the AC input side of the rectifier, or most commonly, directly at the DC-link. Installing a voltage sensor on both sides will bring more information and will be safer for the system.

Motor drives are not the only application that require galvanic isolated voltage sensors. Other applications such as solar inverters and UPS also require these functions to ensure the protection and safety of the application. For such cases, a voltage sensor must accurately measure the DC-link voltage and provide isolation between the high-voltage side and the low-voltage controller side.

The question is, when do we need isolated voltage sensing and when should we choose a non-isolated sensor or simple resistance divider?

There are two main reasons to use such a sensor:

First case: When the microcontroller, which hosts the AD converter, is not referenced to the same point (so DC-) as the voltage measurement (the resistive divider). Care is needed to delineate between different grounding in the system. By isolating both the signal to measure and the microcontroller, we can avoid damage to the system from events such as inductive spikes or lightning strikes.

Second case: The second question is, what safety regulations are in place that require an actual isolation barrier rather than simply relying on the attenuation network? Often, for safety certifications, resistive attenuation is not enough to ensure safe grounding of the system. The voltage sensing then needs to go through an isolated channel in order to ensure an adequate safety barrier.

When the whole system is being designed around different equipment in place, adding the safety requirements, without defining specific equipment, can be more cost-effective by using the existing devices (such as a controller or a PLC) to do the monitoring. In this case, the DVC 1000 offers the necessary easy-to-use voltage sensing with the appropriate isolation to the control application. This direct sensing will be even easier using the standard interface (+/-10V or 4-20mA) of the DVC 1000, which is compatible with the standard analogue inputs of the controller. The versatility of the DVC 1000 to measure AC and DC will allow a wide range of applications.

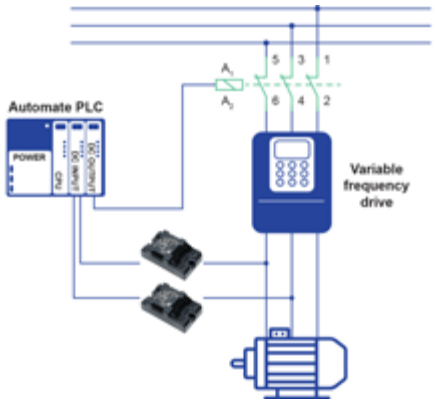

Figure 3: Isolating with a DVC1000 allows existing control elements to monitor power applications

For higher integration, the DVC 1000 is also available in a PCB mounted version, for further space saving. Likewise, the panel mounted version, the DVC 1000-P, is self-sufficient and does not require additional components.

With installations becoming ever smaller, LEM developed a new technology for these voltage measurements. Based on the isolating amplifier technology, these developments gave rise to the DVC series.

To complete its range of digital voltage sensors offering smaller dimensions, LEM has developed a new voltage sensor for measuring voltages up to 1000V RMS nominal and 1500V peak.

To measure voltage (VP), the DVC series uses only well-known electronic components, the major one being an isolating amplifier. The voltage to measure (VP) is directly applied on the sensor primary connections through an internal resistor network and some components allowing the signal to feed an isolation amplifier.

This allows an isolated signal to be recovered and then conditioned in order to supply a voltage or a current at the sensor output connections, which is an exact representation of the primary voltage.

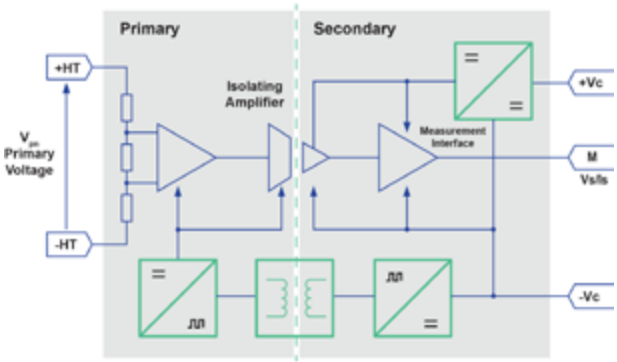

Figure: An isolating amplifier provides an exact representation of the input voltage at the output terminals

An internal isolated DC-DC converter is used to supply the electronics on the primary side.

Isolating Amplifier technology features

- Any kind of signal - DC, AC, pulsed, complex - can be measured.
- Galvanic isolation between primary (high power) and secondary circuits (electronic circuit).
- Fast dynamic response for a wide frequency bandwidth.
- Small volume needed.

This new family, known as DVC, consists of two main products, one for PCB mounting (DVC 1000-P) and one for panel mounting (DVC 1000), where a DIN rail mounting adaptor is also proposed as an option.

Figure 5: DVC 1000x series mounting options

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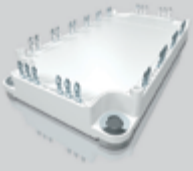

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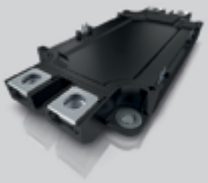

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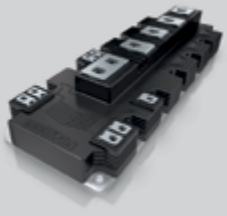

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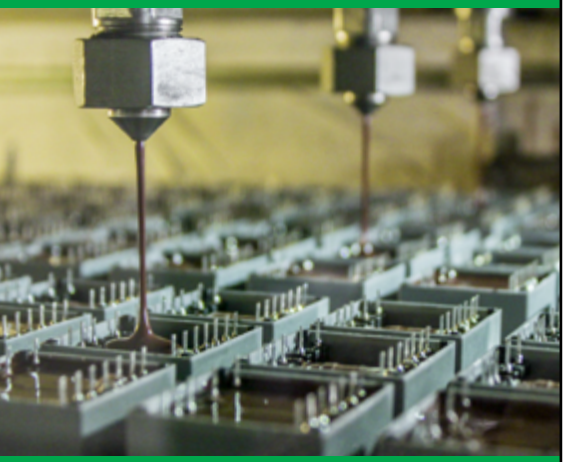

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The DVC 1000-P (soldered to a PCB) is powered with + 5V power supply and converts a bipolar input voltage into an output voltage centred on a 2.5V voltage reference. This reference is accessible by the user, who can use their own reference as an alternative.

The DVC 1000 (panel mounted) is powered with +/- 15 to 24V power, and converts a bipolar input voltage of 1000VRMS (+/- 1500V peak) into a bipolar instantaneous current output of +/-30 mA peak (DVC 1000 model) or a voltage output of +/- 10V peak (DVC 1000-B model) or a 4-20 mA unipolar instantaneous current output at 0…+1000V DC (DVC 1000-UI model) (unipolar DC Voltage measurement only).

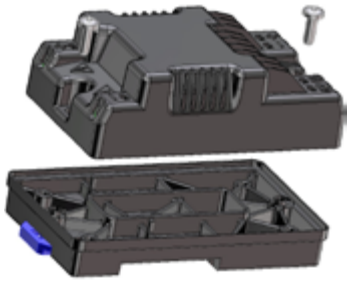

Figure 6: DVC 1000-P for PCB mounting - DVC 1000 models for panel mounting

Figure 7: DIN rail mounting adaptor proposed as an option with DVC 1000 models

	DVC 1000 DVC 1000 B	DVC 1000 UI	DVC 1000-P
Primary voltage Nominal	+/- 1000V	1000 V	+/- 1000V
Primary voltage Measuring range	+/- 1500V	1000 V	+/- 1500V
Secondary	-30mA to 30 mA (max) -10V to +10V (max)	4…20mA	+0.5V to +4.5V (max)
Power supply	+/- 15V DC (+5/- 7%) +/- 24V DC (+5/- 7%)	+15…24V (+5/- 7%)	+ 5V DC (+/- 5%)
Overall accuracy (-40 to +85°C)	±1.7%	±1.7%	±1.5%
Response time at 90%	12µsec	17µsec	8µsec
Typ. Bandwidth –3dB	35.000 Hertz	35.000 Hertz	44.000 Hertz
Isolation voltage level	4.2kV (50 Hz/1min)	4.2kV (50 Hz/1min)	4.2kV (50 Hz/1min)
Partial discharge level	1650 V (< 10pC)	1650 V (< 10pC)	1650 V (< 10pC)
Consumption	20 mA (max)	22 mA (max)	29 mA (max)

Figure 8: Performance provided by the DVC series

This technology brings a significant space saving. For comparison, a standard voltage sensor using insulating digital technology occupies around 304 cm3 of volume, whereas the DVC 1000-P needs only 37.4 cm3, representing an 87 % space saving.

The unit also weighs only 22g, 67% less compared to a LV 25-1000 model based on Hall effect closed loop technology. For instance, the panel mounted DVC 1000 versions measure only 29 x 51 x 89 mm and can be mounted on panels for a total occupied volume of only 131.6 cm3 with a weight of only 57g, making it unique on the market.

The DVC series complies with a range of internationally-recognized safety standards in addition to its adherence to IRIS specifications and uses materials that conform with all relevant fire and smoke requirements (EN 45545), which are mandatory in railway applications.

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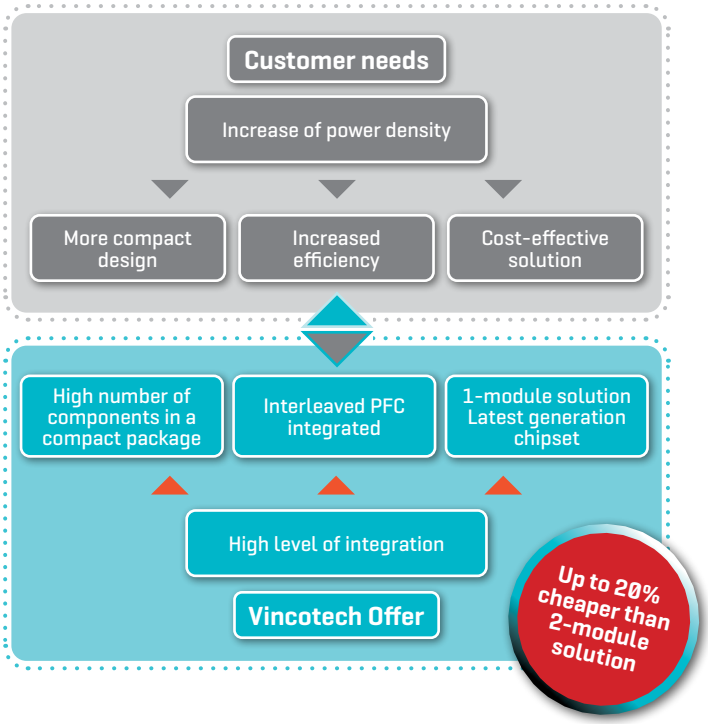

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Gallium nitride FETs have continued to gain traction in many power electronic applications, but GaN technology is still in the early part of its life cycle [1]. While there is much room to improve basic FET performance figures of merit an even more promising avenue is the development of GaN power ICs.

By John S. Glaser, Director of Applications Engineering, Efficient Power Conversion Corporation

The lateral FET structure of modern GaN-on-silicon devices lends itself to the monolithic integration of both power and signal devices, and integrated GaN power ICs are beginning to appear commercially [2], [3]. This integration promises to reduce size and cost while simultaneously improving reliability and performance.

This article provides an example of the benefits via the introduction of an integrated FET and gate driver IC. This IC was conceived primarily as a laser driver for indirect time-of-flight applications and is capable of driving 10 A pulse currents from a 40 V bus. The output rise and fall times of this IC are under 600 ps while switching 10 A, it has an output $R_{DS(on)}$ of approximately 50 mΩ. and can switch at over 100 MHz. This IC is part of a family of components that can accommodate different supply and logic family inputs. All current members of this family have the same 2×3 BGA chip-scale package (see figure 1) with a 1 mm × 1.5 mm footprint. This package has excellent thermal performance and extremely low inductance.

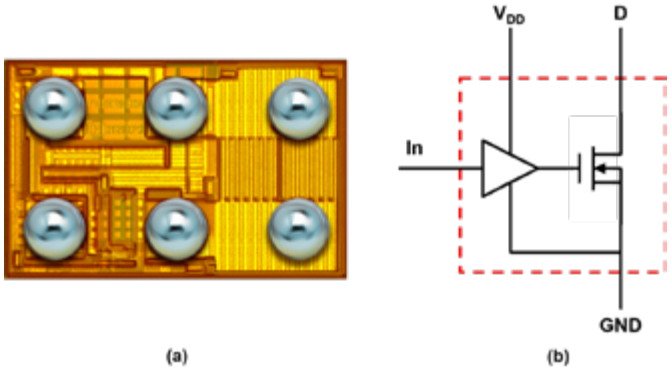

Figure 1: Photo of the IC (a) and block diagram (b) for EPC21601 fully integrated GaN power switch.

Laser Driver Requirements

Laser drivers for lidar are a pulsed power application. Figure 2 shows a simplified laser driver. Initially, switch Q_1 is off and C_1 is charged to the input voltage V_{IN}. A command signal $v_{command}$ causes switch Q_1 to discharge C_1 fully, or partially, through laser diode D_1. Inductor L_1 represents the stray inductance of the $C_1D_1Q_1$ loop. Modern lidar systems demand high current and narrow pulses with short transitions. In simple terms, the faster the driver, the better the resolution; and the higher the current, the further the range. Depending on the lidar system, pulses may range in width from 1 ns to 100 ns, and from 1 A to more than 100 A.

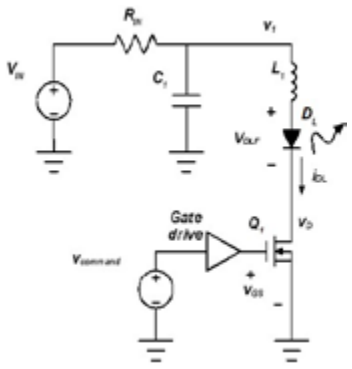

Figure 2: Simplified schematic of the laser driver.

Two major forms of lidar dominate the lidar industry today: direct time-of-flight (DTOF) and indirect time-of-flight (ITOF) [4]. Typical DTOF lidar sends individual pulses and times the reflection to compute the distance to the target. ITOF lidar works by comparing the phase of a transmitted and reflected pulse train. ITOF lidar has recently shown tremendous growth due to the ability to use simplified receivers and therefore achieve lower cost. Imaging chips have been developed based on low cost CMOS camera imaging technology that lets the imaging chip provide distance information for each pixel. This is turn allows an entire frame of distance information to be captured at once. These are sometimes referred to as “flash lidars” since they use the laser as a flash lamp to illuminate the scene. Though initial designs have been done with silicon laser drivers, these have short range and suffer from poor image quality as well as lower frame rates due to the weak and poorly shaped laser pulses. GaN FETs have proven effective in these designs by enabling higher currents and faster pulses with sharper edges in a cost-effective manner.

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Typical ITOF specs for portable lidar systems

Much of the growth in ITOF lidar has been in the medium range, from less than 1 meter to 10s of meters. These systems range from single-point distance measurement systems to megapixel TOF cameras, but the trend skews towards multi-spot and imaging systems due to the ability to capture a wide field of view in one detection cycle. This trend favors a light source that can illuminate the entire scene at one time and this is a natural fit for vertical cavity surface emitting lasers (VCSELs). Individual VCSELs are very small, but since they emit from the die surface, many VCSELs can be integrated on a single die to increase the light output. For small, portable systems, typical pulse current requirements range from 2-10 A. While the voltage drop of a single VCSEL is small at low currents, the equivalent series resistance can cause a substantial voltage drop at higher currents. A series connection of VCSELs can further increase voltage drop. Wire bonds, which are often used to connect to the VCSEL, can contribute additional voltage drop due to the added inductance. Today, the voltage drop of the VCSEL can range from 3 V to 30 V, with many applications needing ≥ 10 V. When operating in burst mode, the pulse frequency may range from a few MHz to beyond 100 MHz.

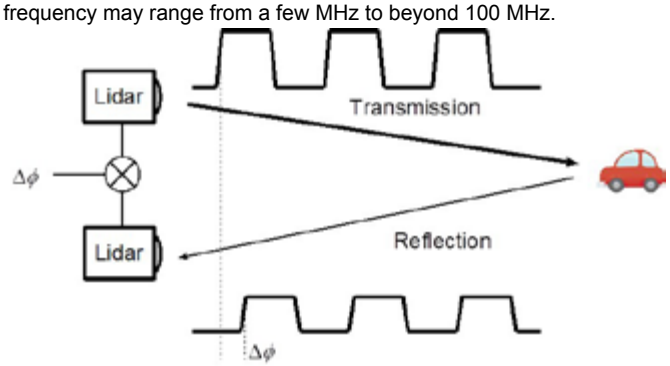

Figure 3: ITOF operation overview diagram.

Since ITOF imagers use phase difference detection, the shape of the waveform is important. The use of rectangular pulses greatly simplifies phase detection and has the added benefit of using a switch as the modulator. This simplifies the laser driver and greatly reduces total system power requirements.

To summarize, a laser driver for an ITOF lidar system should be capable of generating 2 to 10 A pulses from a bus as high as 30V, with switching frequencies ≥ 100 MHz possible, and minimum pulse widths of 2 ns or less. This is a wide range of specifications and the usual approach has been a custom GaN-based laser driver design for each application. With silicon-based laser drivers, much of this design space is completely out of reach.

Benefits of integration

Modern eGaN® power FETs with the required current and voltage ratings have rise and fall times of less than 1 ns and can therefore easily meet the above requirements. In fact, a single 0.81 mm^2 eGaN FET, like the automotive qualified EPC2203, can meet the entire design space above. However, the drive requirements for such FETs are not directly compatible with the outputs of the digital subsystem generating the transmit pulses, since these tend to be low voltage logic of 3.3 V or less and have low drive current capability. Hence, a gate drive is required to interface the digital signal to the FET. This is a problem since there are very few gate drivers capable of driving eGaN FETs up to 100 MHz and beyond while maintaining fast rise and fall times. The few that have the required drive capability consume unacceptable levels of power. Furthermore, the physical distance between the gate drive and FET adds inductance to the gate loop, further decreasing performance. Finally, the gate driver takes space (more space than the FET), adds cost and reduces reliability. GaN technology enables the integration of the gate drive with the main FET, thus improving performance, reducing part count and capturing all the attendant benefits.

Performance

Efficient Power Conversion has developed a family of monolithic GaN IC laser drivers, as shown in Figure 1. Key preliminary specifications for the primary version are shown in Table I.

