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# Bodo´s Power Systems®

Electronics in Motion and Conversion

February 2020

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- DBC connectors
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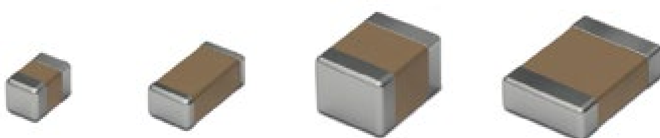

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www.bodospower.com

# We Are Digital Too

From time to time, when speaking to our readers or other interested people, the question is sometimes asked: “Why does Bodo’s Power not have a digital version?”. This made me realise that perhaps I should introduce our business in a little more detail. As many of you already know, our magazine is available digitally and in fact has been from the very beginning in June 2006! There is a full archive containing every edition of our publication available on our website and best of all it’s totally free. So, how do you receive your monthly digital magazine to read? However, you choose, there is one thing that you can rely on, we’re always out on the first of the month. Our slogan is “On Time, Always”. Just go to bodospower.com/archive and enjoy.

If you would like to receive a personal reminder, that is also possible: just subscribe to our newsletter! Around the first of each month “Bodo’s Power News”, our newsletter, will hit your inbox, containing the direct digital link to the latest issue! As part of this service, you will receive some additional newsletters. These extra newsletters are “Special Announcements” from our advertising clients. Without these clients we wouldn’t be able to exist, so that’s where our circle closes. We believe it’s only fair to pay a little attention to the ones who pay for it all! That’s how Bodo started long ago, and if you think about it, you will agree that it is still a good way to serve everyone.

When you are reading this edition it will be early February. Why do I mention this? Because, in addition to all the other very important events, the APEC Conference is coming up. Within the March issue, as is usual for the major shows, you will find a floorplan printed in the centerfold. The floorplan will contain logos of our supporters and if you are exhibiting or attending the conference this

will be of great interest to you. Why is early February important - because there is only a little time left to be included in this floorplan. If you’re interested, please contact us or one of our representatives and we will make it happen! We are, once again, a media partner and we will both be attending the show and distributing our magazine at APEC.

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 of 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:**
If you are absolutely sure that you can live without holding the physical magazine in your hands, go digital. If you’re unsure, do both, and find out which you like!

Best regards

## Events

**Embedded World 2020**
Nuremberg, Germany February 25-27
www.embedded-world.de/en

**BEVA 2020**
Detroit, MI, USA February 26-27
www.beva-detroit.com

**Power Analysis & Design Symposium 2020**
Eching, Germany February 5
www.omicron-lab.com/training-events

**Satellite 2020**
Washington, DC, USA March 9-12
www.satshow.com

**APEC 2020**
New Orleans, LA, USA March 15-19
www.apec-conf.org

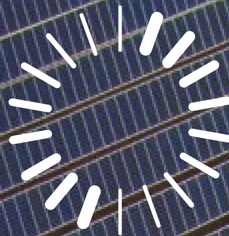
**EMV 2020**
Cologne, Germany March 17-19
https://emv.mesago.com

**AMPER 2020**
Brno, Czech Republic March 17-20
www.amper.cz/en.html

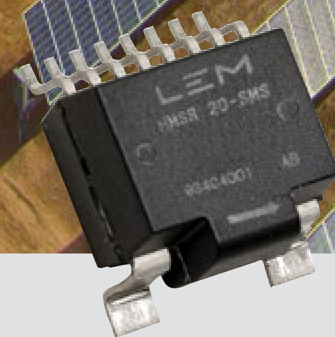
**SEMICON China 2020**
Shanghai, China March 18-20
www.semiconchina.org

**CIPS 2020**
Berlin, Germany March 24-26
www.cips.eu/en

E-World 2020
Hall 5 / Stand 211



# Miniature current sensor




## HMSR

Packaged as SO16 surface-mount device with a height of just 6 mm, HMSR current sensor is adapted to the power electronics world for a perfect integration thanks to its SMD automatic assembly and space saving. As a reinforced insulation level, cost effective and miniature solution for current sensing, HMSR provides solutions to photovoltaic, white goods, windows shutters, air-conditioning, high switching frequencies drives applications.

- **6, 8, 10, 15, 20 or 30 $A_{RMS}$ nominal current**
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- **Double overcurrent detection outputs**

**www.lem.com**

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# Donating €12,000 to 'Clean Water for Ghana'

In lieu of Christmas gifts to customers, Vincotech again donated to the same worthy cause the company had supported during the year. Plan International, an aid organization that Vincotech has been proud to work with over the years, will put this €12,000 grant to good use in the name of the company and its customers. Earmarked for the 'Clean Water for Ghana' project, this funding will help afford people in the country's Eastern, Central and Volta regions better access to drinking water and sanitary facilities. Although Ghana's growing economy is a success story, people in rural areas, especially, have yet to benefit. Just 66 percent of the

population has access to drinking water and a scant nine to sanitary facilities. This infrastructural project aims to improve the water and sanitation situation for around 32,000 people by building and renovating 36 water points in communities, schools and health centers, and installing sanitary facilities for some 12,000 boys and girls at 36 schools. Community training on sanitation and sustainable water management goes to help to make these improvements permanent. Eckart Seitter, Senior VP Sales & Marketing at Vincotech, says, "Supporting this kind of project may seem like a drop in a bucket, but lots of droplets make a mighty ocean. We're just happy to be helping people in developing countries help themselves with basic infrastructure and skills they can use to improve local living conditions."

**www.vincotech.com**

# Expansion of Network in North America

Asahi Kasei America has opened an office in Novi, Michigan, to strengthen its marketing function in North America, mainly in the automotive field. In the Asahi Kasei Group's medium-term management

initiative "Cs+ for Tomorrow 2021," mobility is identified as a priority field for provision of value in the Material business sector. In North America, Asahi Kasei manufactures and sells car interior materials, compound resins, and battery separators, and sells electronic components as well as provides technical support to customers in the automotive industry. Many Asahi Kasei products have been adopted by major automobile manufacturers in the region. The major American automobile manufacturers called the "Big Three" have their headquarters in the Detroit area, and there are also many parts manufacturers located around Novi near Detroit. By concentrating the company's automotive marketing functions at the center of the industry, Asahi Kasei will continue to propose innovative products that meet rapidly changing market needs. In addition to mobility, there are many other potential growth fields in North America. To accelerate new business creation, Asahi Kasei America will continue to strengthen its marketing function in collaboration with the Marketing & Innovation unit of Asahi Kasei Corp. which was established in April 2019.