Parameter	Condition	Minimum	Nominal	Maximum
V_D				40 V
I_D				10 A
V_{DD}			5 V	5.5 V
V_{IH}		1.6 V		
V_{IL}				0.8 V
Pulse width	10 A, 20 V	2 ns		
Propagation delay	10A, 20 V		3 ns	
Max switching frequency	10 A, 20 V		100 MHz	
Transition time	10 A, 20 V		600 ps	
R_{ON}			41 mΩ	54 mΩ
I_{DD}	5A, 20 V, 30 MHz		50 mA	

Table I: Key specifications of the EPC21601 laser driver at 25°C.

There are three members of the IC family: (1) 2.5 V logic input with a 5V supply to the IC, (2) 5 V logic input and a 12 V supply, and (3) low-voltage differential signaling (LVDS) input enabling it to be driven directly from high-speed digital ICs in a noisy digital environment. All three variations are available on the same 2×3 BGA chip-scale package with a 1 mm × 1.5 mm footprint and require only a single bypass capacitor.

Figure 4 shows some typical waveforms driving a 2 Ω low inductance load in place of the laser. With a supply voltage of 20 V, the resulting current pulses have an amplitude of 10 A. Figure (4a) shows a single pulse. The drain voltage v_{drain} fall time t_f measures the turn-on time, and tr the turn-off time. At the maximum rated current, tf = 602 ps and tr = 306 ps. Lidar transmitters often use burst mode, with one reason being the need to prevent laser overheating. Figure (4b) shows a 100 MHz burst of 10 cycles. The IC can operate at 100 MHz and 10A continuously but burst mode operation is to prevent the load power dissipation from excessive heating.

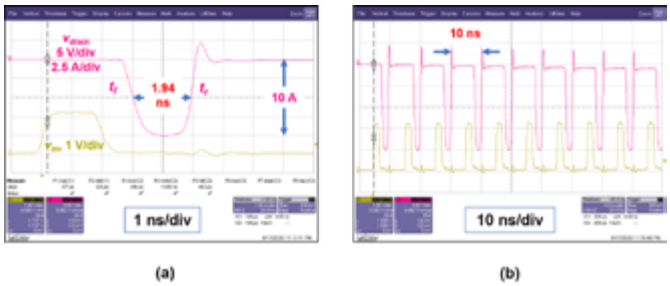

Figure 4: Single pulse waveform (a) and 100 MHz burst waveform (b). Both cases use 2.5 V logic level input and 20V supply with 2 Ω load. Yellow trace is input (1 V/div) and red trace is drain voltage (5 V/div or 2.5 A/div)

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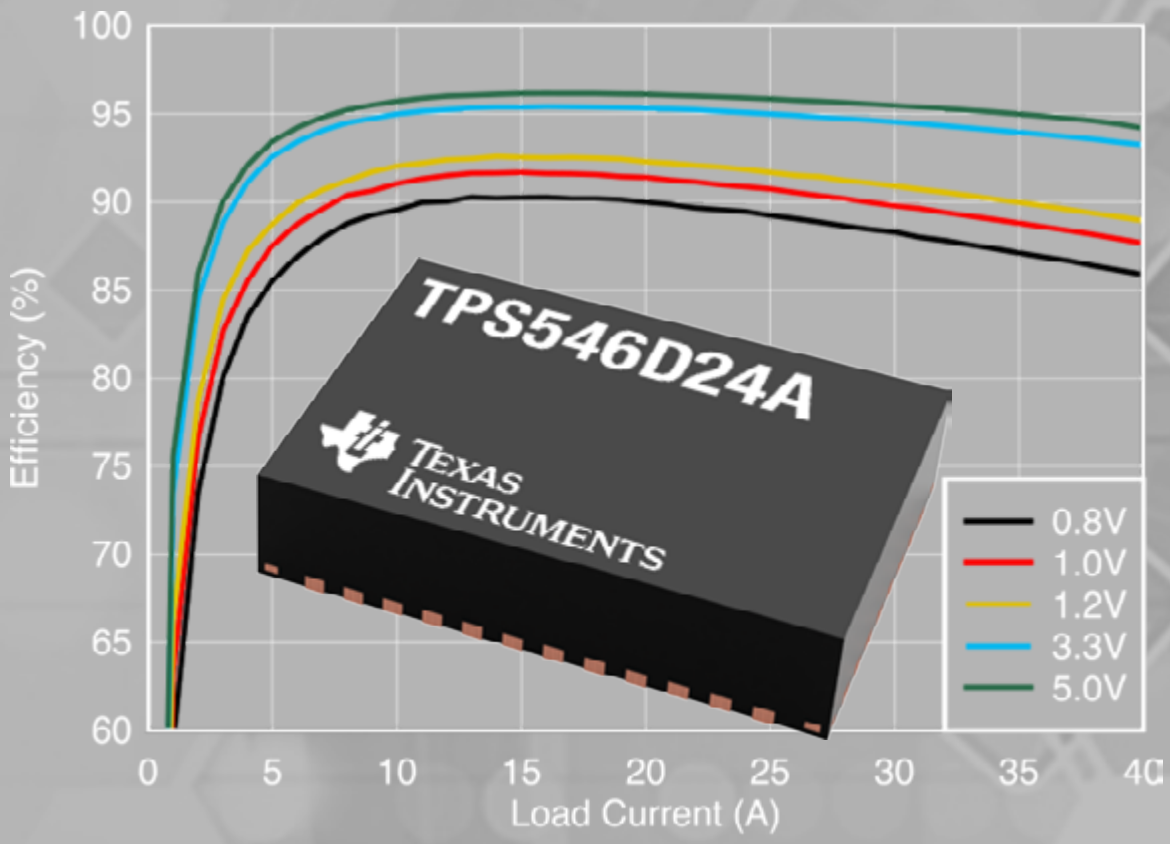

V_{IN} = 12 V L = 300 nH

f_{SW} = 325 kHz R_{DCR} = 0.15 mΩ

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Figure 5 shows some typical waveforms driving a vertical cavity surface emitting laser (VCSEL). Figure (5a) shows a single pulse and Figure (5b) shows a 100 MHz burst of 10 cycles. The VCSEL packaging includes a bond wire that adds considerable inductance, which results in drain waveform ringing and a slower optical output risetime. Note that the higher impedance due to this inductance and the 10 V transition result in a turn on time (fall time tf) of less than 300 ps.

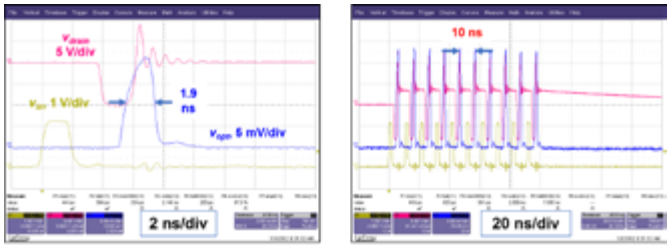

Figure 5: Waveforms driving a vertical cavity surface emitting laser (VCSEL). Single pulse waveform (a) and 100 MHz burst waveform (b). Both cases use 2.5 V logic level input and 10V supply with a VCSEL load. Yellow trace is input (1 V/div), red trace is drain voltage (5 V/div) and blue trace is optical receiver output (5 mV/div).

What's next?

There are several other potential applications for the newly developed IC. A more traditional power electronics use would be a tiny boost converter for circuits that have only a 5 V supply and which need an additional higher voltage. In fact, such a converter would be very useful to develop the laser driver bus voltage in a lidar application. Another potential application would be a small Class *E* or *EF*^{n} inverter [5], [6], or converter for tiny wireless power sources. There are many possibilities and with a 40 V, 10 A logic-controlled power switch capable of 100 MHz switching, the door to new applications and ideas is wide open.

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New International Standard for Magnetic and Capacitive Couplers

The German preliminary standard VDE V 0884-11:2017-01 has specified the requirements regarding reinforced and basic isolation for magnetic and capacitive couplers since 2017. Now, the IEC has published an international standard that is based on the VDE V 0884-11. This article explains the difference between the new IEC 60747-17:2020 Ed. 1 and the VDE V 0884-11. It also outlines the improvements that have been made with regard to photocouplers and the relevant photocoupler standard IEC 60747-5-5:2020 Ed.2.

By Wolfgang Frank and Heiko Rettinger, Infineon Technologies AG, Germany

The preliminary standard, VDE V 0884-11, which succeeded its predecessor VDE V 0884-10:2006-12 in January 2017, defined for the first time strict requirements regarding lifetime predictions of the isolation. Such requirements are part of the new international standard IEC 60747-17, as are safety-promoting improvements concerning photocouplers. Table 1 shows the most important differences.

Standard and scope	IEC 60747-17 Magnetic/ capacitive	VDE V 0884-11 Magnetic/ capacitive	IEC 60747-5-5 Photocoupler
End-of-life modeling for isolation	yes	Yes	No
Safety factors for end-of-life model	yes	Yes	No
Improvements of isolation and partial discharge (PD) test	yes	No	No
$V_{\_IOSM}$ / $V_{\_IMP}$	Yes / yes	Yes / no	Yes / no

Table 1: Comparison of contents with respect to various coupler standards

End-of-life modeling

The method for modeling the end-of-life (EOL) for the isolation barrier was adopted from VDE V 0884-11. High-voltage stress tests at three different voltage levels according to figure 1 are the basis of the EOL model. Furthermore, the expected time-to-failure at these three voltages have to span at least two orders of magnitude. The resulting data are the basis for the extrapolation to evaluate the isolation ratings of the "maximum rated repetitive peak isolation voltage" V_{IORM} of the coupler. The model itself necessarily aims at a total time-to-failure of at least 20 years. In addition, various safety factors are included, which are also indicated in figure 1:

- Safety factor for the time-to-failure of 1.5 for reinforced isolation and 1.2 for basic isolation
- Safety factor in voltage (V_{IORM}) of 1.2
- In addition to all the safety margins, the model assumes a failure rate at EOL of 1 ppm after 20 years for reinforced isolation.

Improvement of isolation and partial discharge test

Test principle

An improvement in the new international standard IEC 60747-17: 2020 Ed. 1 over VDE V 0884-11 and the photocoupler standard IEC 60747-5-5: 2020 Ed. 2 is the method used for testing the isolation and partial discharge (PD) in the production of the couplers. Each coupler undergoes PD testing, which screens potential weak parts. It is now mandatory to combine the isolation test and the PD test in a single test procedure as depicted in Figure 2. The isolation type test first applies the rated isolation voltage to the device under test (DUT) for 1 minute.

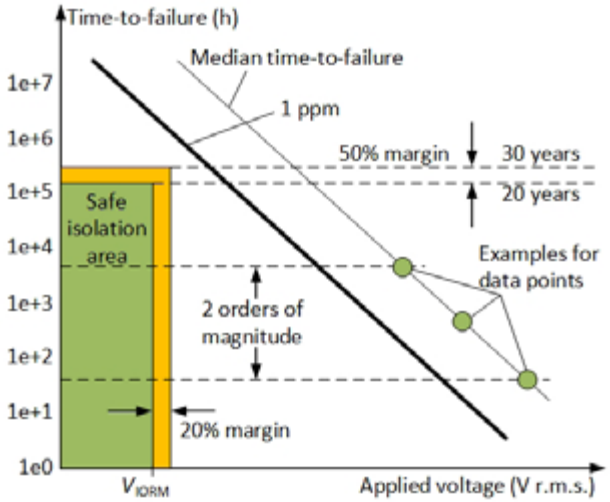

Figure 1: Principle for end-of-life extrapolation

It is important to point out here that the isolation test voltage is higher than the PD inception voltage V_{inc}. This forces a limited partial discharge but does not lead to a break down. The test voltage decreases after the isolation test to the specified PD measurement voltage level $V_{pd(m)}$. The PD measurement voltage level is lower than the so-called "partial discharge extinction voltage" V_{ext}. PD has to be eliminated at V_{ext}. Parts can be screened out that still show excessive PD. Thus, it is mandatory that PD happens during isolation test to be sure, that PD disappears at the right places.

Infineon has installed method b1 of figure 2 for routine tests in production for certified EiceDRIVER™ products. The above mentioned test methods are superior to the method shown in figure 3, which is often used for photocouplers [4], [5]. That particular method allows an undefined time between the isolation test and the PD test. The forced partial discharge event is "extinct", of course, when the stress voltage goes down to zero. In addition, potential free charges can recombine in the insulation, so that almost every DUT can pass the PD test [4], [5].

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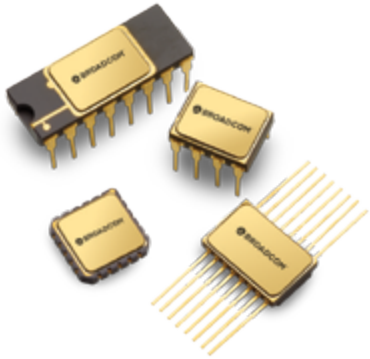

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PD test levels at Infineon

The new standard IEC 60747-17 requires a measurement voltage level of $V_{pd(m)}$ = 1.875·V_{IORM} during the partial discharge test interval. This level is the industry standard for many suppliers. However, the well-known coreless-transformer technology from Infineon can pass much higher partial discharge measurement levels $V_{pd(m)}$, as seen in Table 2. Consequently, Infineon plans to use this superior isolation technology and exclusively measures at higher levels of $V_{pd(m)}$ = 4500 V (peak).

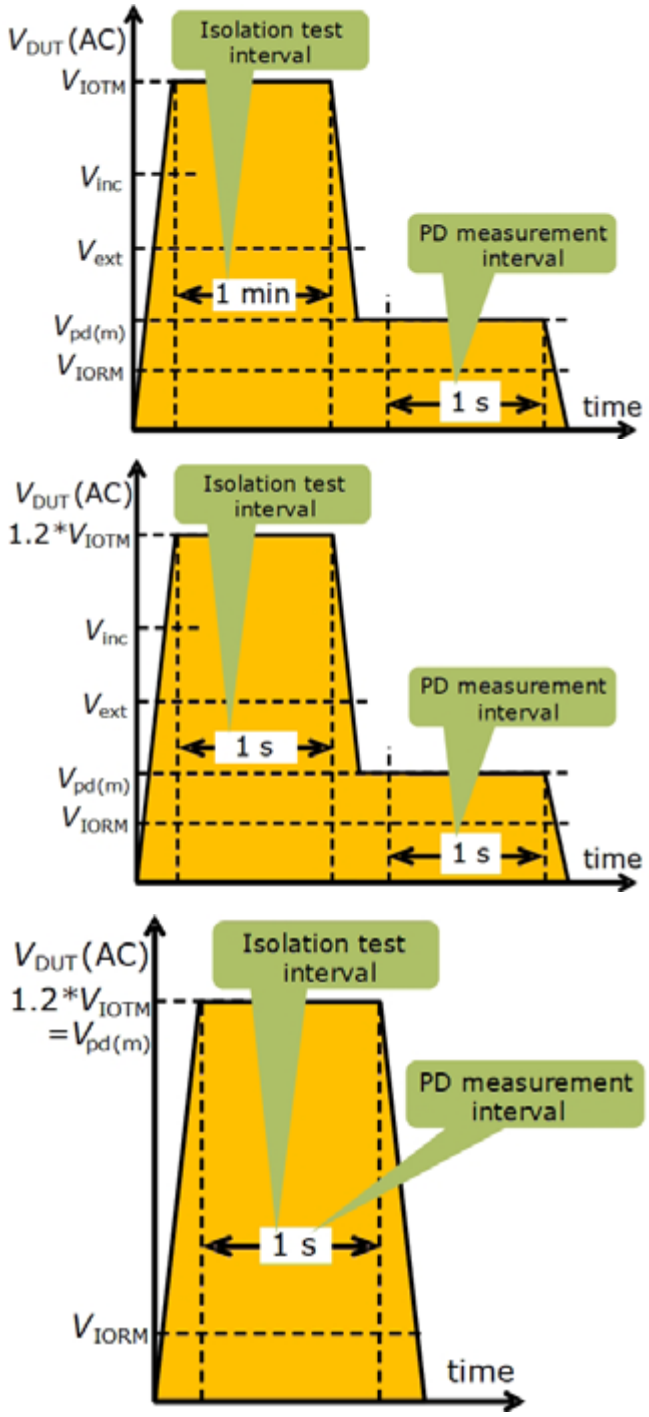

Figure 2: Principle of the combined isolation and partial discharge test:
a) method a (used for type tests)
b) method b1 (used for routine tests)
c) method b2 (alternative for routine tests)

This is a 100% routine test to be performed on the next generation of certified EiceDRIVER™ series such as 1ED34xxMx12M, 1ED38xx-Mx12M, and 1ED31xxMx12H. The most important ratings for such gate-driver ICs are also given in Table 2 based on available results. The maximum rated repetitive peak isolation voltage V_{IORM} is planned for 1767 V peak. This value represents a new level of isolation performance of magnetically isolated couplers.

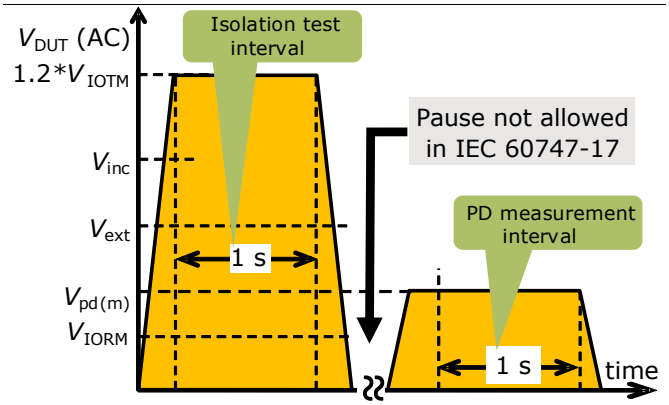

Figure 3: Not allowed PD test method in IEC 60747-17

Parameter / rating (planned)	EiceDriver™ Enhanced (DESAT) 1ED34xxMx12M / 1ED38xxMx12M	EiceDriver™ Compact 1ED31xxMx12H
$V_{pd(m)}$	4500 V (peak)	4500 V (peak)
V_{IORM} (reinforced)	1767 V (peak)	1767 V (peak)
V_{IOSM} (test level)	11000 V (peak)	11000 V (peak)
V_{IMP}	8000 V (peak)	8000 V (peak)

Table 2: PD test voltage levels and certification ratings (planned) of Infineon gate driver ICs

New rating for external isolation capability

The clearance distance of a coupler's package defines the external isolation capability. The clearance should provide those dimensions that are important for meeting the application's needs.
However, the VDE V 0884-11, as well as the photocoupler standard IEC 60747-5-5, require a surge voltage above 10 kV for a reinforced certificate. This voltage level ensures that the internal isolation barrier is strong enough. Small packages cannot pass this test if their clearance distance is shorter than that defined by IEC 60664-1:2020 Ed.2, Table F.2. Therefore, one can perform the surge voltage testing in isolation oil. It enables couplers in smaller packages to obtain a reinforced isolation certificate. IEC 60747-17:2020 specifies the surge isolation voltage V_{IOSM} as the rating for the internal isolation.

The new rating is the external isolation voltage rating, which is specified by the impulse voltage V_{IMP}. The naming of this rating has been inspired by the impulse withstand voltage as per IEC 60664-1:2020. The surge voltage test has to be conducted in the air as the coupler is normally used in the application and no flashover shall be detected. Alternatively, the impulse voltage can be derived from the clearance requirements of IEC 60664-1:2020, Table F.2.

Conclusions

The new international standard IEC 60747-17:2020 overcomes weaknesses in comparison with its predecessor standards and photocoupler standards. It allows only those PD test methods, which

have a proven physical background. This ensures that no weak parts find their way into commercial devices. Infineon adopted the combined isolation and partial discharge testing right from the start. The superior isolation capability of the Infineon coreless-transformer technology allows testing its new EiceDRIVER™ isolated gate driver ICs 1ED34xxMx12M, 1ED38xxMx12M, and 1ED31xxMx12H at much higher partial discharge measurement voltage levels compared to the minimum requirements of the new standard. This ensures the industry benchmark quality of Infineon's gate-driver ICs.

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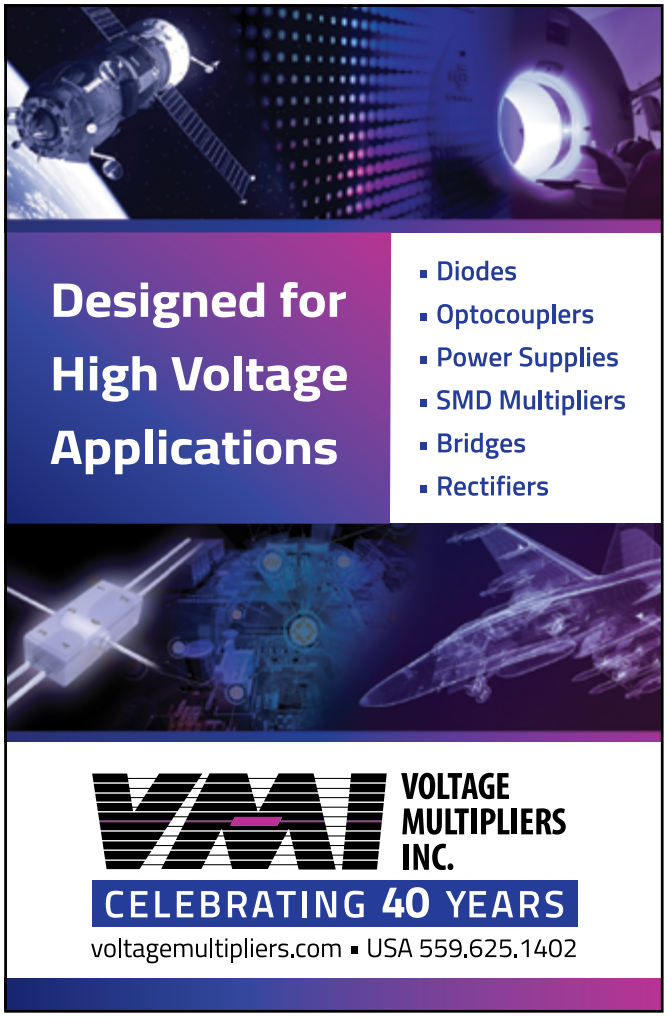

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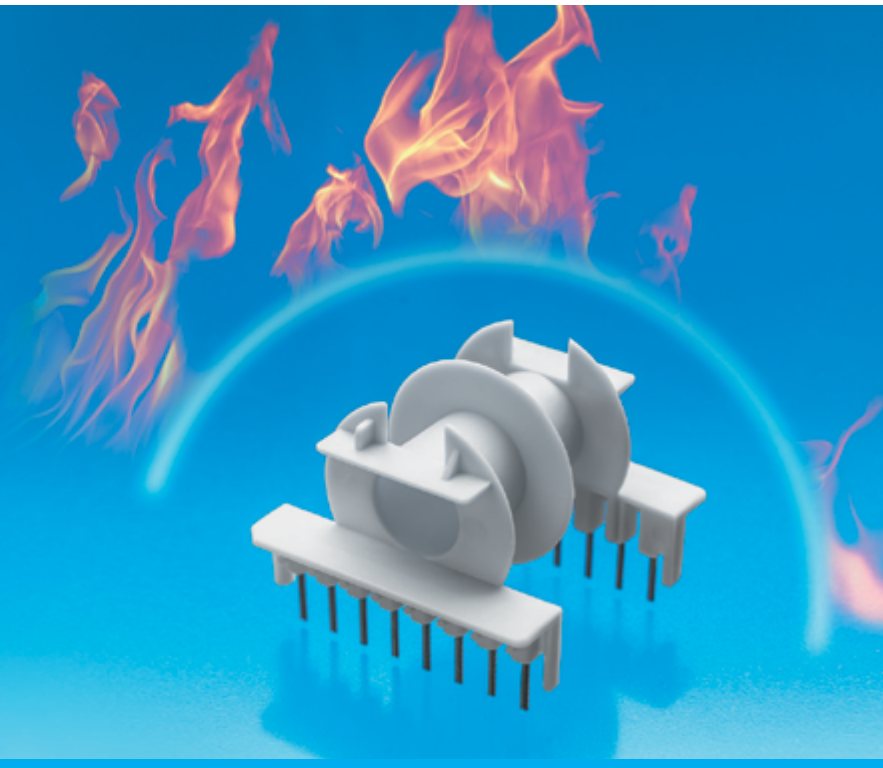

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Testing for Shoot-Through in Half Bridge Power Converters

Hard switching in half bridge configurations for power converters and inverters is a commonly used technique for efficient power conversion, in particular at higher power levels. With the increasing switching speeds made possible with Silicon Carbide (SiC) technology, the potential for a short circuit across the supply resulting in shoot-through current increases. The influence of parasitic coupling capacitance from the switch node to the gate becomes more and more critical.

By Marcus Sonst, Application Development at Rohde & Schwarz in Munich

Coupling capacitance can lead to high-side gate glitches resulting in unwanted turn-on conditions, with both transistors of the half bridge conducting at the same time, causing a short circuit resulting in a high current flow. Such a shoot-through current condition can destroy the transistors. Increasing the robustness of high-power designs is a critical design criterion. It is important to make sure there are no critical glitches on the high side gate of the half bridge, with the margins between high switching speed and shoot-through conditions constantly narrowing. Increasing precision in a successful design demands increasing precision in the measuring instruments used to assess the values of critical parameters.

To verify the risk of shoot-through events, the gate to source voltage on the high-side and low-side switch have to be measured simultaneously (in the time domain, using an oscilloscope). Glitches on the high-side gate signals may not exceed a predefined voltage level in order to prevent the corresponding transistor from accidentally being turned on. This task requires a complex trigger setup for a sequence of trigger events on the high side and the low side and very high trigger accuracy, with the trigger thresholds precisely defined. After the trigger setup is configured, the device under test is operated at different load and environmental conditions to identify critical conditions throughout the specified range of operation to investigate the risk of a shoot through.

The digital trigger has made a significant improvement in the accuracy of measurements made with oscilloscopes. In contrast to an analog trigger, there is no separate trigger path. A digital trigger is applied to exactly the same digital data in real time, and with the same resolution and bandwidth as the displayed data; if a signal can be detected by the oscilloscope, it can also be triggered on.

The advantages of digital triggers for identifying critical points for verifying shoot-through risk include:

- High flexibility in setting up the complete sequence of high-side and low-side trigger conditions.
- Individual setting of the trigger hysteresis to optimize the trigger sensitivity for the respective signal.
- High trigger sensitivity at full bandwidth to capture small, unwanted glitches.
- Very low jitter values for stable triggering.
- Trigger in real time on the acquired data as it is acquired at maximum resolution and bandwidth; no critical event is missed.

Modern oscilloscopes like the R&S RTE and R&S RTO feature advanced, easy-to-use, digital triggers as well as specifications ideal for meeting power electronic test requirements.

As an example of using a digital trigger, a 500 W DC/DC converter based on a symmetrical half bridge topology is used to demonstrate how to identify critical gate timing events that can lead to a shoot through. Thanks to real-time operation, while the trigger value for the high side gate signal is adjusted to the largest acceptable value, any switching event that violates this value, so bearing the risk of a shoot through, can be easily identified. The converter operates with input voltage between 36 V and 72 V and generates an output voltage of 3.3 V. The switching frequency is 400 kHz. According to the data sheet, the lowest possible threshold voltage of the MOSFET gate is 2 V.

After connecting the oscilloscope to the DUT, using the oscilloscope application dialog configure all relevant trigger options:

Firstly, select a trigger sequence so that it is possible to define three events (A, B, R) in a sequence. Define the first trigger event (A) as a negative edge trigger to catch the falling edge of the gate-to-source-voltage at the low-side switch (Figure 1). Define a suitable trigger level for this condition. This trigger event will catch every switch-off event on the low-side switching device during continuous operation of the half bridge.

Figure 1: Trigger setup: Edge event on negative slope for trigger A at the low side switch.

Secondly, define the next trigger event (B) of the sequence to detect a glitch on the gate-to-source-terminal on the high-side switch (Figure 2). This trigger is only active after the first trigger event (A) has occurred. Define the glitch level, polarity and width values according to the worst case condition of the application.

Thirdly, define a reset condition (R) to reset the first pre-trigger event after a specific timeout in case no glitch event has occurred. The maximum on-time of the low side switch defines the timeout value in the trigger setting.

Figure 2: Trigger setup: Glitch event for trigger B at the high-side switch.

To identify the safety margin, reduce the trigger level for the high side gate glitch trigger starting at 2 V until a trigger event happens. At 1.88 V (the green box) trigger events are generated as shown in the measurement result (Figure 3). This means a safety margin of 120 mV, in this case. The designer must decide whether this is sufficient for the robustness of the converter or inverter system.

Fig. 3: Measurement result of a half bridge configuration.

In addition to investigating the trigger, additional information about the circuit, such as the resonance frequency (in the blue box) between the leakage inductance of the transformer and the output capacitance of the switch are also determined.

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Accomplishing Closed-Loop Accuracy in Advanced Open Loop Current Sensors

The demands of engineers, designing in power electronics systems of distributed resources, are the current sensors with low power consumption. And the current transducers that have higher current measurement with high accuracy, are desired.

By Lily Kim, Marketing Manager, J&D Smart Sensing

To meet these demands, J&D developed open loop current sensors to measure higher current with low power consumption. See figure 1 to find the graph of accuracy vs. temperature / current range characteristics. The open loop technology of IDCS series uses a potentiometer to compensate DC offset and secondary output. At this time, J&D designed a schematic diagram that protects temperature characteristics that are exacerbated by potentiometers.

As you can see the graphs from figure 1, comparing 1-1 and 1-2, J&D has improved temperature characteristics by the advanced schematic diagram.

If you see the figure 1, high error ratio appears in the high current and high temperature. To solve this issue, zero-near DC offset, zero-drift IC and high permeability permalloy core have been used(The advanced schematic diagram, figure1-2). With this schematic diagram, the error ratio has been improved by 0.5% accuracy in the higher temperature.

As power electronics systems of distributed resources get smaller, J&D was concerned what if humidity and temperature issues occur. This is because it is highly related to the space inside that "high humidity" inside affecting the electrical devices to the efficiency of components, and when "the temperature of the primary conductor gets higher" than 100°C, it will affect the reliability of the product and will reduce its lifetime. J&D has built-in humidity and temperature sensors as options to protect the equipment from humidity and high temperature so that users can find the dangers.

1. Features of J&D's IDCS series

These IDCS Series are innovative open-loop current sensors whose performance is said to approach that of closed-loop transducers, improving control and system efficiency at a much lower price.

> "The error ratio has been improved by 0.5% accuracy in the higher temperature and the higher current"

1) Features

(1) IDCS Series have a wide range of unipolar power supply, 5~24V and bipolar power supply, ±15V.

(2) Since the CTs are made with lighter weight, this saves up to 15% of weight of the equipment.

2) Advantages

(1) J&D's IDCS series got a patent to 6 hall elements enabling to improve position error. Hall elements' positions are designed to be less affected when mounting on busbars.

(2) Schematic design for faster response times. IDCS Series has a response times with 3 µs, faster than the general open loop CTs' response, 10~5 µs.

(3) A wide range of frequency. (-3dB) is shown in IDCS Series at up to 50kHz, while other open loop CTs has it at 25kHz.

(4) IDCS series solid core CT supports busbar mounting, maintaining accuracy even at high temperatures.

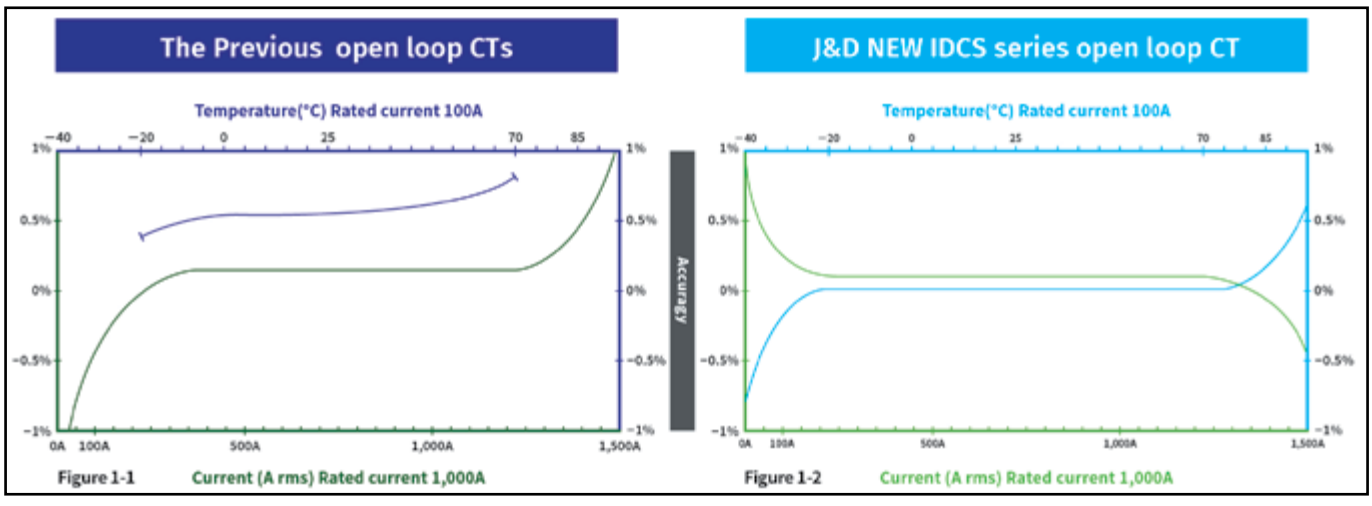

Figure 1: Comparison of the previous open loop CTs and J&D New IDCS series open loop CTs by the graphs of accuracy vs. temperature / rated current

(5) Proper to protection of DC/AC current.
(6) High current measurement is able to be done with less power consumption.

3) Optimized design
(1) Types of Busbar / Pannel mounting
(2) Designed to be safe from vibration and shock vibration
(3) Suitable size for using in a compact power Inverter.

4) Options
(1) Humidity sensor
- Built-in humidity sensor protects the equipment from high humidity that affects performance of power electronics systems.

(2) Temperature sensor
- Built-in temperature sensor protects the equipment from high temperature that can be dangerous and cause damage to the power electronics systems.

(3) 3 Connector types
There are 3 types of connector for IDCS Series, Type A, B and RJ12. See figure 2 for details.
· Type A : Molex 39-28-8040 (Old# 5566-04A-210)
· Type B : Molex 5045-04AG or Geoyoung LPH01-04
· The Plug & Play RJ12 Port : A RJ12 connection makes quick, easy, and reliable wiring, and it also prevents wiring errors.

2. Benefits of using J&D products for Power Quality customers such as Inverter / ESS / UPS etc

As you can see in the figure 3, J&D Split core CT, IDCS Series, got a patent on 6 hall elements. And it is designed to be easily mounted on the busbar, and to be appropriate for power metering of AC/DC power meter. The IDCS series' safety from vibration and shock and its suitable size for using in a compact power monitoring are also one of the advantages for power electronics systems of distributed resources. Thanks to its CTs' advantages, IDCS Series used with Powerside's P-Qube 3 meter has been registered as a reference for applying to ESS(Energy Storage Systems) developed in LS Electric, from Korea.