**www.asahi-kasei.co.jp**

# Strengthening Presence in Specialty Chemicals

Mersen has announced the acquisition of GAB Neumann, a specialist in the design, manufacture and sale of graphite and silicon carbide (SiC) heat exchangers for the chemicals market.
Éric Guajioty, Group Vice President, Advanced Materials, said: "We are delighted to welcome the GAB Neumann teams to Mersen. Their

extensive and recognized expertise will help the Group strengthen its footprint in anti-corrosion equipment across German-speaking Europe (Germany, Austria and Switzerland). The addition of their annular groove graphite and silicon carbide heat exchangers to our product portfolio also makes Mersen a unique and central player in exchangers and solutions for today's high value-added pharmaceuticals and specialty chemicals markets."
The acquisition will enable Mersen to strengthen its position in the chemicals market in Germany – particularly in the replacement segment – and provide its customers around the world with an enriched offer of products and services. A family-owned company based in Maulburg in the state of Baden-Württemberg in south-west Germany, GAB Neumann was founded in 1965 and has 45 employees. It will join the Advanced Materials segment and will contribute around €10 million to annual Group sales.
The transaction, which is subject to the approval of the German antitrust authorities, is expected to be finalized in early 2020.

**www.mersen.com**

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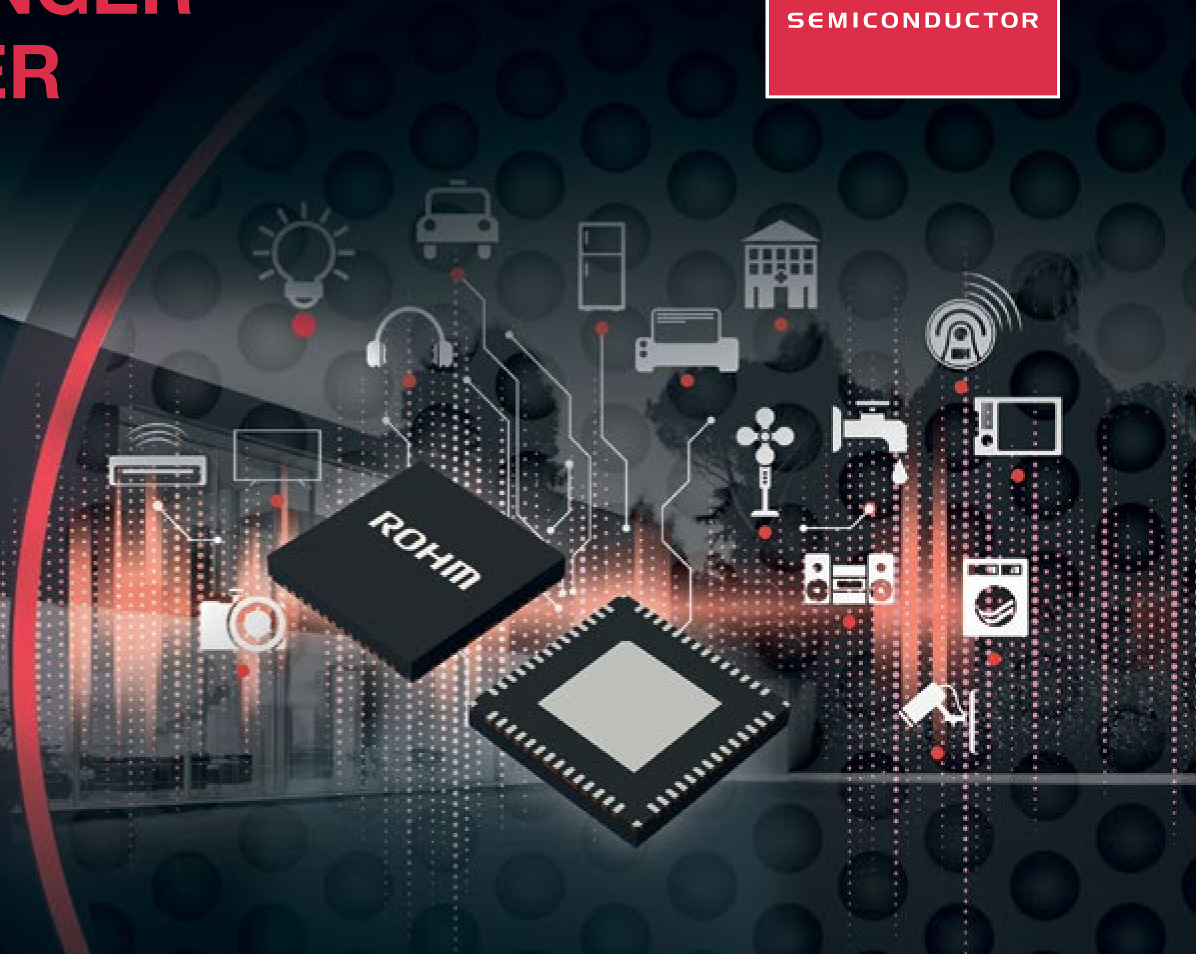


## NEW PIN COMPATIBLE, POWER AND COST OPTIMIZED PMIC FOR NXP I.MX 8M NANO SOC

The power architecture of ROHM's BD71850MWV is optimized for lowest power dissipation and improved operational times. The BOM is down to its minimum as the full integrated buck regulators will need just one single output capacitor, the I2C interface is 3.3V tolerant and the multi-functional power button is realized as single-switch function.

### KEY FEATURES

- Upgradable design, no external active components required
- Pin-compatible PMIC solution for i.MX 8M Nano and Mini
- No need for PCB re-design while switching from Nano to Mini or vice versa
- Optimized power architecture for lowest power dissipation and improved operational times
- DCDC regulators proven in existing higher performance designs
- Optimized BOM – covering component tolerances, biasing degradations, thermal degradations and aging
- State-of-the-art single control button for power-on/-off and rest function
- Proven and approved design by SoC vendor (NXP)

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## Certified According to IATF 16949

SCHURTER Electronic Components s.r.l. production site in Ilfov, Romania, received the audit certificate according to the automotive standard IATF 16949:2016. This standard of the IATF (International Automotive Task Force) places the highest demands on the system and process quality of a company. The certification attests to the production of components and solutions at the highest quality level. The Automotive Standard IATF 16949:2016 represents one of the strictest and most demanding certifications. SCHURTER has taken this certification of the production site in Romania as a logical step to continuously improve itself. With the certification of the production of electrical circuit boards, entire systems can now also be offered according to IATF. This further development from component supplier to complete solution provider underlines the consistent company orientation.
SCHURTER's orientation towards IATF 16949 also serves all SCHURTER customers and is therefore not only important for automotive customers who can benefit from the improved processes.

**www.schurter.com**

## Pre-APEC Power Magnetics at High-Frequency Workshop

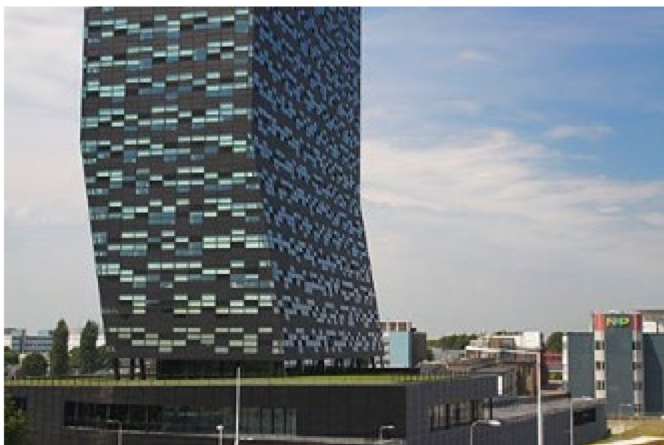
The Power Sources Manufacturers Association (PSMA) and the IEEE Power Electronics Society (IEEE PELS) are jointly sponsoring the fifth high-frequency magnetics workshop, “Power Magnetics @ High Frequency,” on Saturday, March 14, 2020. The workshop will be conducted on the day before and in the same venue as APEC 2020 at the Ernest N. Morial Convention Center in New Orleans, LA.
This day-long event will continue the focus on identifying the latest improvements in magnetic materials, coil (winding) design, construction and fabrication, evaluation and characterization techniques and modelling

and simulation tools to satisfy the technical expectations and requirements of higher application frequencies. This year’s workshop will address two specific issues of interest: improving models of power magnetic components based on characterization and performance data and associating then advantages of different winding techniques for different applications. The target audiences for this workshop include anyone working to achieve higher power densities, low profile aspect ratio, higher efficiencies and improved thermal performance. Continuing Education Units (CEUs) will be available to workshop attendees.
Previous workshops have completely sold out, so individuals interested in attending this year’s event are encouraged to register early.

**www.psma.com**

## New Ownership Opens Up Opportunities

Nexperia announced that Wingtech Technology – a Chinese computer and telecom equipment manufacturer – has officially obtained a controlling stake in Nexperia from Beijing Jianguang Asset Management Co. Ltd (JAC Capital). Headquartered in Nijmegen, Netherlands, Nexperia will stay an independent company, operating under Dutch law, and with the same management team, led by CEO Frans Scheper.



The new ownership comes as Nexperia is experiencing a very successful period, significantly out-performing the market, launching more new products and with an expanded manufacturing capacity of more than 90 billion parts annually. Automotive is a key industry from Nexperia, and the company is increasing its already-burgeoning portfolio of AEC Q100/101-qualified parts. The company also leads in the consumer, communications and industrial markets. It continues to innovate with compelling new products that are efficient in power, size and performance.
Comments CEO Frans Scheper: “Expanding our business in China has been one of our main goals since we launched in 2017. The change of ownership is another step that confirms we are on the right track and it will open up new opportunities for Nexperia, like 5G and related sectors. We have ambitious growth plans and will continue to invest to support both new technologies and expanded capacity at our worldwide facilities.”

**www.nexperia.com**

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## Advancing GaN in Electric Vehicles

GaN Systems announces that SPARX Group Mirai Creation Fund II has made an investment in GaN Systems. Mirai fund provides capital to companies with the goal of accelerating innovation, Vehicle Electrification being one of the major targets, to generate a "new power" that will shape the future and impact our world. The goals and principles of the fund align well as the automobile industry as a whole is shifting toward a "mobility company" in this once-in-a-century period of profound transformation. "The combination of confidence in our best-in-class device performance, the release of the industry's highest current rated devices, and our device reliability exceeding the AEC-Q101 automotive industry standards, has contributed to more and more automotive OEMs and Tier 1 companies investing in our company and using our devices," said Jim Witham, CEO for GaN Systems. "It's great to see so many automotive companies taking advantage of the benefits of our GaN as the industry shifts from internal combustion engines to Electric Vehicles." "After evaluating a variety of power semiconductor technologies and designs, GaN has emerged as a critical building block for power in automotive applications and our investment in GaN Systems complements our vision to shape the future and impact our world," said Shuhei Abe, President and CEO of SPARX Group.

**www.gan-systems.com**

## Joining Partner Program to Reduce Customer Time-to-Market

Innolectric announces that it has joined the STMicroelectronics Partner Program to leverage ST's innovative technology to make its products even more efficient and robust while increasing those products' visibility to ST's customers. In addition, within the ST Partner Program, both partners are collaborating on developing efficient power electronics with a view to the future. For example, the innolectric on-board charger supports vehicle charging internationally, according to current national standards. Beyond this flexible charging capability, charging options range from 22kW AC to over 350kW DC. This "One-Device-Solution" delivers above-average efficiency of >96% with good availability. innolectric products stand for performance and reliability.

Tim Karcher, CEO of innolectric AG, said: "For innolectric, the efficiency of our own products is decisive for the success of our customers. The ST Partner Program and close cooperation with STMicroelectronics enable our customers to rely on the most efficient technology for power electronics. In the future, we will continue to work with ST on the development of efficient power electronics to meet the growing demand for eMobility".

"The ST Partner Program helps customers' design teams access extra skills and resources to aid engineering development and shorten time-to-market for new products," said Alessandro Maloberti, Partner Ecosystem Director, STMicroelectronics. "By selecting, qualifying, and certifying our program partners, we are taking yet another major step in helping customers accelerate design and development, and ship to market the most robust and efficient products and services."

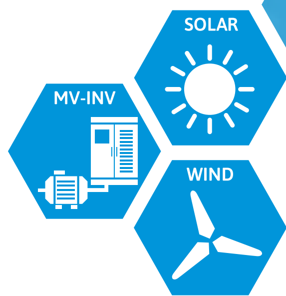
**www.innolectric.ag**

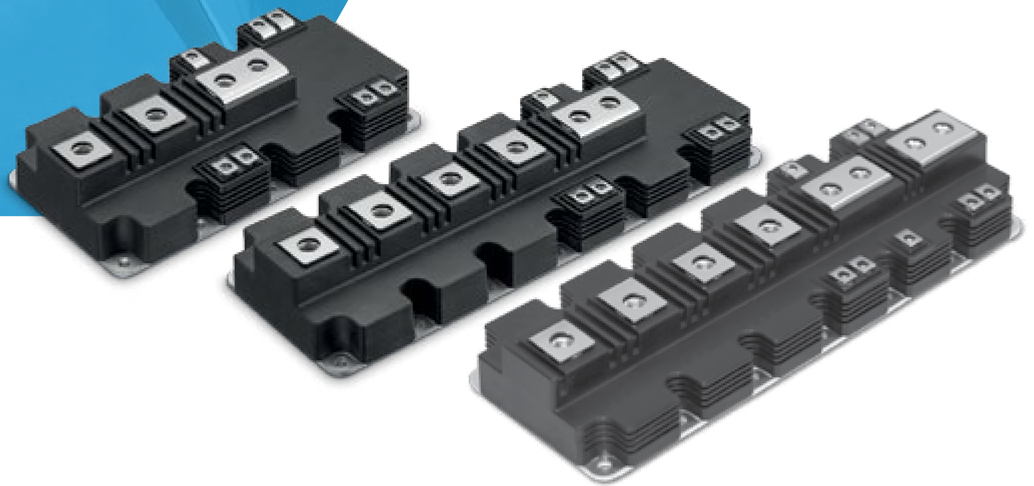
## Readout System for Large Arrays of Quantum Dots

Leti and its research partners have demonstrated a potentially scalable readout technique that could be fast enough for high-fidelity measurements in large arrays of quantum dots.