" Worry costs. The cost can be money, time or chance. With J&D, you no longer have to worry about whether to use an open-loop or a closed-loop. We provide solutions that can be free from the worries. The IDCS Series' compact size, low power consumption and the competitive price give you a chance to accomplish something great. "

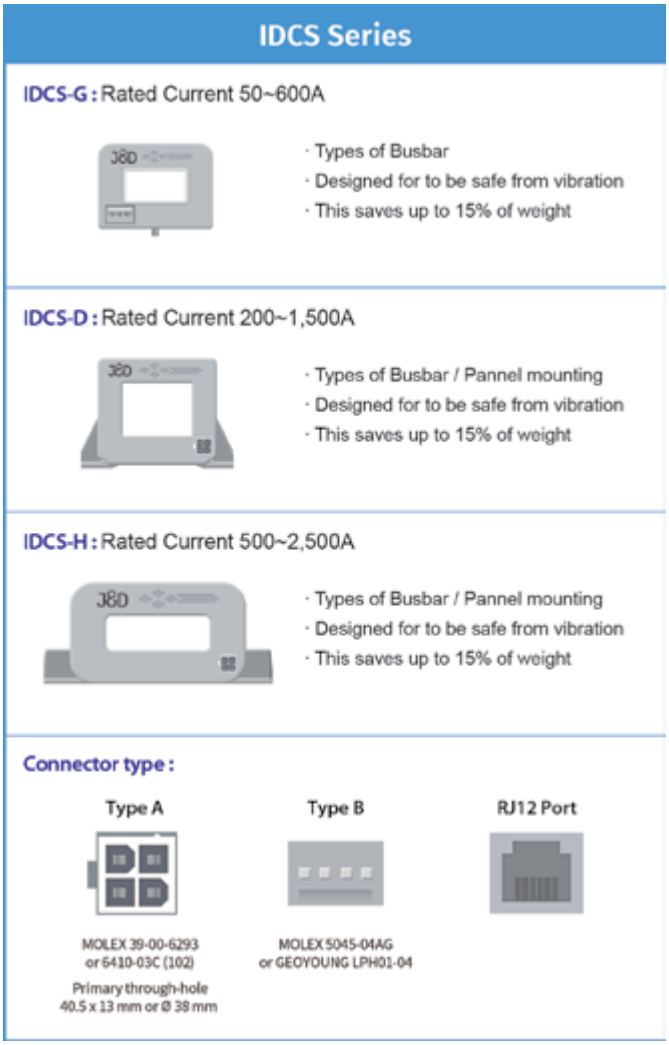

Figure 2: IDCS series

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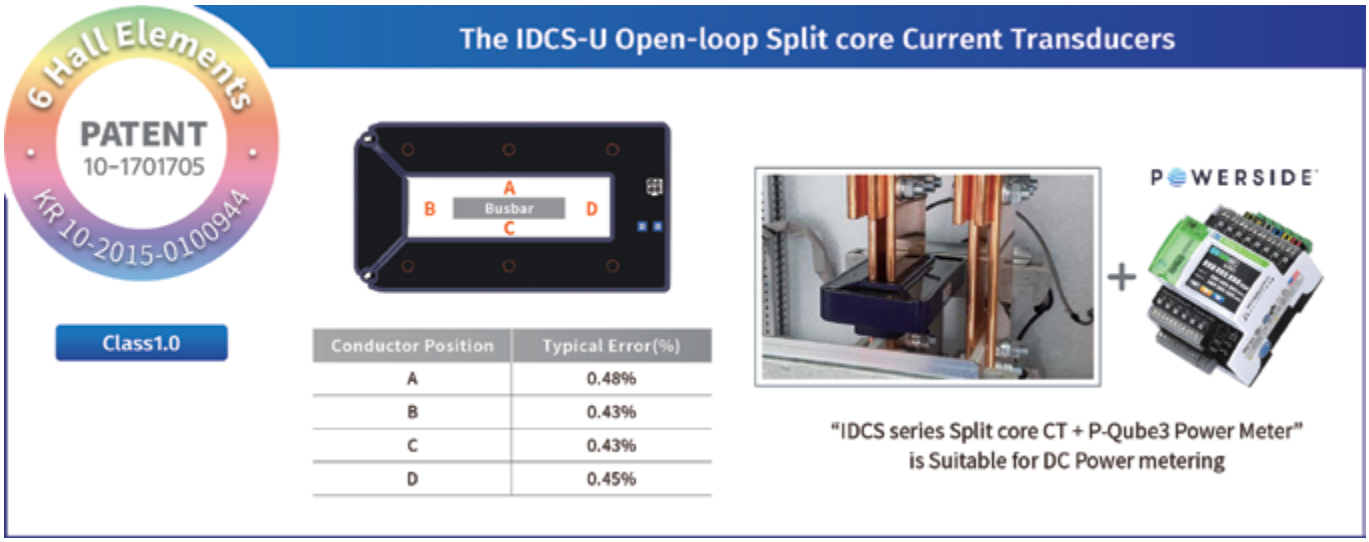

Figure 3: The patent number, position error and the combination of "IDCS open loop split core CTs and the P-Qube3 meter"

The Flying-Capacitor Boosters: Capacitor Sizing, Balancing and Pre-Charge

This article is the second part of article series about flying-capacitors boosters (first part "The Advantages and Operation of Flying-Capacitor Boosters" was published in October 2020 edition of Bodo's Power). The first part described the advantage of it, which is increasing the efficiency while being still low at system cost. The second part focuses on the challenges the flying-capacitor topology may encounter. Solutions to tackle capacitor sizing, balancing and pre-charge are introduced here.

By Viktor Antoni, Development Engineer - Electronic Design, Vincotech, Hungary

Introduction

Using high-efficiency solar inverters is reaching more and more popularity in a design, however, it is not the most economical. To achieve a cost efficient solution, not only the inverter has to be low cost and high efficient, but also the booster stage. The flying-capacitor booster solution can increase the efficiency while being still cost efficient. However, it has also some challenges as capacitor sizing, balancing and the pre-charge. This article will describe the solution for this challenges.

Sizing of the Flying-Capacitor

The voltage supplied by a flying-capacitor has a key role in this topology. To keep the voltage ripple on the capacitor low, a suitable capacitor size is needed. To determine the needed capacitance, the switching frequency and the maximum allowed voltage ripple need to be considered. The size of the capacitance can be calculated as:

$$C_{FC} = \frac{I_{peak}}{\Delta U_{FC} \bullet 2 f_{SW}}$$

where is the maximum allowed voltage ripple, is the maximum current, and is the switching frequency of the transistors.

The Balancing of the Capacitor Voltage

For the appropriate operation the flying-capacitor, voltage has to be half of the output voltage. To achieve this, it must be regulated at all time. This can be done by changing the operation modes. As it can be seen in Table 1, Mode 1 and Mode 4 have no effect for the flying-capacitor, so for regulation Mode 2 and Mode 3 have to be used. The regulation state diagram can be seen on Figure 1.

The needed modes are depending on the duty cycle. In case of ≤ 0.5, the operation will be the following:

Mode	Transistors		Inductor current		FC voltage	DC-link voltage
	T25	T27	D<0.5	D>0.5		
Mode 1	OFF	OFF	decreasing	-	-	increasing
Mode 2	OFF	ON	increasing	decreasing	increasing	decreasing
Mode 3	ON	OFF	increasing	decreasing	decreasing	increasing
Mode 4	ON	ON	-	increasing	-	decreasing

Table 1: Output and FC voltage states

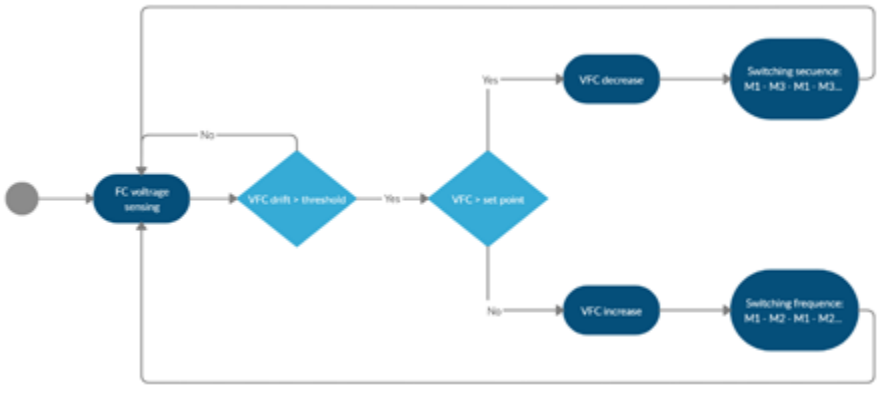

Figure 1: The flying-capacitor regulation

… → Mode 1 → Mode 2 → Mode 1 → Mode 3 → …
If the flying-capacitor voltage exceeds the set point, the operation can be modified to decrease the voltage:

… → Mode 1 → Mode 3 → Mode 1 → Mode 3 → …
If the flying-capacitor voltage is less than the set point:

… → Mode 1 → Mode 2 → Mode 1 → Mode 2 → …
In case of ≥ 0.5, the needed modification will be the same, only Mode 4 will be used instead of Mode 1:

… → Mode 4 → Mode 3 → Mode 4 → Mode 3 → …
to decrease the voltage

… → Mode 4 → Mode 2 → Mode 4 → Mode 2 → …
to increase the voltage

CIPOS™ Maxi with CoolSiC™ MOSFET

The world's first 1200 V transfer molded silicon carbide IPM solution for industrial drives and HVAC applications

High-performance CIPOS™ Maxi Intelligent Power Modules (IPMs) integrate 6 CoolSiC™ MOSFETs with an optimized 1200 V 6-channel SOI gate driver to increase reliability, provide excellent protection and optimize PCB size and system costs.

Key features

- Fully isolated dual inline molded module with DCB
- Integrated bootstrap functionality
- Under-voltage lockout on all channels
- Turnoff of all six switches during protection
- Cross-conduction prevention
- Allowable negative VS potential up to -11 V for signal transmission at V_{BS}=15 V
- Low-side emitter pins accessible

Key benefits

- Exceptional power density: 1200 V IPM with a power rating of 8 kW
- Gate driver technology with enhanced robustness for excellent protection
- High efficiency up to 99%
- Wide switching speed range up to 80 kHz
- Adapted to fast-switching applications with lower power losses
- Simplified design and manufacturing

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The Pre-Charge of the Flying Capacitor

This section describes the details of the method proposed by Mitsubishi Electric Corporation [1] to protect the flying capacitor booster, when there are no control signals (e.g.: during startup). In case when all the control signals of the transistors are low, the flying-capacitor voltage cannot be regulated. In that operation an extra effort is needed to keep the flying-capacitor voltage on the safe side. Failing to eliminate the overvoltage on the semiconductors may cause a fatal error in the system. There are two operation modes, when all the transistors are OFF: 1) When the input is applied and the output is equal with the input (e.g.: startup), and 2) when the input is zero and the output is not. This happens, for example, when one string is not connected to the circuit and other boosters are working. In both two cases the voltage of the flying-capacitor is zero, and the voltage sharing of the two transistors is not defined. To keep the voltage level of the semiconductors below the breakdown voltage, additional balancing has to be used.

During startup the current flows through the two diodes and charge the output capacitance. In this case the output voltage is equal to the input voltage, while the flying-capacitor voltage is zero. This is dangerous for the lower switch. To eliminate this problem, another current path has to be added, in which the current can charge also the flying-capacitor. For this a diode can be used, a cathode of which has to be connected to a capacitive voltage divider, where the lower point of the flying-capacitor is clamped at the half of the DC-link voltage. This can be seen on Figure 2.

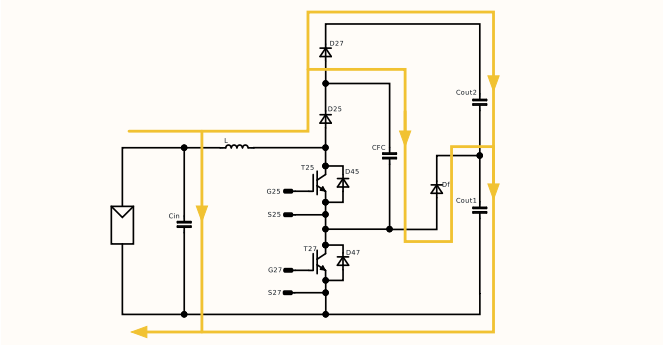

Figure 2: The additional current path during startup

As the voltage of the capacitor can be calculated from the following expression: $V = \frac{Q}{C}$, and the charge will be the same for C_{out1} and $C_{out2} + C_{FC}$, the flying-capacitor voltage will be the following:

$$V_{FC} = V_{OUT}\frac{C_{out1}}{C_{out1} + C_{out2} + C_{FC}}$$

where V_{OUT} is equal with V_{In} (if the forward voltage of the diodes are not considered).

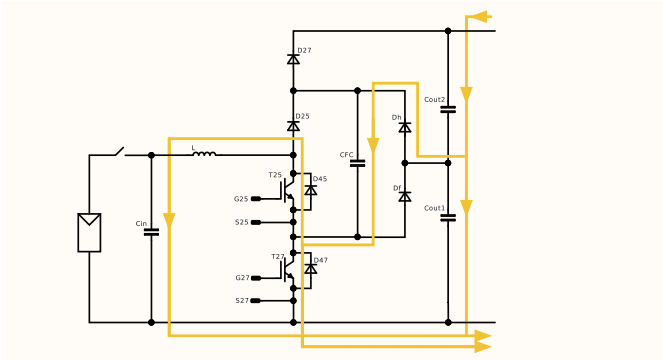

Figure 3: The additional diode when V_{In} is zero

If the capacitance of C_{out1} and C_{out2} is equal and the capacitance of C_{FC} is significantly smaller than the capacitance of C_{out1} and C_{out2}, the voltage of the flying-capacitor is half of the output.

$$C = C_{out1} = C_{out2},\ \ C_{FC} \ll C,\ \ V_{FC} \approx \frac{V_{In}}{2}$$

When the string is not used and other boosters are working, the input voltage is zero, while the output voltage is not. In this case another diode has to be added to charge the flying-capacitor.

As it can be seen on Figure 3, the current path is the following:
$C_{out2} \rightarrow Dh \rightarrow C_{FC} \rightarrow D45 \rightarrow L \rightarrow C_{in}$
In this case the sum of the flying-capacitor voltage and the input voltage can be calculated as the following:

$$V_{fci} = V_{OUT}\frac{C_{out2}}{C_{out1} + C_{out2} + C_{FC} \times C_{in}}$$

As in the last expression, if C_{out1} and C_{out2} is equal and C_{FC} and C_{in} *is* negligible compared to C_{out1} and C_{out2} , the voltage is half of the output voltage.

$$C = C_{out1} = C_{out2},\ \ C_{FC} \times C_{in} \ll C,\ \ V_{fci} \approx \frac{V_{OUT}}{2}$$

This voltage is divided on the two capacitors. If the capacitance of the C_{FC} is much smaller than the C_{in} capacitor, then the voltage of the capacitor is as low as it can be considered zero, and the voltage of the flying-capacitor is near to the half of the output voltage.

This method can be improved by closing the T27 switch. In this case the voltage is not divided by C_{in} and C_{FC} capacitors and the current path will be the following:
$C_{out2} \rightarrow Dh \rightarrow C_{FC} \rightarrow T27$
And the flying-capacitor voltage:

$$V_{FC} = V_{OUT}\frac{C_{out2}}{C_{out1} + C_{out2} + C_{FC}}$$

Design Considerations

During normal operation T27 creates an overvoltage spike at turn-off. If Df turns on to clamp this spike, T27 switch will be loaded with the reverse recovery of Df. To avoid Df clamping this overvoltage spike, an additional Zener diode (Dz) can be added in series with Df. The Zener voltage of the Zener diode should be higher than the spike of turn-off. This can be seen on Figure 4.

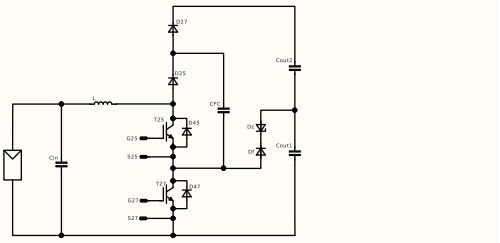

Figure 4: The additional Zener diode

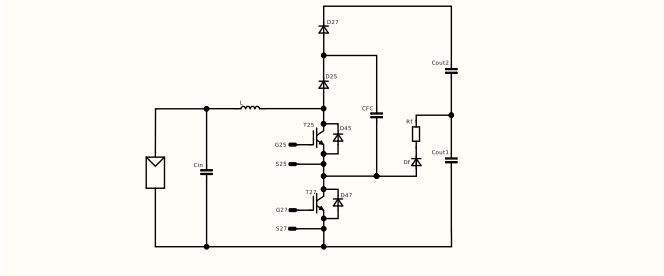

Figure 5: The current limiting resistor

If the voltage of flying capacitor is extremely higher than $\frac{V_{OUT}}{2}$ an additional current ripple will appear on the inductor. This ripple causes increased losses and noise. This ripple can be also moderated with this Zener diode.
If the voltage of C_{FC} is less than the voltage of C_{out2} an equalization current will flow between C_{FC} and C_{out2} resulting an unbalance between C_{out1} and C_{out2} . This unbalance can be decreased with a current limiting resistor (Rf) which can be seen on Figure 5.

Conclusion

The flying-capacitor booster is a high-efficient, low cost solution for solar inverter applications. The main advantages are the frequency multiplication, the lower semiconductor voltage, the lower voltage and current ripple, the lower switching losses, and the low EMI emission. The flying-capacitor size is significantly smaller than the required DC-link capacitor used in traditional booster topologies with the same power rating. The challenge is to regulate the voltage of the flying-capacitor especially when all the transistors are in OFF state (i.e.: before the converter is turned on). The balancing can be achieved by state regulation. Also the pre-charge challenge can be solved easily by additional diodes based on Mitsubishi Electric Corporation's patent. With these diodes the flying-capacitor booster is a cost efficient alternative for the other booster solutions with higher efficiency.

References

[1] T. Okuda and H. Ito, "DC/DC POWER CONVERSION APPARATUS". United States Patent US 2013/0021011 A1, 24 01 2013.