The international research team reported its work on developing a toolkit on a SOI MOSFET-based prototyping platform that enables fast reading of the states of charge and spin. The study explored two gate-based reflectometry readout systems for probing charge and spin states in linear arrangements of MOS split-gate-defined arrays of quantum dots. The first system gives the exact number of charges entering the array and can help to initialize it. It can also read spin states, albeit in relatively small arrays. The second one gives the spin state in any quantum dot regardless of the array length, but is not useful for tracking charge number. Both readout schemes can be used complementarily in large arrays. The study's findings "bear significance for fast, high-fidelity, single-shot readout of large arrays of foundry-compatible Si MOS spin qubits," the paper notes. "The short-term efforts for our team going forward will be a joint optimization to increase speed and reliability of the readouts," said CEA-Leti's Louis Hutin, lead author on the paper. "The longer-term goal is to transfer this know-how on a larger scale and to less conventional architectures, featuring an optimized topology for error correction."

**www.leti-cea.com**



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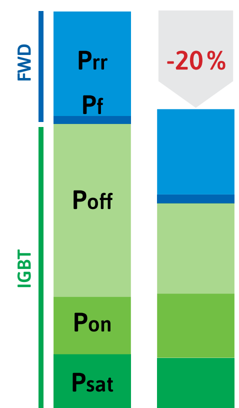



PrimePACK™ is registered trademark of Infineon Technologies AG, Germany.

## IC Design Center on All About Circuits

EETech is pleased to unveil the newest addition to All About Circuits (AAC), the IC Design Center for IP Cores. This IC Design Center comes on the heels of AAC's recent redesign and will provide new, in-depth resources for IC Design experts and novices alike. Recognizing that IC design information is often challenging without widely available technical resources, EETech looked to the experts to bring this industry-leading IC Design Center to life.
"Expanding to IC design has allowed us to work with specialists in the field to provide

engineers with high-level, extremely accurate information built by their peers," says Kate Smith, Director of Digital Content for EETech. "With their help, we have created an accessible, comprehensive, and in-depth repository of information for IC designers."

The IC Design Center provides up-to-date, open-source technical content, design tools, and more that will speak to engineers at any level of IC design. With the support of AAC's strong EE community, the addition of the IC Design Center continues to fulfill the needs of engineers looking to expand their IC design knowledge. In addition to content, designers will also have access to a vast open-source library of IP cores to aid in the IC design process.

**www.eetech.com**

## ECPE Events

**ECPE Tutorial 'Drivers and Control Circuitry for IGBTs and MOSFETs'**
18 - 19 February 2020, Barcelona, Spain

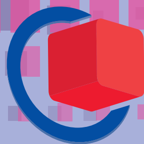
**ECPE Workshop 'Magnetic Components in Power Electronics'** - draft programme published!
19 - 20 February 2020, Grenoble, France

**ECPE Tutorial 'EMC in Power Electronics'**
- further information published soon
22 - 23 June 2020, Eindhoven, Netherlands

**CIPS 2020**
in conjunction with ECPE Annual Event
24 - 26 March 2020, Berlin, Germany

**www.ecpe.org**


Nuremberg, Germany
25–27.2.2020



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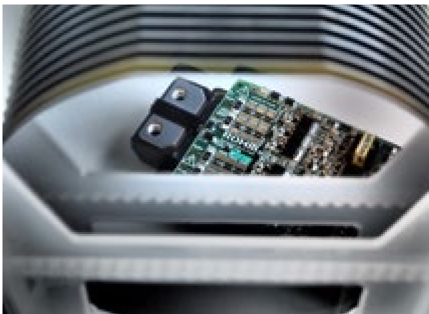
NÜRNBERG MESSE

# Multi-Year Silicon Carbide Wafer Supply Agreement

SiCrystal

A ROHM Group Company

ROHM and STMicroelectronics announced it signed a multi-year silicon carbide (SiC) wafers supply agreement with SiCrystal, a ROHM group company having a top share of SiC wafers in Europe. The agreement governs the supply of over 120 million dollars of advanced 150mm silicon carbide wafers by SiCrystal to STMicroelectronics during this period of demand ramp-up for silicon carbide power devices. "This additional long-term SiC substrate supply agreement comes on top of the external capacity we have already secured and the internal capacity we are ramping. It will enable ST to increase the volume and balance of the wafers we will need to meet the strong demand ramp-up from customers for automotive and industrial programs over the next years", said Jean-Marc Chery, President and CEO of STMicroelectronics.



"SiCrystal is a group company of ROHM and has been manufacturing SiC wafers for many years. We are very pleased to enter into this supply agreement with our longstanding customer ST. We will continue to support our partner to expand silicon carbide business by ramping up wafer quantities continuously and by providing reliable quality at all times", said Dr. Robert Eckstein, President and CEO of SiCrystal, a ROHM group company.
The adoption of power solutions with SiCs is accelerating in both the automotive and industrial markets. With this agreement, the two companies will contribute to the widespread use of SiC in these markets.

www.sycristal.de

# A Very Special Symbiosis: SMSI Conference and SENSOR+TEST 2020

The success story of the scientific conferences in the area of sensor and measuring technology in conjunction with the SENSOR+TEST goes back over thirty years. From the 22 to the 25 of June, 2020, the next step is being taken with the SMSI 2020 – Sensor and Measurement Science International. Researchers, developers, and specialists from all over the world especially appreciate the symbiosis with the parallel trade fair at which they can continue the innovation dialog.

The worldwide leading forum for sensor, measuring, and testing technology, SENSOR+TEST (www.sensor-test.com) has been accompanied for many years by diverse, first-rate conferences. Examples are the AMA Conferences SENSOR and IRS2, the Fachtagung Sensoren und Messsysteme-, as well as the etc, the European Test and Telemetry Conference. Besides the exciting talks on research and development, what the many participants appreciate is the proximity to the parallel trade fair. This is where they can see and experience important novelties and developments at live demonstrations, have an innovation dialog with the experts, and initiate new partnerships.
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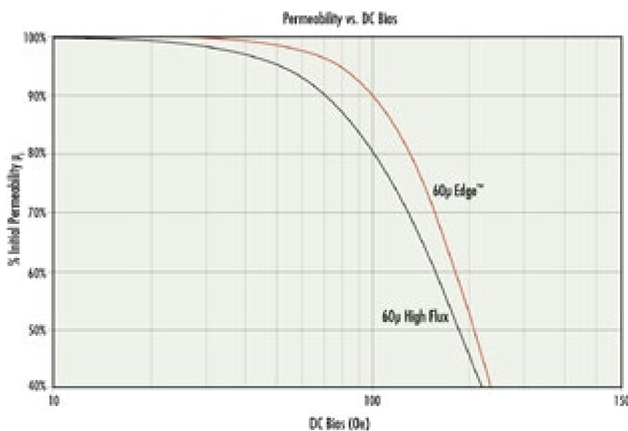


*Figure 1: Edge permeability vs DC bias comparison*

The inherent advantage of powder alloy cores is their DC bias performance, meaning how well the material maintains inductance under current loading. For high current inductor applications, High Flux has often been the design solution that gives the smallest package size since it offers the best DC bias performance with the highest saturation level. Magnetics' Edge boosts that saturation level even higher. For comparison, 60 permeability Edge reaches 50% rolloff at 205 Oersteds, vs. 185-195 Oersteds for best-in-class high flux materials, and 165 Oersteds for 6.5% Silicon Iron powder cores. Not only that, but the performance tradeoff that designers had to accept when using High Flux – inferior AC losses – is removed, because Edge core losses are reduced to a level similar with MPP (molypermalloy powder).

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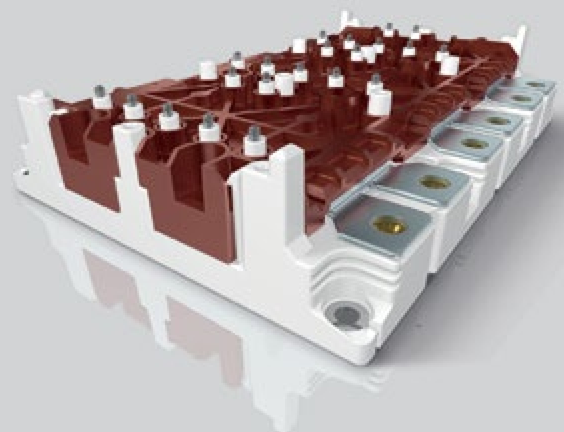

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# SiC Based Totem Pole PFC for Industrial Power Supplies

*For industrial power supplies, energy efficiency is a key product feature since any energy, which is not delivered to the load but is converted to waste heat, is a direct cost factor in system operation. In addition, any waste heat from inefficient energy conversion results in additional demands on the air conditioning system.*

*By Christian Felgemacher and Aly Mashaly, ROHM Semiconductor GmbH*

One particular area that is characterised by high energy demands and a need for high efficiency power supplies are data centres. To minimise the cost and the ecological footprint of the higher and higher demand for computing infrastructure power very efficient energy conversion systems are of essence here. The SiC based Totem Pole PFC discussed in this article can play a role in addressing this challenge.

**Introduction**

Electric power transmission in the power grid uses alternating current (AC) to supply energy from the power generators to the loads. However, many modern electronic loads such as computer processors require direct current (DC) to operate. Therefore, a power supply unit (PSU) at the input of most modern electronic loads converts the available AC to DC. Additionally, such a PSU converts the voltage to a level suitable for distribution in the system to drive the final loads. In many cases, the DC-to-DC conversion stage also implements galvanic isolation to provide protection. If the power required by the system is low (typically no more than 3.6 kW) the input is single phase AC with a voltage of between 85 and 265 V and a frequency of 50 or 60 Hz depending on the region in the world. The general structure of a single-phase power supply unit is illustrated in Figure 1.

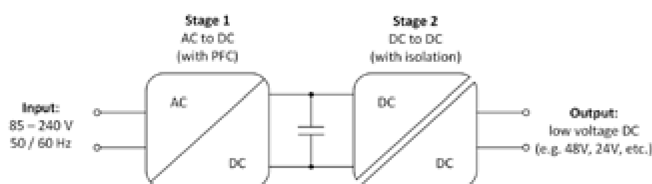


*Figure 1:*
*General high-level structure of a single-phase power supply unit*

To achieve the highest efficiency level certification of 80 Plus Titanium a redundant power supply needs to reach at least 96% efficiency at 50% of its nominal load with 230V input voltage. Additionally, targets for 10%, 20% and 100% load as well as 115V input voltage also have to be met. If an efficiency of 98% is assumed for the DC-to-DC stage of the PSU, as can be expected if a soft-switching converter is implemented, the AC-to-DC stage also needs to achieve at least 98% at half load to reach the overall target of 96% for 80 Plus Titanium.

**Topologies for AC to DC conversion with power factor correction**

In this article, the focus is on the AC-to-DC stage with power factor correction. Multiple circuit topologies exist for this part of the power supply unit. Some of the common options are shown in Figure 2. The classical and probably simplest topology for realising a single-phase PFC stage is the Boost PFC topology. Here a low frequency diode rectifier is combined with a standard boost converter usually comprised of a SJ MOSFET and a SiC SBD. The gate-driving of the SJ MOSFET is controlled in order to draw a sinusoidal current from the AC supply. For larger power (e.g. 3.6 kW) a common approach is to realise the booster in an interleaved version consisting of two inductors, two SiC SBDs and two SJ MOSFETs. In this way, a high efficiency and suitable output powers can be realised. One limitation of this topology is the conduction loss of the low-frequency rectifier bridge. This limits the achievable maximum efficiency of the classical boost PFC.

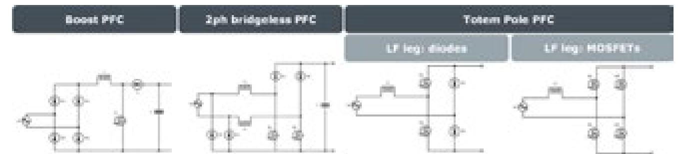


*Figure 2: common topologies for single-phase PFC*

Alternative topologies such as the two phase bridgeless PFC and the Totem Pole PFC avoid the low frequency input rectifier and thus can reach higher efficiencies. While good performance can be achieved with the two phase bridgeless PFC topology, the main disadvantage is that either bridge-leg is only utilised during half of the grid period. This results in a high cycling load and poor utilisation of the components.

The two variants of the Totem Pole PFC shown in Figure 2 are an alternative that gains more and more appeal with the availability of wide-band-gap devices such as SiC MOSFETs. While the topology is already widely described in literature its practical use was limited to low power using SJ MOSFETS because the body-diode performance of these devices did not permit operation in continuous-current-mode (CCM). To avoid the hard commutation of the high loss body-diodes in SJ MOSFETs this circuit needs to be operated in discontinuous-current-mode (DCM) which results in large ripple current.

Modern wide-bandgap power semiconductors such as SiC MOSFETs as well as GaN HEMTs now enable the Totem Pole PFC to be operated with low ripple currents in CCM. This is possible, because the body-diodes of the SiC MOSFETs are suitable for hard commutation and only have low reverse recovers losses.