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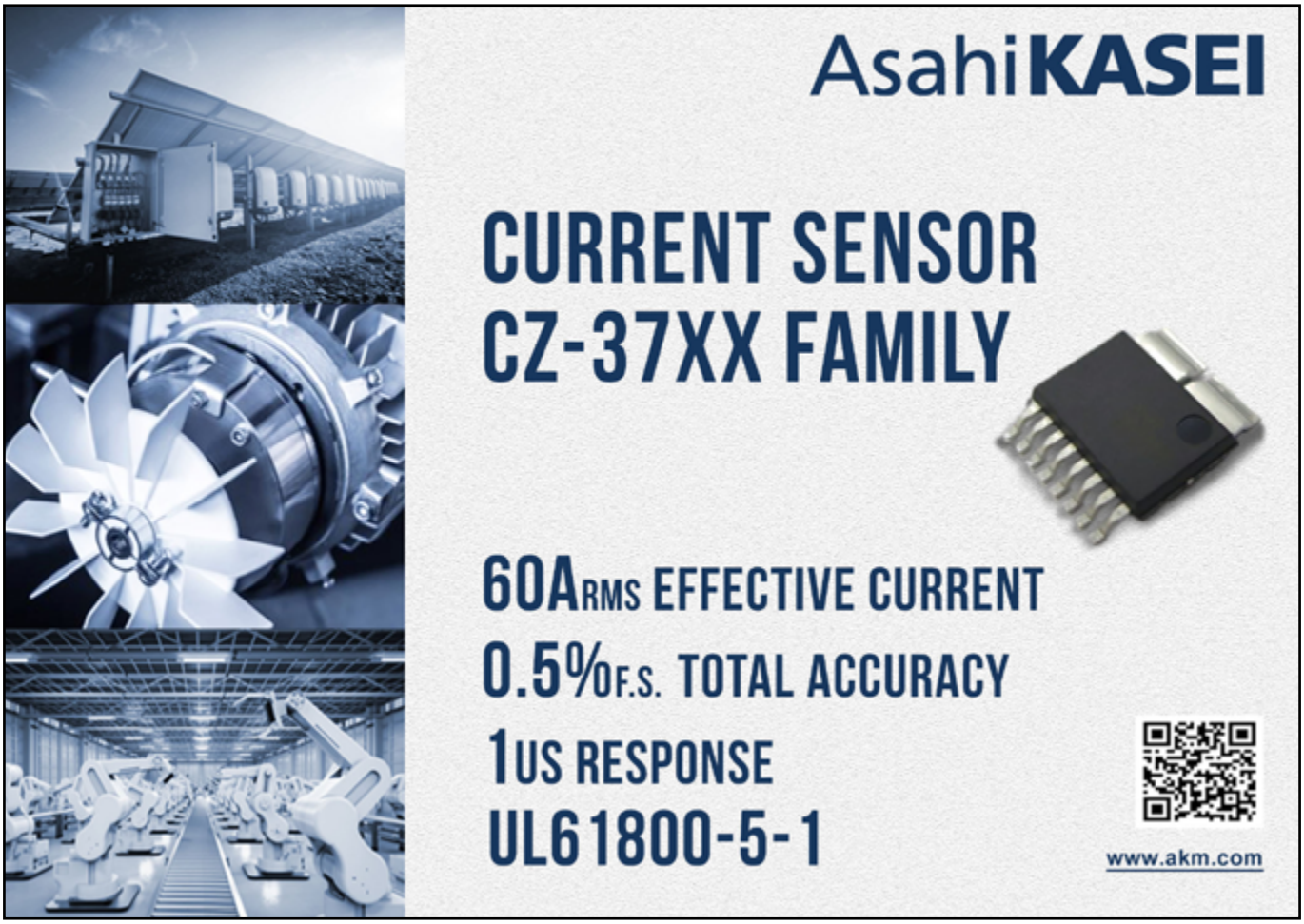

The 'Holy Grail' of Integrated Voltage Regulators (IVRs)

Power management designers have long been the last to complete their power portion of a new system design. At the beginning of the project, they get a very rough view of what the power supply section will need to drive. Often, towards the end of the system design, models or simulations of the system to be powered result in sometimes dramatic changes to the power management requirements (up to 2x).

By Mukund Krishna, Manager of Product Marketing, Empower Semiconductor

With these new requirements and little time, the power designers will typically begin to finalize their circuit design on a 'postage stamp'-sized area of board real estate. If they are fortunate, a separate power supply board may be allowed, but located 'who knows where' in the system, but still on a total area footprint typically too small to handle all the power components along with adequate heatsinking.

Take heart, power designers, enter the Empower Integrated Voltage Regulator (IVR) series EP70xxC with 'Zero' external components in a 5mm x 5mm package! A power designer's dream come true!

Traditional power solutions need many discrete components externally supporting the power IC. This leads to bigger footprint, more complex design, with poor system power efficiency, inadequate response time, and lower accuracy than would be desired. Complexity can be the enemy of reliability and development effort.

The Empower IVR is a patented technology that is able to do what no one has done before---eliminate all external components by integrating them into the integrated circuit (IC). This improves efficiency and provides as much as 10 times reduction in printed circuit board (PCB) footprint. This fully integrated IVR design reduces the power architecture complexity, and that leads towards better reliability of the system as well as a compressed development schedule.

The article will discuss a brief overview of the IVR and its benefits. Then there will be a series of application examples for each application area and how the IVR benefits each application first outside an SoC and later can move onto the SoC.

What is an Empower Integrated Voltage Regulator?

The Empower IVR is a switching voltage regulator, with very high performance, that has all the discrete external components, that other IVRs need externally, integrated within a single package. This makes the power design so much more simplified with the bonus of 50-90% reduction in PCB area footprint.

The Empower IVR uses an advanced CMOS geometry architecture which also enables the IC to be integrated directly onto an SoC package. In some cases, the IVR can be positioned below the SoC either on the PCB itself or the SoC package. Apart from the dramatic reduction in PCB footprint, the Power Delivery Network (PDN) shrinks to levels unachievable through traditional power converters, which waste a lot of power in their PDN.

This IVR exhibits a higher transient accuracy with a 100x faster settling time and nanosecond speed Dynamic Voltage Scaling (DVS), enabling processor power state changes in nanoseconds. Nearly instantaneous voltage delivery will eliminate the excess voltage and wasted power otherwise suffered with traditional power converters. This enables up to 50% savings in energy.

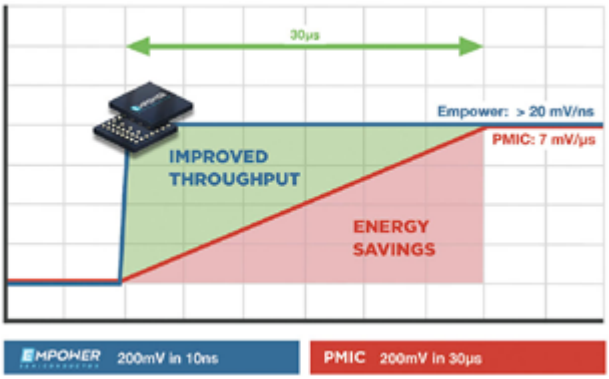

Figure 1: 1,000x Faster DVS Can Lead to 50% Energy Savings

Empower's development tools make all the difficult decisions that designers traditionally had to worry about. Power designers are able to select their operating preferences with a GUI to configure the IC via a high speed I3C bus.

Improved transient accuracy and faster settling time

Conventional DC/DC converters typically operate at low frequencies, in the region of 0.3 MHz to 3 MHz, in order to have high efficiency in their design. The drawback of a low operating frequency, meaning low bandwidth, is large output and input filtering components to achieve decent transient response. The need for large output capacitors, arranged in parallel, are necessary to get the 100uF or higher capacitance needed for adequate performance. In contrast, the wide bandwidth Empower IVRs lead to high accuracy voltages even during full scale levels with extremely fast transients. Recovery times, with Empower IVRs, are 100x faster with an output voltage drop of 1/3 or less.

Applications

Figure 2 shows some of the main applications for the IVR.
Other applications are Magnetic Resonance Imaging (MRI) and high bandwidth data links such as PCIe

Data Center, AI, and 5G

The rapid growth of Data Center, Artificial Intelligence (AI), and 5G systems are driving the huge bandwidth growth in data centers. There will be 175 zettabytes of information that will need to be managed over the next five years, leading to exponential growth in power/energy consumption with as much as 8,000 TeraWatt-Hour projected over the next ten years.

Figure 2: Target markets/Applications

Empower's IVR is perfect for the ever-increasing power density needs in the data center. This IVR series will reduce size and cost, thus improving system efficiencies in network systems, graphics processing units (GPUs), and optical transceivers.

Figure 3: The rapid growth of the Data Center, Artificial Intelligence (AI), and 5G systems has challenging power density needs which will be served by Empower's IVR family

Switches, routers, server, interface cards

In optical network interfaces, communications devices such as switches and routers are usually located a distance away from each other (possibly up to several kilometers), connected with fiber optic cables. The switch or router will process information packets as the transceiver interfaces with the cable and will translate the received optical signal into electrical impulses, and return electrical impulses into optical signals. Empower IVRs are ideally positioned to address the increasing power density requirements driven by the rapid evolution of network data rates. Empower's IVR family has almost ideal transient response, reducing system power management cost, as well as improving system efficiency.

Optical Transceivers

Fiber optic transceivers are the critical components of fiber optic transmission networks. They are designed in a small form factor with integrated optical subassemblies suitable for high-density networks. With the growing increase in speed in optical transceivers, the power consumption of the optical transceiver module inevitably will increase, while the form factor needs to remain the same or even reduce in size and complexity. This will create pressure on the module designer to use highly integrated chips consuming the lowest possible power.

Empower's, no external component, IVR series eliminates external inductors and capacitors, reduces the power management footprint by three to ten times, and improves overall system efficiency. The IVR family's size enables it to be included easily into the transmitter optical sub-assembly (TOSA) as well as in the receiver optical sub-assembly (ROSA).

Processors, AI, GPU

The IVR family will improve transient response, reduce power management footprint as much as three to ten times, and enable vertical power to eliminate distribution power loss.

IVR implementation option

Empower's IVR family enables the power IVR to be very close to the SoC package, either on the top or the bottom of the PC board. The resulting Power Delivery Network (PDN) is much simplified versus a traditional power solution, reducing power loss and thermal stress.

The unique integrated design and performance of the Empower IVR makes it an excellent choice for designers to have the needed flexibility of meeting size, weight, and power (SWaP) in the data center, AI designs, as well as 5G communications architectures.

Figure 4: Implementation option for Empower's IVR

Optical network architectures also greatly benefit from this 'Holy Grail' of IVRs, making these systems more efficient, smaller, and lower cost with less complexity. These all lead to faster time-to-market.

Conclusion

If there were a choice between traditional power converters, and one that offers higher density, requires no external components, provides better performance and enables shorter time to market, the choice is clear.

Power management designers are beginning to discover the 'Holy Grail' of IVR power solutions. Traditional power solutions will no longer suffice, especially when time-to-market is essential, board space is at a premium, and design complexity affects system reliability.

Designers will embrace a single power solution with zero external components. Better transient accuracy with faster settling time and higher transient accuracy are all features that power designers need. Integration into an SoC package or substrate is almost necessary with the current trends.

A GUI that configures the IC through an I3C bus makes a designer's efforts much smoother and faster.

This IVR solution is applicable to a whole range of applications, making it attractive for inventory reasons and making procurement a much happier exercise. Empower is heralding a new era in power design with more of these solutions to come.

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Switched-Capacitor Converter Simplifies Migration from 1S to 2S Battery Architectures

Power-hungry portable electronics are pushing battery capacities upward. As an example, mobile point-of-sale (POS) devices are built with integrated thermal printers that increase the power draw and may require a higher capacity battery.

By Bakul Damle, Mobile Power Business Management Director,
Sagar Khare, Mobile Power Business Manager, and Nazzareno (Reno) Rossetti,
Analog and Power Management Expert, Maxim Integrated

A higher battery capacity is obtained by using more cells, in series or in parallel. For example, to double capacity, the easiest thing to do is to move from one cell (1S1P, i.e. 1S) to two cells in parallel (1S2P, i.e. 2P). This solution doubles the delivered power and preserves the voltage rating of the electronics downstream while increasing the current drawn from the battery. However, the problem comes when charging the battery since a standard USB-C cable is rated for 3A. Charging a 2P battery requires twice the current, which may exceed the 3A limit. Alternatively, the charging rate may be halved, leading to twice the charging time.

Figure 1: Mobile Point-of-Sale Terminal with a Thermal Printer

The USB Type-C standard supports 15W, 5V, 3A or 25W, 5V, 5A with a special electronically marked cable. But special cables and higher power adapters are both expensive and uncommon, so it is important for the application to support the standard 3A cable rating.

One way to meet this constraint and increase the power delivered is to use two Li+ batteries in series 2S1P, i.e. 2S rather than in parallel. Two series cells can be charged using the same current as a single-cell scenario and provide double the capacity. Now the problem is that your low-voltage charging and regulating electronics become incompatible and you must shop for higher voltage devices to connect the 2S battery to your system. This choice potentially creates problems in the availability of high-voltage devices and poses issues in inventory and the sourcing of charge and control devices of different voltage ratings. It also presents loss in purchase power due to volumes spread across different devices.

Alternatively, a 2:1 step-down converter (Figure 2) can be used to halve the 2S battery voltage and apply it to downstream low-voltage electronics. This way, the step-down converter can power the existing 1S circuits while enabling the use of 2S batteries.

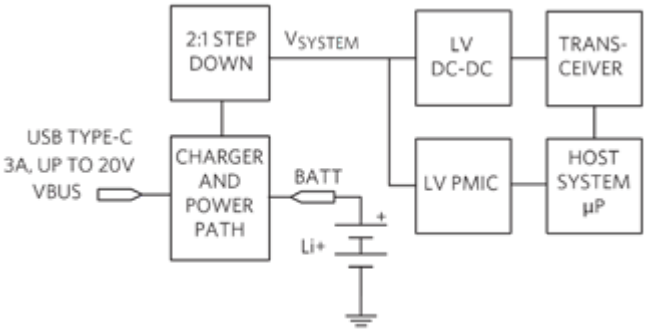


Figure 2: 2S Low-Current Battery Management System with 2:1 Step-Down Converter

In this design solution, we propose a 2:1 switched-capacitor converter (SCC) as the step-down converter of choice. The IC simplifies the migration to higher battery voltage by converting the 2S battery voltage to a 1S-equivalent output and allows designers to preserve the existing downstream 1S power architecture.

Why SCC?

The first thing that comes to mind for a step-down converter is the inductor-based buck converter. However, SCCs exhibit greater efficiency in a case like ours in which the ratio of the input voltage to the output voltage is an integer number (2). The SCC also has lower switching losses compared to an inductive buck converter. In the buck converter, each switch blocks the full input voltage and supports the full output current. In a 2:1 SCC, the switch only blocks half the input voltage resulting into lower switching losses. Finally, the SCC benefits from the significantly higher energy density of capacitors over inductors, resulting in a smaller PCB area. All the factors discussed above makes the SCC an ideal solution in this application.

MERSEN RELEASES FISCHERLINK™ 2.0

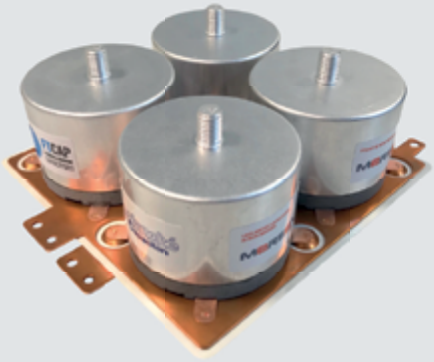
ULTRA LOW INDUCTANCE CAPACITOR –BUSBAR CONNECTION

FISCHERLINK 2.0

• Optimized compact design bringing together

FTCAP capacitors laser-welded on

high temperature MHi-T™ series laminated busbar



Increased capacitance density

• up to 20 % more capacitance in the same volume

Minimal inductance

• extremely low inductance < 9 nH through compact designs

Easy to install, easy maintenance

• Assembled and tested 100 % before delivery, there are no additional installation costs.

• Capacitors and busbars packaged together under one part number offer additional savings in administrative costs.

FTCAP and Leclanché Capacitors belong to the Mersen Group

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SCC Operation

Figure 3 illustrates the two-phase SCC architecture. In the first cycle, FETs S1 and S2 are ON and C_{FLY1} is charged while supplying the load. Simultaneously, FETs S7 and S8 are ON, and C_{FLY2} is discharged to supply the load.

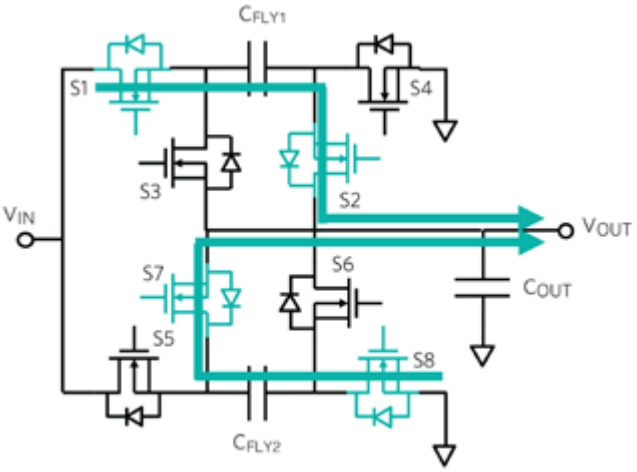

Figure 3: Operation of a 2-Phase SCC Architecture

Figure 4 shows the SCC waveforms corresponding to the first cycle illustrated above.

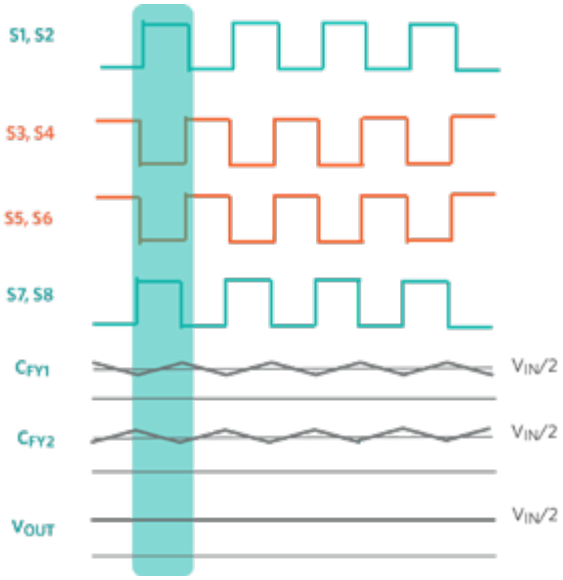

Figure 4: SCC Waveforms of a 2-Phase SCC Architecture

The next cycle is completely symmetric to the previous one: S1 and S2 are turned OFF while S3 and S4 are turned ON and C_{FLY1} supplies the load. At the same time, S7 and S8 are turned OFF while S5 and S6 are turned ON. C_{FLY2} is charged while also supplying the load. The two-phase operation reduces the ripple on the output capacitor.

The Switched Capacitor Converter

As an example, the MAX77932 is a two-phase switched capacitor converter with integrated power switches that delivers 8A output current and divides the input voltage by two (see Figure 5). The IC is suitable for applications that utilize 2S Li+ batteries while powering circuitry that operates at a 1S-equivalent voltage. It is also suitable for applications migrating from 1S to 2S battery configurations and allows designers to preserve the existing downstream 1S power architecture.

High Efficiency

The SCC efficiency, shown in Figure 6, exceeds 98% at 0.5MHz switching frequency. Such high efficiency helps reduce heat losses and helps keep the application temperature below the 'skin temperature' level of discomfort.