**Details of Totem Pole PFC operation**

To operate a Totem Pole PFC in continuous-current-mode (CCM) two high-frequency power semiconductor switches with high performance body-diodes are required. These are denoted Q1 and Q2 in Figure 3. SiC MOSFETs can be used for Q1 and Q2 very effectively. For the

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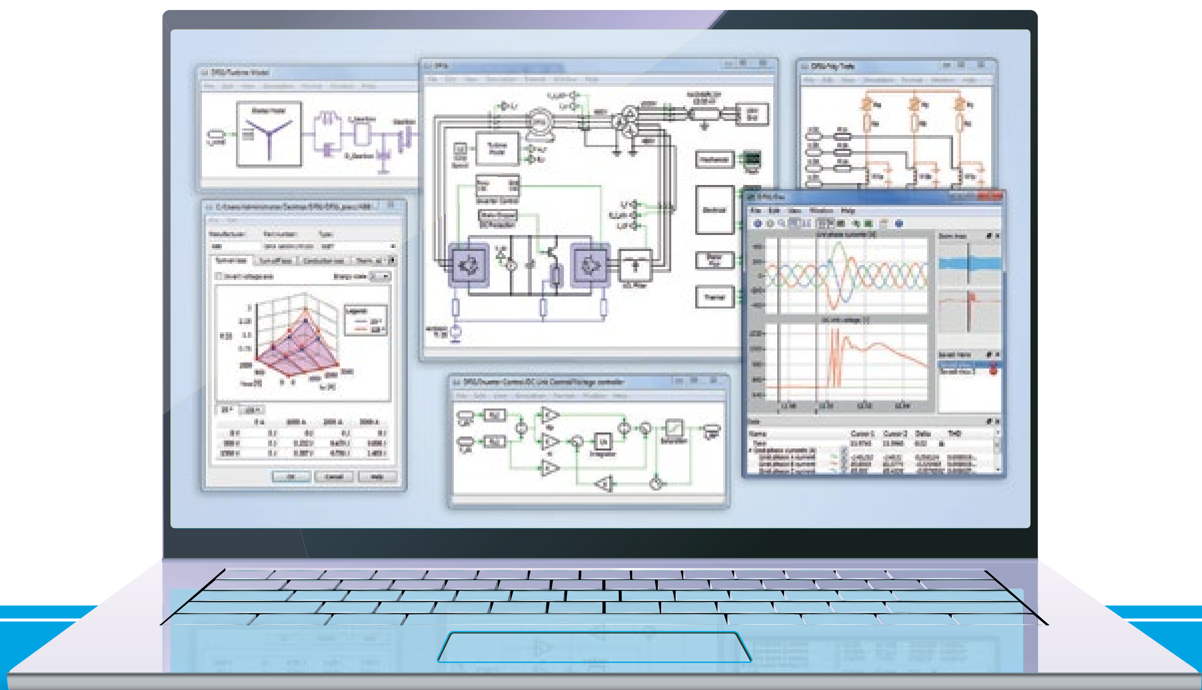

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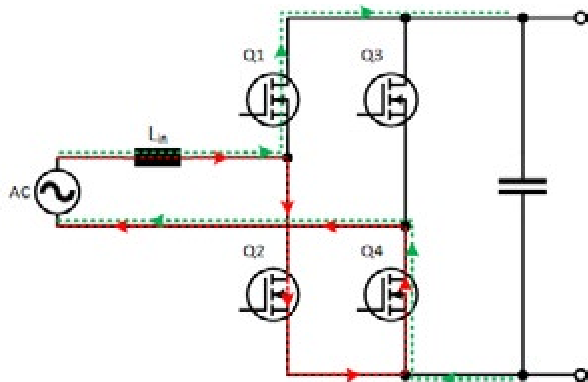
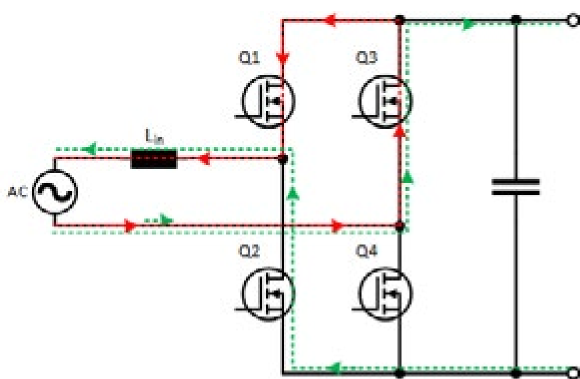
two switches operated at grid frequency (Q3 and Q4 in Figure 3) no high-performance body-diode is required and Si SJ MOSFETs can be used here. For a more cost-optimised design with slightly lower performance, it is possible to replace Q3 and Q4 with diodes.




*a) Positive half-wave*




*a) Negative half-wave*

*Figure 3: Current paths in Totem Pole PFC. Red: Current path to charge inductor, Green: freewheeling path*

In this topology, the Si SJ MOSFETs are switched with grid frequency. In the positive half-wave Q4 is permanently on, as indicated in Figure 3 a). While the primary boost-switch Q2 is on the current rises in the input inductor $L_{in}$. In this phase, the load is supplied from the DC link capacitor. At turn-off of Q2 the current commutates to the body-diode of Q1. After a short dead-time the gate of Q1 is turned on and the channel of the SiC MOSFET takes over the current (synchronous rectification). The idealised currents, along with the gate signals, for Q1 and Q2 during the positive half-wave are illustrated in Figure 4.

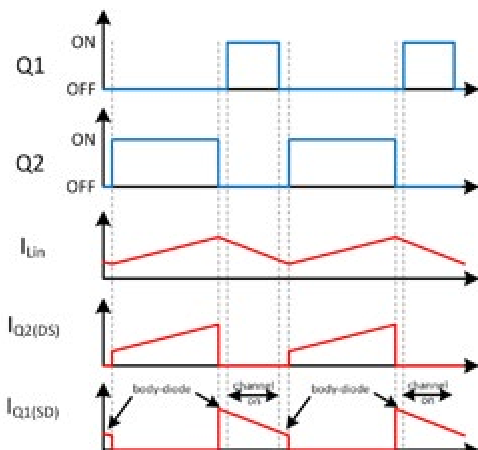



*Figure 4: Idealised currents and gate signals for Q1 and Q2*

In the negative half-wave of the input voltage the switches Q1 and Q2 interchange their function as primary switch and synchronous rectifier. Additionally, the current flows through Q3 in this half-wave while Q4 remains off. The current paths in the negative half-wave are shown in Figure 3 b).

The operation description shows that the body-diodes of the SiC MOSFETs are hard commutating. However, this is not problematic in SiC MOSFETs as the body diode reverse recovery loss is very low.

**Demonstrator for 3.6 kW Totem Pole PFC**

In order to illustrate the performance of a Totem Pole PFC based on SiC MOSFETs a demonstrator for the following specification was designed.

| | |
|---|---|
| Input voltage | 85 to 265 V, 50 Hz |
| Output voltage | 400 V |
| Maximum output power | 3600 W at $V_{in}$ = 230 V |
| Switching frequency | 100 kHz |

Figure 5 contains a photo of a demonstrator designed to these specifications. Size and compactness were no key design targets for this set-up, as the main objective was accessibility to key components of the converter for easy testing. In the test set-up 650V 60mΩ SiC Trench MOSFETs (SCT3060AR) in a TO-247-4L package are used as the high-frequency switches (Q1 / Q2 in Figure 3) alongside 600V 60mΩ Si SJ MOSFETs (R6047ENZ4) for the leg which operates at grid frequency. With the 60mΩ SiC MOSFET a good compromise between switching and conduction loss is reached for the selected switching frequency and the specified maximum output power. Further efficiency gains could be reached by replacing the line-frequency operated SJ MOSFETs with lower $R_{DS(on)}$ types, as switching loss for these components is not relevant.

For gate-driving of the SiC MOSFETs the isolated gate-driver BM61S41RFV is used for both high-side and low-side to take full advantage of the driving-sense pin of the TO-247-4L. For driving the Si SJ MOSFETs a 2 channel gate-driver IC (BM60212FV-C) is used and boot-strap supply of the high-side is realised.

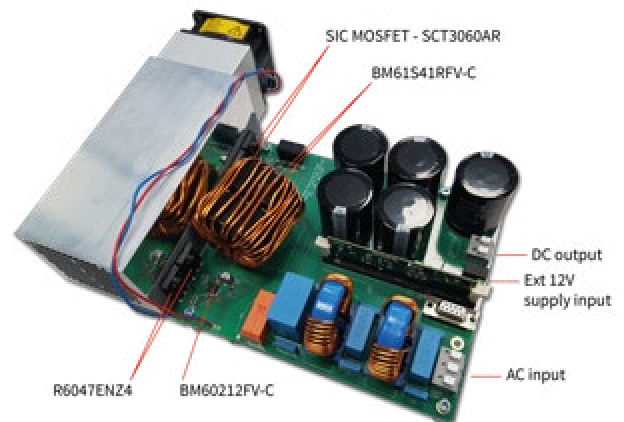



*Figure 5: Demonstrator for 3.6 kW Totem Pole PFC*

**Experimental Results for SiC based Totem Pole PFC**

Using the mentioned demonstrator measurements were performed at up to 3.6 kW output power. The measured efficiency across the output power range for low-line ($V_{in}$ = 110 V) and high-line ($V_{in}$ = 230 V) is shown in Figure 6. At high-line input, a peak efficiency of 98.5% was reached and between ca. 500 W and full load the efficiency remains above 98%.

During testing the case temperature of the power devices was monitored using infrared thermography. The result in Figure 7 shows that upon reaching full output power the case temperature of the devices reached approximately 100°C at an ambient temperature of 25°C. Loss reduction measures and improvements in the cooling path can help to ensure thermal stability also at increase ambient temperature.

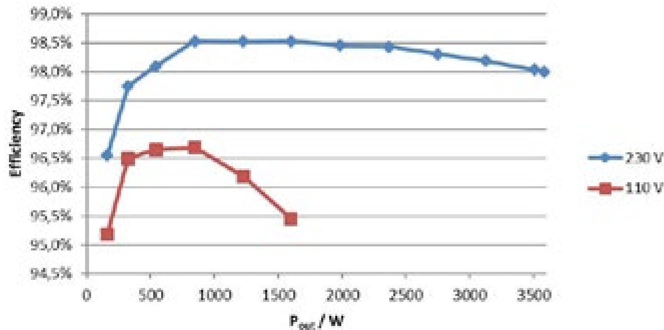



*Figure 6: Measured efficiency for Totem Pole PFC Demonstrator ($V_{out}$ = 400 V, $f_{SW}$ = 100 kHz, SCT3060AR, R6047ENZ4)*

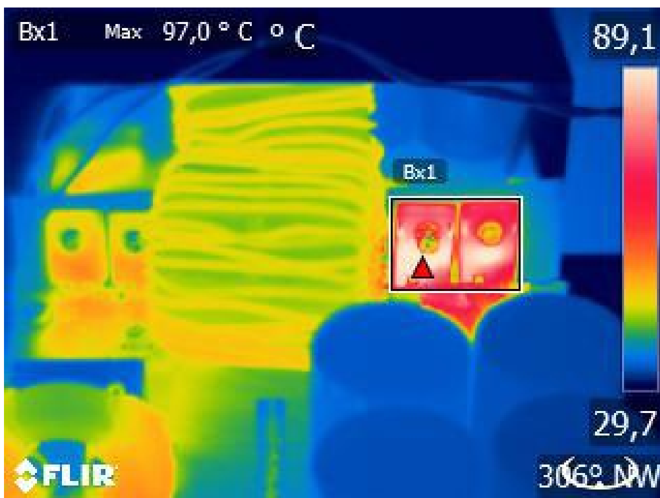



*Figure 7: Thermal measurement of semiconductor case temperatures ($V_{in}$ = 230V, $V_{out}$=400V, $f_{SW}$ = 100 kHz)*

As can be seen from the measurement results a Totem Pole PFC using SiC MOSFETs and Si SJ MOSFETs can be a performant solution for a 3.6 kW AC-to-DC stage of a power supply unit. The achieved efficiency is sufficient, even at 100 kHz switching frequency, in order to achieve 80 Plus Titanium certification for a power supply provided a DC-to-DC stage of an efficiency in the region upwards of 98% is also used.

**Summary**

For many kinds of power supplies, a high efficiency is a key requirement. Especially for power supplies for computer systems, clear requirements need to be met to obtain certain energy efficiency labels. The limitation of traditional AC to DC conversion topologies is the diode bridge rectifier at the input. The conduction loss in these diodes can limit the achievable overall efficiency. The Totem Pole PFC shown here is a very promising alternative topology to overcome this limitation. It was shown that efficiencies of significantly above 98% can be reached using commercially available SiC MOSFETs and Si SJ MOSFETs from ROHM Semiconductor.

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# Smart Solutions for the Next Generation of Power Electronics Systems

*The XHP™ 2 package from Infineon Technologies AG is designed for future-oriented power electronics systems. It addresses the needs for scalable and low inductive inverter designs and can handle blocking voltages up to 3.3 kV.*

*By Karsten Schoo and Wilhelm Rusche, Infineon Technologies*

**Technical concept**

The existing XHP™ 3 has been designed for blocking voltages from 3.3 kV up to 6.5 kV addressing new designs in traction applications. As an additional member of the XHP™ package family, the 1700 V XHP™ 2 has recently been introduced. In Figure 1 the XHP™2 package and the half-bridge topology is depicted.