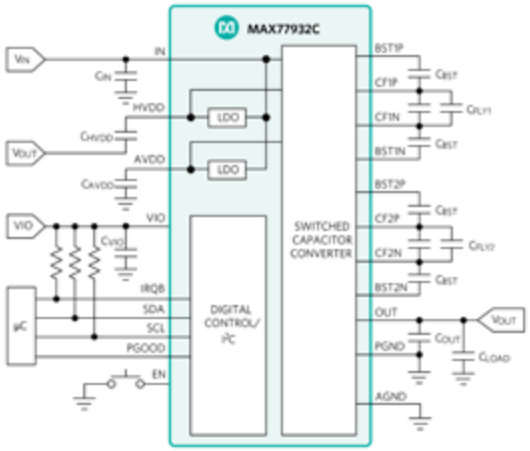

Figure 5: SCC Block Diagram

With such a high efficiency, a two-stage solution made of one SCC and a low-voltage (LV) buck converter (LV DC-DC in Figure 2), will win against a single-stage high-voltage (HV) buck converter. In comparison to the HV buck converter, the LV buck operates with lower switching losses and a higher duty cycle. Table 1 represents the two-stage solution advantage. To illustrate the effect of a 2% efficiency

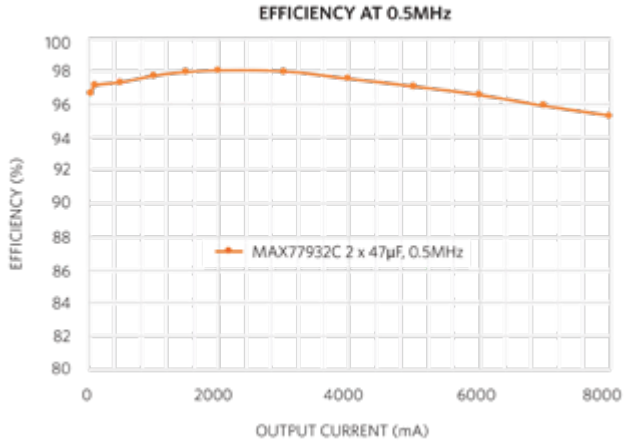

Figure 6: 2:1 SCC High Efficiency

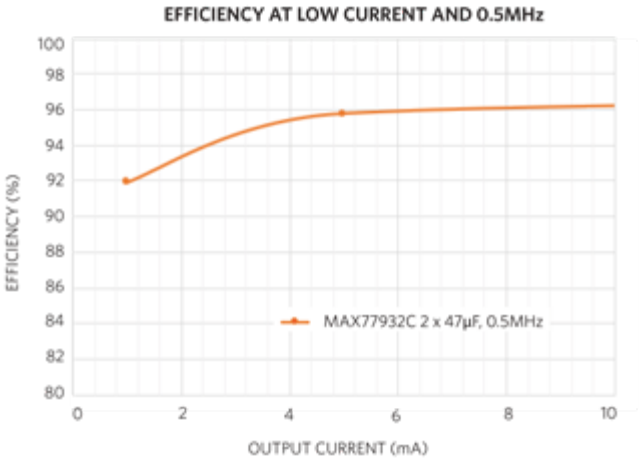

Figure 7: 2:1 SCC High Efficiency at Light Load

advantage, consider the case of a 12V, 3A, 36W charger, which is a common power level used in USB-C PD applications. The higher efficiency of the SCC solution results in approximately 0.7W lower heat dissipation. In this case, an IC with junction-to-ambient thermal resistance of 35°C/W will operate 25°C cooler without any thermal management material. This improved thermal performance makes it easier to keep the device 'skin temperature' within an acceptable range.

The IC has also an outstanding efficiency at low current. Figure 7 shows efficiency above 92% with currents in the 1mA to 10mA range. With portables spending extended amount of times in standby, this feature significantly enhances the battery life.

TOPOLOGY	SCC EFFICIENCY	BUCK EFFICIENCY	OVERALL EFFICIENCY
SCC+LV BUCK	~98%	~94%	~92%
HV BUCK	N/A	~90%	~90%

Table 1: SCC Advantage

Small Footprint

The IC is available in a tiny, lead-free 0.4mm pitch, 2.4mm x 2.8mm 42-pin wafer-level package (WLP). The combination of small chip and small passives yields a PCB footprint net area of only 14.6 mm². The comparison in Figure 8 shows a 27% footprint advantage compared to a competitor's similar solution.

Frequency dithering

Switching noise from DC-DC converters can produce Electromagnetic interference (EMI) with a dominant frequency peak that disrupts radio signals or operation of other electronics nearby. The SCC offers a programmable frequency dithering mode to mitigate EMI. Dithering reduces the dominant peak and spreads the noise over a wide frequency band, making it easier for the device to comply with frequency emission standards.

Conclusion

The increasing power requirements of portable devices like mobile point-of-sale systems with thermal printers is pushing upward the capacity of their batteries. Although moving from a 1S configuration to a 2S configuration enables faster charging, it seemingly requires higher voltage downstream devices. The 1S downstream circuitry can be preserved by connecting the 2S battery to the system with a 2:1 step-down converter. We showed that for such a configuration, the switched-capacitor converter (SCC) yields the best overall system efficiency, reduces EMI with frequency dithering and is best suited for preserving the existing 1S downstream power architecture.

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Bakul Damle is the Mobile Power business management director at Maxim Integrated. His current interests include battery and power management specifically in fuel gauges, energy harvesting, wireless charging, and battery authentication. He has several patents in test and measurement. Bakul holds a Master of Science degree in Electrical Engineering from the California Institute of Technology and a Bachelor of Technology in Engineering Physics from the Indian Institute of Technology.

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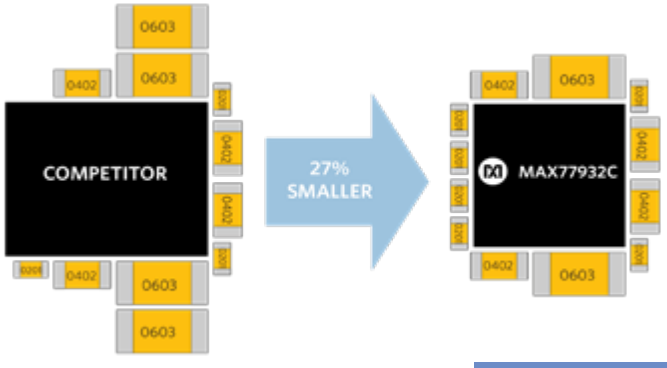

Figure 8: 27% Footprint Net Size Advantage

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High Voltage Detectors in Power Electronics: The Forgotten Safety Watchdog

While prominent for AC lines, DC voltage detectors are hard to find and seldom used in power electronics specially for voltages higher than 1000V, voltages that are life threatening. Why is this when HV DC rails are becoming popular in power electronics?

By Luis Otero, Saker Medium Voltage

Introduction

Voltage detectors (VD from now on) have the function of signalling the presence of voltage in a conductor within a system, mainly for safety reasons during research or when a service operation is going to be carried out. Most of the time the monitored conductors come from low impedance sources whose voltages and energies are considered life threatening. In simpler words, voltage detectors make visible the invisible.

Hazardous voltages to the human body can start at very low levels. It is however difficult to know when electricity can cause serious injury or be fatal. Indeed the particular level will depend on body weight, skin humidity and point of contact, but definitively typical voltages found in DC rails for power electronic modules do clearly exceed this level, specially considering that DC rails in power electronic modules have energy stored in low impedance capacitors with potentially very high discharge currents.

The US agency OSHA publishes a table of the reactions of the body when subjected to different currents.

Current	Effect
1mA	Tingling sensations
5mA	Subtle shock, but can let go of object
10-30mA	Painful shock, freezing current, loss of control
50-150mA	Strong pain, strong muscular contraction, cannot let go
>1A	Cardiac arrest, burns, nerve damage

Power electronics and HV

Power electronics applications have been making its way into high voltage use, or medium voltage depending on the normative reference, enabled by new system topologies and semiconductors. Also new distribution grid architectures are laid out around medium voltage, be it AC or DC, to allow for new sources and consumers of energy. The need to develop new power electronic applications in medium voltage is backed up by research and development of high voltage semiconductors by different manufacturers and it has seen a steep rise in the last decade, be it diodes, thyristors, IGCTs, SiC Mosfets or IGBTs.

Indeed medium voltage DC is something that is becoming of increasing importance in modern networks as evidenced for example in photovoltaic energy, MV DC-DC converters, MV distribution grids or the IEEE 1709 Medium Voltage DC Power Systems on Ships standard.

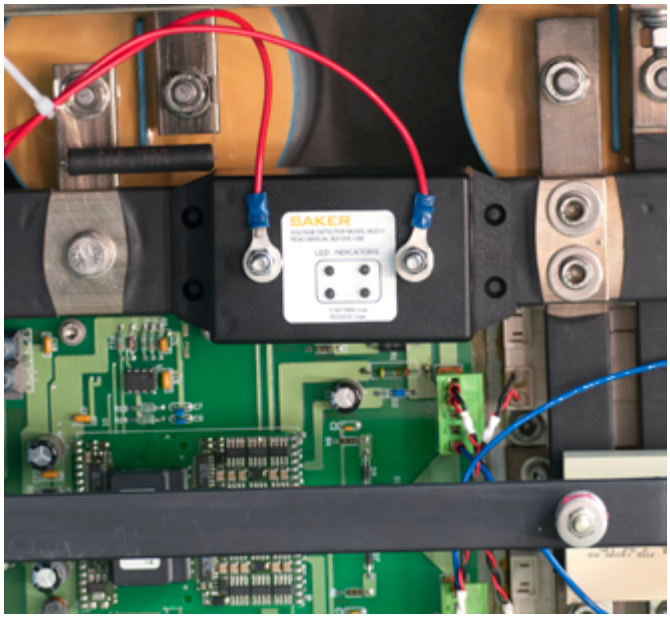

Figure 1: Photo of the MVD15-detector

Although companies and research centres have more resources available when working with high DC voltages in power electronic modules to provide safety for users, it is not uncommon to see multimeters used as voltage detectors, for example at universities. This practice should be avoided since DMMs do not provide a clear indication, can be configured for AC or DC but not both, and are limited to 1000V.

IEC Standard	Summary	Voltage
61243-1	Capacitive type to be used for > 1 kV	AC
61243-2	Resistive type to be used for voltages 1 kV to 36 kV a.c	AC
61243-3	Hand-held two-pole voltage detectors <1500V	AC/DC
61243-5	Voltage detecting systems that are single-pole and capacitively-coupled 1-52kV	AC
61243-6	Non-contact voltage detectors (NCVD) for use at nominal voltages above 1 kV AC	AC

Traditionally voltage generation, distribution and use has been in AC. Thus equipments and installations have mainly needed AC voltage detectors and the development of these has been supported by the IEC 61243 standard. Following is a table that summarises them. The main conclusion from this table is that there are no standards for DC or combined AC/DC high voltage detectors, be it hand-held or fixed type detectors.

Since the use of high voltage DC is quite prominent these days both in power electronics and transmission and since HV clearly poses a life risk to researchers and service personnel it is not understandable why this type of device has been virtually ignored by the industry.

Figure 2: Photo of the MVD

Main characteristics of VD

At Saker we recognized this problem and with our commitment to safety in handling high voltage equipment decided to develop a line of fixed type voltage detectors for use in power electronics and cabinets that work both on AC and DC and detect voltages >1000V. First we determined what the main characteristics of voltage detectors should be:

Clear indication. The presence of voltage must signalled in a clear way, either by a pulsating bright light, loud sound or both. Since fixed type VD are continuously monitoring the presence of voltage a loud sound would be annoying in practice and a bright blinking light is considered appropriate.

High reliability. The last thing you want to fail is a voltage detector as this is what a user will eventually trust, so VD must be protected against over voltages and be designed with ample safety margins. For example the lower the input current to the VD the better as this decreases internal power dissipation. One of our models, the MVD30 consumes less than 200uA even at its maximum DC input of 3500V, and can withstand large over voltages.

Autonomous. VD must be 100% independent of the system they are trying to monitor. A failure in the system in which they are part must not affect the VD at all.

Also important specifications of VD are size, activation voltage range, current draw, maximum continuous voltage, and over voltage withstand. Dielectric strength test voltages are also important since when installed in a power inverter a VD is now part of a larger high voltage system in which insulation coordination must be also met.

Our solutions

Saker designs and manufactures fixed type VD for power modules, cabinets or test platforms. They cover detection voltages from 20V to 40000V and there are two types, passive and active VD. Passive VD rely only on the current provided by the line it is monitoring, this is the case for example of the MVD series.

Active detectors have the advantage of a greater detection range. This need aroused for example when we were contacted by a client that wanted to detect for the presence of voltage in a MV AC line, but needed a fairly low activation voltage (50V) because capacitors were connected to this line and trapped charges could present a DC voltage in the line even when the AC line was switched off. The MVDZ detector provides a solution to this need, it is an active type detector for fixed installations. A high voltage insulator contains a string of high voltage resistors and detection electronics. A control box installed in a cabinet panel connects to the insulator, and signals if voltage is detected. Self-testing means are also carried out when this device is powered by a push button. Being a high voltage detector partial discharges are important, and this type of detector is free from them due to the vacuum casting process and the very high 405 MOhm input impedance.

Figure 3: Photo of the MVDZ detector

The MVD series will suit most power electronic modules with small footprint, activation voltages starting at 20V and rated maximum up to 3500V. These modules have 4 high intensity LEDs that blink when voltage is present. There is also the option to install a plastic fiber optic cable to bring the light pulse to the panel of a cabinet.

Conclusion

Every researcher working with high voltages in power electronics is encouraged to increase safety while working with it. Voltage detectors are only a part of an integral safety system aimed at protecting the user from fatal shock but they provide a last line of awareness in detecting the presence or not of voltage.

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Two Terminal Bipolar Power Supply

A 2-quadrant power supply — one that provides a positive or negative voltage to the same output terminals — can easily be produced using the LT8714 4-quadrant controller. The 2-quadrant supply shown here can be used in a variety of applications ranging from window tinting — where changing polarity changes the alignment of crystal molecules — to test and measurement equipment.

By Victor Khasiev, Senior Applications Engineer, Analog Devices

The LT8714 data sheet describes the operation of the 2-quadrant supply in the first quadrant (positive input, positive output) and in the third quadrant (positive input, negative output). Note that in both quadrants the power supply is sourcing current, thus producing a power source, not a power sink. The second quadrant and fourth quadrant produce a power sink.

Circuit Description and Functionality

Figure 1 shows an electrical schematic of the LT8714 as a 2-quadrant power supply. The powertrain consists of NMOS QN1, 2, PMOS QP1, 2, inductors L1, L2, coupling capacitor CC, and input and output filters. Inductors L1 and L2 are two discreet, noncoupled inductors, an approach that can reduce the cost of the converter. Proper selection of active and passive components requires understanding the voltage stresses and current levels present in each quadrant. For this purpose, the functional topologies for the positive output are shown in Figure 2.

When the volt-second balance is in a steady state, the duty cycle can be derived from the expression:

$$D = (V_{IN} - V_O) / (2 \times V_{IN} - V_O)$$

To verify the design, demonstration circuit DC2240A was reworked to match the schematic shown in Figure 1. The input voltage is a nominal 12 V, with output voltages of ±5 V at a maximum current of 6 A for both. The measured efficiency for the design is shown in Figure 3. The positive output exceeds that of the negative output, which matches the results of theoretical calculations. The voltage stress and current on the components are much higher in the negative output configuration, increasing losses, and decreasing efficiency.

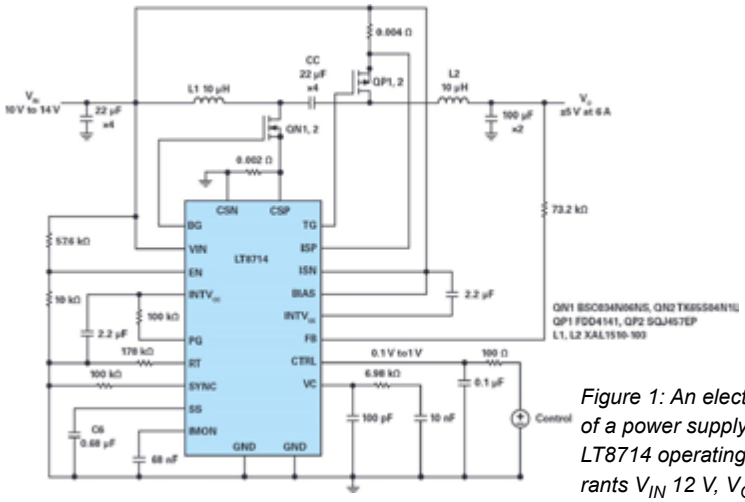

Figure 1: An electrical schematic of a power supply based on the LT8714 operating in two quadrants V_{IN} 12 V, V_O ±5 V at 6 A.

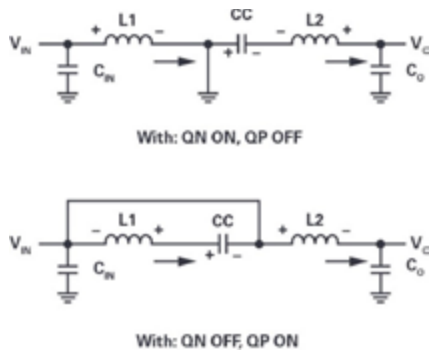

Figure 2: The topology of a 2-quadrant operation with a positive output.

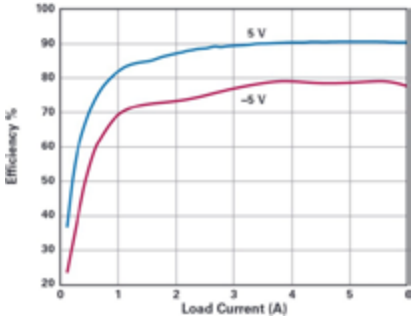

Figure 3: Converter efficiency curves with V_{IN} 12 V, V_{OUT} +5 V and –5 V, and a maximum IO of 6 A.

Figure 4 illustrates the excellent linearity of the output voltage vs. control voltage V_{CTRL}. For this configuration, the circuit was loaded by a 1 Ω resistor, and the control voltage was varied from 0.1 V to 1 V.

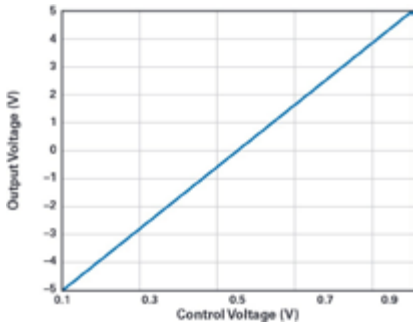

Figure 4: A graph of the output voltage, V_{OUT}, as a function of control voltage, V_{CTRL}. As V_{CTRL} changes from 0.1 V to 1 V, the V_{OUT} changes from –5 V to +5 V.

Using two LTspice® models, we were able to analyze the LT8714's performance with a power good indication in the first model and using uncoupled inductors in the second model.

Conclusion

This article demonstrates a simple 2-quadrant voltage source circuit using the LTC8714. The design was tested and verified to have excellent linearity from the LTC8714 controller.

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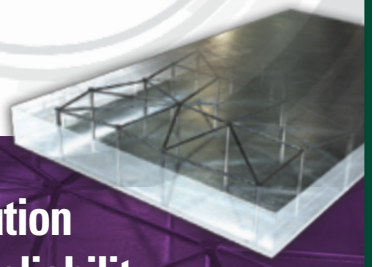

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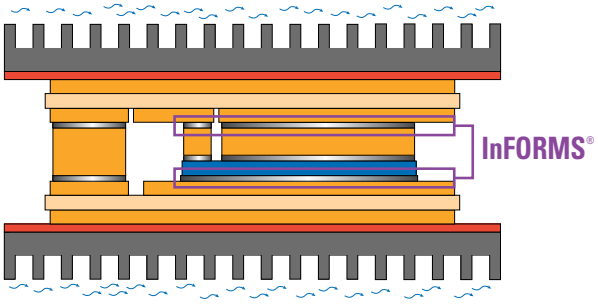

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Damp-Oscillation Solution for Validation of the Nanocrystalline Core for Common Mode Choke

The increasing usage of rectification technology results in a significant increase of mutual electromagnetic interference. Usually RF input chokes, i.e. common mode chokes are used as a universal solution for the problem.
The typical material for such applications is a variety of ferrites in the present.

By JC Sun, Bs&T Frankfurt am Main GmbH

And the high-permeable MnZn Ferrite material is preferred for conductive distortion while the low permeable material for radiation distortion. In the past decades the nanocrystalline tape wound core demonstrates its technological advantages, and already successfully replaces number of ferrite design, especially for high current applications, such as in motor drive, which is under harsh and high ambient temperature. Correspondingly, the design skill with nanocrystalline tape wound cores is well illustrated in VAC book [1].
Common-mode-cores are an effective measure to reduce common-mode-interference and they can be easily installed over the supplying cables of any drive system. The common-mode-current that flows through the parasitic capacitances of motor cables and motor housing can be reduced by using those cores significantly. The filtering effect can easily be improved by installing multiple common mode cores, which extends the saturation time and keeps the stray inductance low. But there is a general problem, in term of validation of tape wound core for common mode choke application.

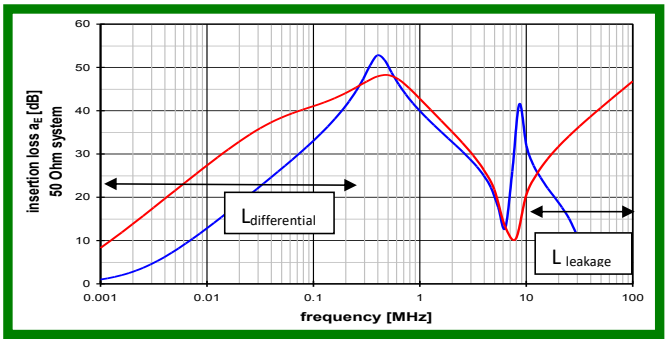

Figure 1: Function principle of common mode choke nanocrystalline vs. ferrite design

First of all, let us take a look at the design performance of common mode chokes over the whole frequency spectrum, the magnetization inductance is responsible for noise source (< 150 kHz) and the leakage inductance is for high frequency attenuation, i.e. > 10 MHz. Thus, the resonance peak stiffness and its relevant temperature influence, pending on magnetization inductance and capacitors, are the key design parameters for efficient absorption of harmonics.
In terms of the application for nanocrystalline tape wound cores, the high saturation flux density provides potential high capability for noise absorption in good sake of compact size of the choke, the high permeability offers potential to reach given inductance value with less number of turns, which consequently shifts the resonance peak far behind the those of ferrite design, due to less parasitic capacitance. Additionally, the saturation/leakage inductance is kept pronounced low, acting as perfect magnetic switch at high switching status. Finally, the high Curie temperature enables the thermal stability for dissipative large power drive application.
So the material advantages are convincing, but the validation performed for a choke design still meet much uncertainty, where geometric parameters play important role to differentiate in terms of flux linkage and inductance instead of flux density and permeability. This geometry is a processing parameter, which is almost process know how of makers. (this sentence is hard to be get the point, maybe rephrased) Only typical value is provided, not helpful for specification of limit value, which makes the validation very challenging for filter designer and their demanding customers.
In this article, the damping-oscillation solution is presented with detailed principle description and technical discussion to address the challenges of nanocrystalline tape wound cores` validation. Case studies of the solution and results discussion are also presented to demonstrate the proposed measurement solution.

Status quo description

The specification of ferrite material is described in IEC standard IEC 62044-2 (small-signal excitation), limited within +-20% and while the AL value of nanocrystalline tape wound core is normally measured differently. Based on the standard, the initial permeability and the corresponding AL (inductance) value are measured under room temperature 23°C, 10kHz and < 0,25 mT.
As illustrated in a typical datasheet attached[2], the only magnetic property of the core-A_L value, is specified as a nominal value and two setting values are described for two different frequency 10 kHz and 100 kHz while I_{eff} X N= 40 mA, which is corresponding permeability at 2,5 mA/cm.
Also μ_3, where the index 3 indicates the measuring condition, H=3 mA/cm are given as following

I_{eff} x N = 40 mA
f = 10 kHz
Specified value: 13,1 µH < A_L <21,9 µH
f = 100 kHz
Specified value: 10,1 µH < A_L < 20,3 µH,

to providing very limiting value for the magnetic core. Besides, the tolerance as limit value is corresponding as -15% +45% @ 10kHz and -50% + 35% @ 100 kHz

This gradual deviation makes choke design benchmarking difficult, and even more difficult to compare nanocrystalline tape wound cores from different sources. The small signal measurement is important and necessary, but not enough to describe the performance of common mode choke because it lost the precision at large current amplitude.
Therefore, a better and practical method is needed for wide spreading of nanocrystalline technology, and BsT-Pulse offers simple, easy and transparency, addressed on this challenge.

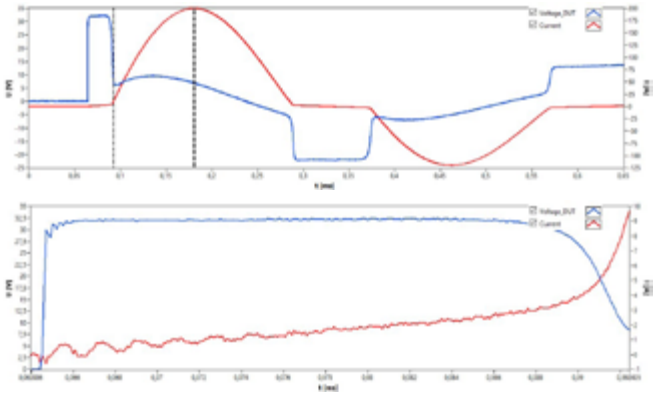

Figure 2: Demonstrated measurement results, from Bs&T pulse:
(a) Total damped oscillation time decay
(b) Expanding plot for the very-beginning damping period;
Sample: 2 stacked tape wound core V144 and wound with labor strip of 0,5 m for 3 turns)

BsT&Technology and its data evaluation
Damped oscillation method compliant modified IEEE 389 standard is a magnetic validation solution with transient high current amplitude, which enables large excitation. Its full reversal current enables further completion of re-magnetization path and Bs&T pulse micro (<1kV) is a device of integration hardware/ software solution with the damped oscillation method. The fundamental operational principle of Bs&T Pulse micro has been presented in [2]. During the damped oscillation, the initial stored energy in the capacitor can be fully discharged to magnetize the common mode choke, and it provides large excitation due to fast switching speed of thyristor. An illustration of the initial measurement data of voltage and current time diagram is shown in Figure 2. In Bs&T pulse solution, all the waveform can be traced as raw data for analysis afterwards.

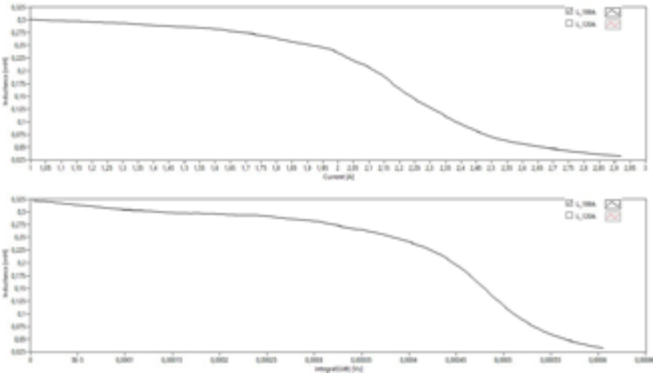

Figure 3: Measurement of differential inductance vs. magnetization current (a) and flux linkage (b) with damp-oscillation method

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Description of common mode choke

The device under test is a common mode choke, which is cored with two tape wound cores, wound with laboratory cable (half meter, R_{dc} about 10 mΩ) with 3 turns, R_{AC} about 34 mΩ and connected directly into terminals of BsT-pulse. BsT-pulse micro is equipped with a defined capacitor of 430µF inside, so that the nonlinear common mode choke and large storage capacitor form the LC resonance.

Inductance (magnetization)

The differential inductance can be directly read from the voltage and current curve by time around the first current peak amplitude, either vs. magnetization pulse current amplitude in (a), or flux linkage in (b).

BH curve

With given parameters, i.e. nominal value for magnetic effective length and cross section and number of turns, nonlinear BH curve can be validated, in Figure 4 (a) as unipolar and (b) bipolar excitation.
The differential inductance is roughly rated as 270 µH, properly given as the results seen in Figure 3, the nonlinearity towards current and flux linkage is given as well.
The bipolar excitation indicates the capability of noise absorption.

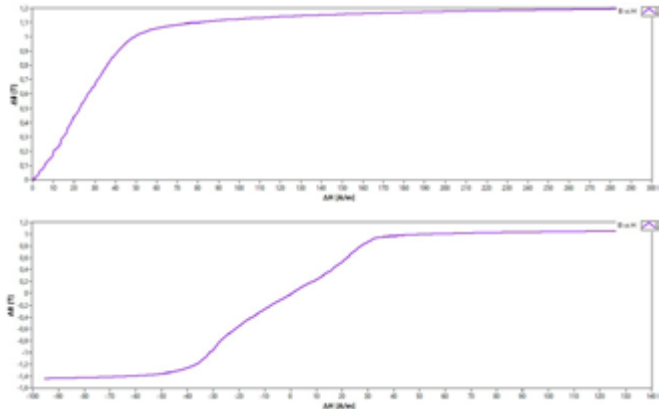

Figure 4: Magnetization curve of unipolar (a) and bipolar (b) excitation

Saturation / leakage inductance

The saturation / leakage inductance is calculated as half sinusoidal curve Figure 5 [7]

$L_{sat} = (\tau/\pi)^2/C = 15{,}6\ \mu H$

$\tau = 323{,}7\ \mu s - 66{,}7\ \mu s = 257\ \mu s$; $C=430\ \mu F$

$L_{sat} = \mu_0\mu_r N^2/C_1 \sim 15{,}6\ \mu H$

$C_1 = l_e/A_e$

This value is confirmed by calculation with $\mu_r \sim 1$
Damping coefficient is calculated as following [8]

$$a = \frac{ln\frac{i1}{i2}}{t2 - t1}$$

a= ln i_2/i_1 /(t_2-t_1) = 1800 Hz
with i_1 199 A at t_1 0,18 ms, i_2 120 A at t_2 0,46 ms
for f = 1/(t_2-t_1)= 3,57 kHz

Until now, the characteristic of this common mode choke cored with nanocrystalline material is completely accompanied:

- Small signal as indicated with µ3 at 10kHz and 100 kHz, moreover
- Large signal delivers the choke performance
- Differential inductance vs. current and flux linkage Figure 3 (a) (b)
- Leakage inductance for the saturation phase, half sinusoidal time slot Figure 5
- Damp coefficient and corresponding resonance frequency
- Flux density after geometrical normalization indicated the typical Bs of nanocrystalline of 1,2 Tesla, seen in Figure 4

Additionally, the AC resistance, which is important for ohmic loss during the saturation phase, is delivered at current peak with $\frac{dI}{dt}$ =0. The measured AC resistance is in the case 3 times higher than the DC

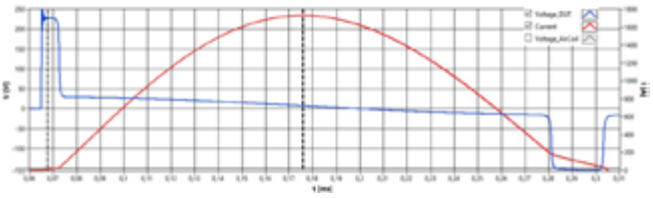

Figure 5: Estimation of leakage inductance for saturation interval, half sinusoidal time slot

resistance because only the voltage drop on the inductive part is to be taken into consideration to illustrate the magnetic properties. The precise measured value for AC resistance, as a by-product of impulse measurement, has significant importance for this particular application with respect of loss, mainly ohmic loss throughout saturation time period.
It is worth to mention that the nanocrystalline tape wound cores are mostly embedded in a plastic case, and it is difficult to stabilize the packing factor due to thickness of ribbon (~22µm) from manufacturing point of view
It is difficult to have precise data, but with Bs&T-Pulse with given parameter by makers, it can be easily validated.

Theoretical model about impulse magnetization

The very classical eddy current model assumes constant permeability over homogeneous magnetic cross section, which is not dependent of excitation. [4] In reality the two fundamental requirements for classical eddy current model are not given. Magnetization front model [5][6] distinguishes dynamic magnetization rate dB/dt and delivers reasonable result for dynamic differential permeability, which is proportional to specific resistance; in addition, available flux linkage in voltage second, which is reversal proportional to thickness of ribbon and magnetization rate dB/dt [T/µs], indicates different impulse energy will formulate different voltage and current decay and consequent BH curve, due to different dB/dt velocity of magnetization condition.

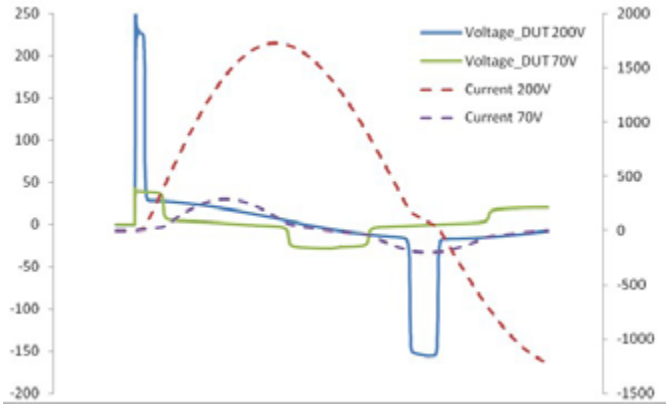

Figure 6: Damped oscillation voltage and current decay with same DUT but under different discharging voltage level i.e. dB/dt

Figure 6 demonstrates difference for two voltage and current decays with the same DUT (stress annealed nanocrystalline tape wound core, wound with half meter labor stripe ½ meter, with 8 turns. The same flux linkage consists of different height of voltage (50V vs. 220V) and pulse duration, and the current time curve is significantly different (200A vs. 1800A), the ratio is related to energy intensity in cap, because the leakage inductance at saturation is obviously equal for the same choke design.

The specific resistivity, ribbon thickness (rapid solidification process) and flux linkage (post annealing process) are material properties, which are depended on chemical composition and processing route by manufacturer. However, the magnetization rate is highly dependent on the applications. As common mode chokes withstanding impulse magnetization, the induced influence can be sensitized with different discharging voltage to illustrate different rates of dB/dt by the impulse results from Bs&T-pulse which provides the total core performance with respect of flux linkage capability to absorb the noise energy. The results using Bs&T-Pulse is the only proper validation methodology, which delivers core performance for common mode applications.
The complete inductance analysis vs. demagnetization current and flux linkage are presented in Figure 3 (a) (b), and delta B vs. delta H Figure 4a, with given geometry for winding, and number of turns.

The differential inductance vs. current, from demagnetization path, is also important, because the first current peak eliminates the uncertainty of status of component under test, due to remanence, and this measurement ensures a direct comparison.
The saturation inductance is of essential importance in terms of effective energy transfer in the saturated state and the peak current amplitude, the saturation inductance can be calculated as

$$L_{sat} = (\tau/\pi)^2/C$$

where τ is the current pulse width, C is the value of the internal capacitor, the frequency of the current pulse during saturation can be determined from $f_{sat} = 1/2\tau$ [7]

It is worthy while to mention, that core relaxation loss, pending on dB/dt can be further studied with different discharge voltage, the nonlinearity of relaxation loss decoupled from excitation condition, i.e. frequency and flux density amplitude, is very much pending on specific time slot, where dB/dt ~ 0, while the current amplitude experiences its half sinusoidal peak.

Conclusion

Nanocrystalline tape wound cores with its high permeability, high Curie temperature and its diversification of manufacturing process capability (field and stress annealing) win increasingly preference of number of designers. However the conventional small-signal measurement cannot meet the requirement of specification with limit value alone. The difficulty of validation is discussed, and Bs&T pulse is offering a convincing validation solution for the components, both for core manufacturer and components manufacturer, and finally for end users. Further investigation can be performed with different magnetization velocity dB/dt, i.e. discharge voltage starting from some tens of voltage Bs&T-pulse micro until some tens of kV, with Bs&T-pulse macro.

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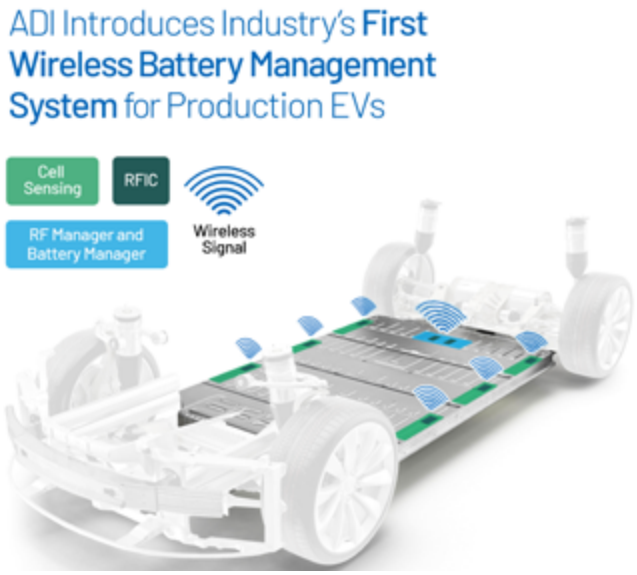
PCB mount	1.46×1.08×0.69"	1.46×1.08×0.79"	2.07×1.08×0.93"	2.92×1.85×0.91"
Chassis mount	2.17×1.70×0.91"	2.17×1.70×0.91"	3.48×1.50×0.95"	3.82×1.90×1.00"

Wireless Battery Management System for Electric Vehicles

Analog Devices announced the industry's first wireless battery management system (wBMS), which enables automotive manufacturers increased flexibility to scale their electric vehicle fleets into volume production across a wide range of vehicle classes. This is the first wireless battery management system available for production electric vehicles, and it will debut on General Motors' production vehicles powered by Ultium batteries. The implementation of ADI's wBMS eliminates the traditional wired harness, saving up to 90% of the wiring and up to 15% of the volume in the battery pack, as well as improving design flexibility and manufacturability, without compromising range and accuracy over the life of the battery. ADI's wBMS includes all integrated circuits, hardware and software for power, battery management, RF communication, and system functions in a single system-level product that supports ASIL-D safety and module-level security building upon ADI's proven industry leading BMS battery cell measurement technology. By delivering high accuracy for the lifetime of the vehicle, the system enables maximum energy use per cell required for best vehicle range and supports safe and sustainable zero-cobalt battery chemistries, such as lithium iron phosphate (LFP). "We are pleased to collaborate with ADI to take the wBMS technology to production as part of our ground-breaking Ultium battery platform," said Kent Helfrich, Executive Director, Global Electrification and Battery Systems at General Motors. "ADI's wBMS technology enables the more widespread electrification of our fleet, and we look forward to a continued collaboration with ADI to deliver innovation in safety, quality, and performance for the future."



www.analog.com

Bandwidth Upgrades for Selected Oscilloscopes

Rohde & Schwarz announces a promotion for its oscilloscope portfolio: When purchasing a four-channel model of the R&S RTO2000 or R&S RTP oscilloscope, customers can now upgrade to the next bandwidth level for no additional charge, saving up to 20.000 EUR. Sufficient measurement bandwidth is essential for developing state-of-the-art electronics, particularly driven by the quest towards ever-faster communication devices. Therefore, upgrading to a higher bandwidth today will turn out as a future-proof investment for the challenges of tomorrow. Taehoon Kim, vice president product division oscilloscopes at Rohde & Schwarz, comments: "We know that having enough bandwidth is crucial for every oscilloscope application. By giving our customers additional bandwidth with their new oscilloscope, we want to support their innovative strengths for current and future projects." The "Boost your bandwidth" offer is available worldwide from Rohde & Schwarz until December 31, 2020.

www.rohde-schwarz.com

Advanced Interfaces for HV Power Supplies

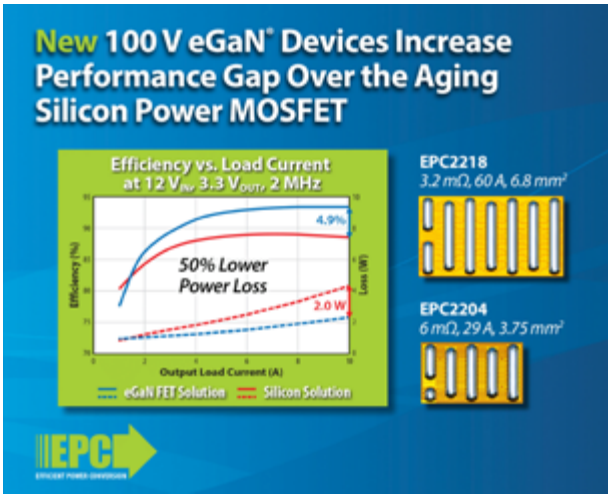
Dean Technology announced the availability of advanced interface options on the UMR-AA and UMR-A series of high voltage power supplies. Using additional pins, the advanced interface options provide for enhanced adjustment and monitoring features consistent with industry standards and known customer needs. The V05 and V10 options are available with +5VDC and +10VDC reference, control and monitoring respectively. The advance interface options allow both the power supply output voltage and current to be monitored and adjusted with the same scaling and include a +5VDC or +10VDC reference voltage. Signals are from 0 to +5VDC (V05) and 0 to +10VDC (V10) for all models and polarities of both the UMR-AA and UMR-A series. Output monitoring signals are fully buffered with high input impedance to ensure consistent accuracy regardless of load conditions. The low impedance outputs provided by these options also have a programming accuracy that makes them ideal for integration into any variety of systems including those with digital and PLC control.

"DTI is filling out our standard power supply offerings exceptionally quickly," said Scott Wilson, Power
Supply Product Manager for Dean Technology. "The V05 and V10 options are important additions, and provide the substructure needed for many of the products to come. I am very excited to have all of this available for our customers at unbeatable pricing."

www.deantechnology.com

100 V eGaN FET Family

EPC advances the performance capability while lowering the cost of off-the-shelf gallium nitride transistors with the introduction of EPC2218 and EPC2204 100 V eGaN FETs. The applications for these leading-edge devices include synchronous rectification, class-D audio, infotainment systems, DC-DC converters (hard-switched and resonant), and lidar for autonomous cars, robotics, and drones. The EPC2218 (3.2 mΩ, 231 Apulsed) and the EPC2204 (6 mΩ, 125 Apulsed) have nearly 20% lower RDS(on), as well as increased DC ratings compared with prior generation eGaN FET products. The performance advantage over a benchmark silicon device is even higher.



The EPC2204 has 25% lower on-resistance, yet is three times smaller in size. Gate charge (QG) is less than half that of the silicon MOSFET benchmark, and like all eGaN FETs, there is no reverse recovery charge (QRR), enabling lower distortion class-D audio amplifiers, as well as more efficient synchronous rectifiers and motor drives. Alex Lidow, EPC's co-founder and CEO commented, "With the clear superiority of these new 100 V eGaN FETs, one might expect them to be priced at a premium. However, EPC has priced these state-of-the-art 100 V transistors comparable with their aging ancestor, the silicon power MOSFET. Designers can take advantage of devices that are higher performance, smaller, more thermally efficient, and at a comparable cost. The displacement of the power MOSFET with GaN devices continues to accelerate."

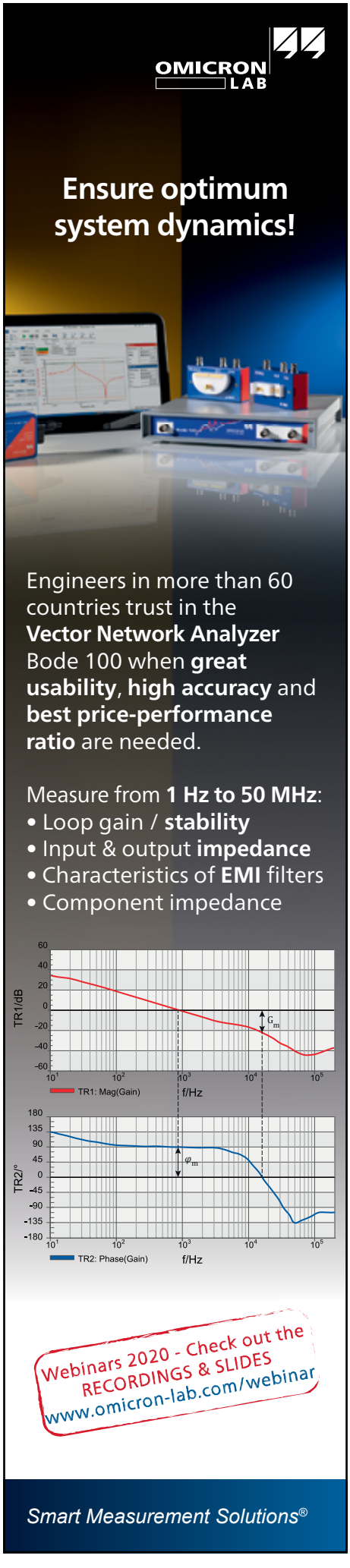
www.epc-co.com

Dispensable Thermal Interface Material

The Chomerics division of Parker Hannifin Corporation announced the launch of THERM-A-GAP GEL 37, the next generation of single component, thermally conductive dispensable materials.

THERM-A-GAP GEL 37 has been specifically designed to limit the batch-to-batch variations typically found in thermal dispensable materials. With a thermal conductivity of 3.7 W/m-K, its tighter, more controlled flow rate of 30g per minute, 50% higher than Parker's GEL 30, vastly improves dispensing in high volume applications. As a conformable, single component dispensable compound, GEL 37 has superior long-term stability and reliable performance. It does not require post cure, which helps to eliminate time consuming hand assembly and decrease installation costs. THERM-A-GAP GEL 37 will easily conform to irregular shapes without excessive force on components and also features a minimum bond line thickness of 0.1 mm. A variety of vessel sizes and configurations are available to suit any application, from hand dispensed syringes, to Semco® and Nordson EFD tubes and large tubs for high volume applications. It is available in weights ranging from 30g to over 23kg. THERM-A-GAP GEL 37 also features a long 18-month shelf life and effective sag resistance to help maintain the shape of the material during the curing process.

www.parker.com



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GaN-Powered LED Drivers

Power Integrations announced a member of the LYTSwitch™-6 family of safety-isolated LED drivers for smart lighting applications – the LYT6078C. This LYTSwitch-6IC uses Power Integrations' PowiGaN™ gallium nitride (GaN) technology to deliver efficiency and performance benefits, demonstrated by the new design example report (DER-920) the company also announced.

The PowiGaN-based LYT6078C IC incorporates a 750 V power switch and delivers flicker-free output up to 90 W with other members of the family providing up to 110 W. Including both the PFC stage and the LYTSwitch-6 LED driver, system efficiency exceeds 90%. Housed in the miniature InSOP-24 surface-mount package, LYTSwitch-6 ICs are protected by an advanced thermal fold-back system, which reduces output power to limit device temperature during abnormal conditions, while still providing light output. LYTSwitch-6 ICs also incorporate Power Integrations' FluxLink™ communication technology, which allows secondary-side control without the need for an optocoupler, and provides better than ±3% CV and CC regulation across line, load, temperature, and manufacturing. All LYTSwitch-6 ICs exhibit fast transient response and easily support pulse-width-modulation (PWM) dimming

.

www.power.com

Dual Choke Filter Inductor Series

Bourns introduced the Model DR334A Line Filter Series. These current-compensated dual choke filter inductors feature higher current capability than typical standard signal line common mode chokes, as well as high stray inductance and differential mode noise rejection. These capabilities make the Model DR334A series ideal line filter solutions for consumer, industrial and other market power line applications, or in applications where power is transferred over signal lines.

The Model DR334A series is available in a bifilar-wound configuration to reach higher common mode impedance, and a sector-wound configuration to reach higher differential mode impedance at high frequencies. Offered in a compact, low profile (height 3.6 mm) size and in a broad range of inductance ratings from 11 µH up to 4700 µH, Model DR334A line filters allow designers to set the filter curve best suited to their application.

The Model DR334A series is AEC-Q200 compliant with an extended operating temperature range of –40 to +135 °C and has a rated voltage up to 80 VDC. In addition, the closed and ferrite toroid core construction of Bourns' latest line filter series delivers a more efficient and robust mechanical design.

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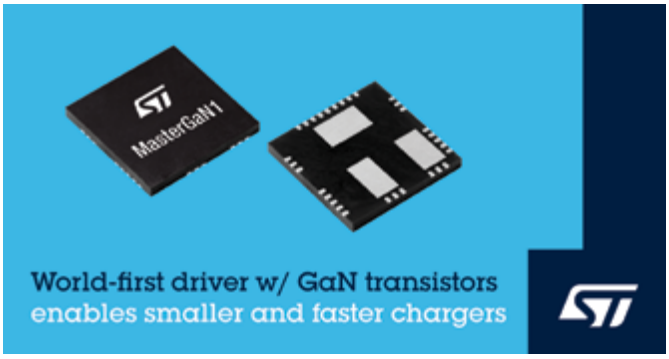
Si Driver and GaN Power Transistors in One Package

STMicroelectronics has unveiled MasterGaN®, a platform embedding a half-bridge driver based on silicon technology along with a pair of gallium-nitride (GaN) transistors. The combination will accelerate the creation of next-generation compact and efficient chargers and power adapters for consumer and industrial applications up to 400W. GaN technology enables these devices to handle more power even as they become smaller, more lightweight, and more energy efficient. These improvements will make a difference for smartphone ultra-fast chargers and wireless chargers, USB-PD compact adapters for PCs and gaming, as well as in industrial applications like solar-energy storage systems, uninterruptible power supplies, or high-end OLED TVs and server cloud.

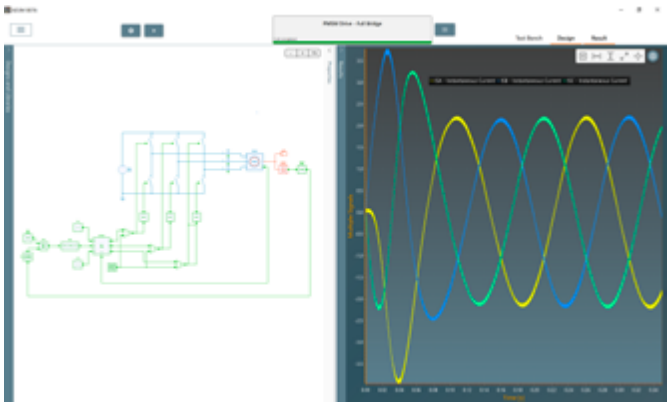
Today's GaN market is typically served by discrete power transistors and driver ICs that require designers to learn how to make them work together for best performance. ST's MasterGaN approach bypasses that challenge, resulting in faster time to market and assured performance, together with a smaller footprint, simplified assembly, and increased reliability with fewer components. With GaN technology and the advantages of ST's integrated products, chargers and adapters can cut 80% of the size and 70% of the weight of ordinary silicon-based solutions.



"ST's market-unique MasterGaN platform builds on our proven expertise and power-design skills to combine high-voltage smart-power BCD process with GaN technology, to accelerate the creation of space-saving and power-efficient products that are kinder to the environment,"said Matteo Lo Presti, Executive VP and General Manager Analog Sub-Group, STMicroelectronics.

www.st.com

Power Electronics and Motor Drive Simulation



SIMBA is a lightweight but powerful Power Electronics simulation environment. The devolpers ambition is to create a platform simple enough for students and lobbyists but sufficiently fast and powerful for most complicated use cases. SIMBA includes a new generation of simulation engine called Predictive Time-Step solver. It automatically finds and uses the optimal time step to simulate all time constants and events of a converter without compromising the accuracy. An independent Python module is also available for advanced tasks and post-processing. The SIMBA Python Library contains hundreds of functions providing direct access to SIMBA such as creating a circuit, modifying parameters, running a simulation, and retrieving results. Feel free to give it a try, install it and play around.

www.simba.io

Superjunction High-Voltage MOSFET

For SMPS designs in industrial applications recent technology trends include the need for high efficiency and power density as well as increased bus voltages. This triggers the need for power devices with 650 V breakdown voltage. With its 650 V CoolMOS™ CFD7 product family Infineon Technologies AG meets these demands. The devices are best suited for resonant topologies in soft-switching applications like telecom, server, solar and off-board EV-charging.

Extending the voltage range of the renowned CoolMOS CFD7 family the 650 V device succeeds the CoolMOS CFD2. The added 650 V products match LLC and zero-voltage-switching phase-shift full-bridge topologies in which they are delivering numerous advantages compared to previous generations. The additional 50 V breakdown voltage, an integrated fast body diode, and improved switching performance make the product family a perfect fit for contemporary designs. Very low reverse-recovery charge and excellent thermal behavior add to the benefits.

The switching losses, as well as RDS(on) dependency over-temperature, are significantly reduced. The product family provides very good hard-commutation ruggedness. Thanks to the improved gate charge (Qg) and the fast switching performance, the 650 V CoolMOS CFD7 family increases efficiency over the whole load range. In the primarily targeted SMPS application, these MOSFETs provide outstanding light-load and improved full-load efficiency compared to the competition. Furthermore, the best-in-class RDS(on) enables customers to increase the power density level of SMPS at a competitive price.

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Ingeteam's converters are tested and labelled to comply with and facilitate the full wind turbine certification process, whatever the site. As the amount of installed renewable power steadily increases around the world, the critical issue of grid stability has become increasingly complex. Grid codes are in constant evolution and the validation and certification process is an area of risk on the critical path of every development project. Ingeteam's high power DFIG wind converters have been specially developed to minimize this risk, making them the most grid friendly and cost competitive drive train topology for onshore applications. Ensuring the correct integration of the power converter with the electrical generator is key to maximize the performance of a wind turbine, especially in DFIG based topologies. Ingeteam's new high power wind converters have been tested in full-scale bench tests in combination with rated power DFIG generators to validate the whole system performance for HW [hardware] and SW [software] integration, and have successfully passed all the combined tests. Moreover, data from these full-scale tests are then correlated with existing data to obtain detailed system models, enabling Ingeteam's engineers to fine-tune performance.
Using a converter cabinet-scale climatic chamber, Ingeteam carries out detailed validation campaigns to provide empirical assessment of all possible climate conditions including the most extreme high-low combinations of temperature and humidity. Condensation tests simulate the worst scenarios to provoke condensation and confirm that there is no risk to the converter even in such extreme cases.
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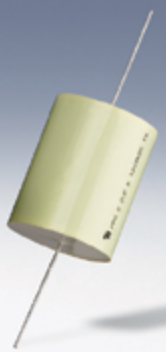
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IPM Modules Based on IGBT Technology

Fuji Electric Corp has added a Small Intelligent Power Module (IPM) as part of the 7th Generation X-Series Portfolio. The latest IPM modules come equipped with a control IC providing IGBT drive and protection circuits, making the design of peripheral circuits straightforward and ensuring high system reliability. The P642 IPM features a product line-up ranging from 50A to 75A at 650V expanding the 15A to 35A at 600V range of the P633A IPM. All Fuji Electric Dual-In-Line Small IPMs come equipped with overcurrent protection, short circuit protection, control power voltage drop protection, and overheating protection, while also outputting alarm signals. “Fuji Electric continues to expand our offering in the dual-in-line small IPM market and the new P642 series is our latest offering expanding our range to 75A” said James Usack, Division General Manager Electronic Devices Division.

www.americas.fujielectric.com

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