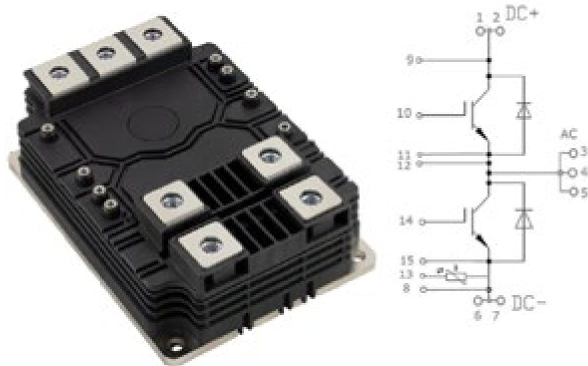


*Figure 1: Typical appearance of XHP™2 from Infineon Technologies AG*

The fleXible High power Platform XHP™ has been developed for applications like traction converters, renewable energy, and industrial drives [1]. To support this future orientation, three AC power terminals have been embedded to ensure high current carrying capabilities, and to minimize the losses in the power connection that are to be consumed by the application design.

The 1700 V XHP 2 module generation makes use of the latest and most rugged 5$^{th}$ generation IGBT and emitter-controlled diode from Infineon Technologies with its .XT joining technology [2, 3]. This combination makes the power device extremely robust against cycling loads [4].

Employing the state-of-the-art 5$^{th}$ generation IGBT and diode technologies from, the maximum module current for the 1700 V XHP 2 has now been further increased up to 1800 A / 1700 V with a continuous junction operating temperature $T_{vj,op}$, of 175°C. In addition to the 1800 A version, an XHP 2 with 1200 A / 1700 V will also be available.

The 5$^{th}$ generation of the IGBT and the diode have demonstrated their ruggedness in the PrimePACK™ module. In the XHP the size of the diode and the IGBT are well-balanced ensuring a sufficient lifetime of the diode in a traction mission profile. This provides optimal performance in traction but also in wind turbine applications.

Similar to the XHP 3, the XHP 2 features a strip line concept inside the module. This ensures very low inductivity in the DC bus bar. As the DC connection is located at the center of the module, a symmetrical design has been implemented. The resulting inductance of the power module of less than $L_s$≤10nH in the commutation loop results in a small overvoltage peak. In Figure 2, an example of a turn-off event of the 1700 V XHP 2 with $I_C$=1800 A at $U_{DC}$=900 V and room temperature is depicted. The measurement shows an overvoltage of only $\Delta U_{CE_Peak}$=320 V under these conditions.

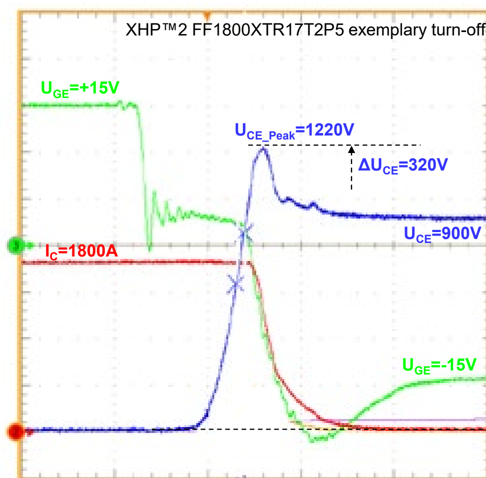


*Figure 2: Example of turn-off event at IC=1800 A; 900 V and room temperature*

With the smart combination of features such as package platform, highest power density, rugged .XT joining technology and excellent cycling capabilities as well as balanced 5$^{th}$ generation chip sizes, the XHP 2 package from Infineon Technologies AG addresses the needs of the next generation of propulsion converters in urban transportation systems [5].

**Performance under heavy cycling conditions**

While driving or accelerating the vehicle, the energy in the converter is conducted mainly by the IGBTs. When the vehicle brakes, the freewheeling diodes (FWD) of the converter have to conduct the generated reverse energy. A simple schematic of the electrical propulsion system is shown in Figure 3.

A typical tram stops after a few 100 meters, while a metro or subway stops at a typical distance of 1000 meters. These short distances in

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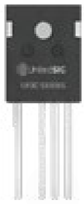

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day-to-day operation result in an enormous stress. In particular, the power modules with their IGBTs and diodes in the electronics circuits of the converter have to withstand heavy electrical and mechanical stress and enormous cyclic thermal stress in daily operation. Figure 4 shows an example of the deployment profile of an electric drive system of a subway.

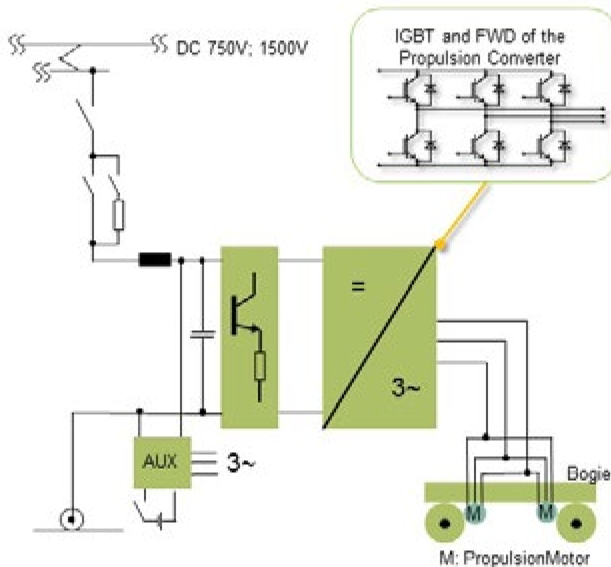


*Figure 3: Schematic of electrical propulsion system*

The major criterion for the long-term reliability or required lifetime of power modules is the capability to withstand these cycled thermal loads. The dominant end-of-life (EOL) mechanisms for standard joining technologies in such demanding applications include solder degradation and the lift-off of the aluminum-bond wires of the chip-joining connection. These die interconnections are highly stressed by the relative temperature swing ∆T at the resulting junction operating temperature $T_{vj,op}$ as well as by the duration of the thermal stress (ton).

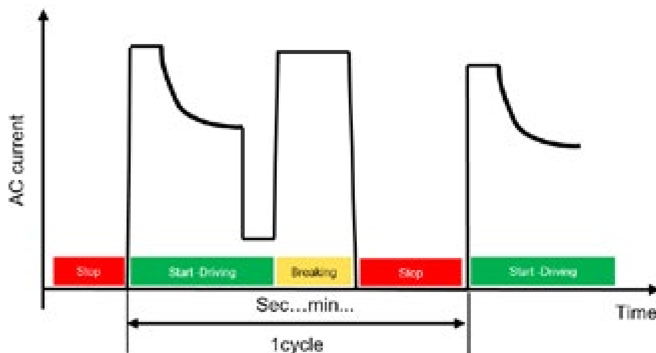


*Figure 4: Generic metro mission profile*

Owing to these challenging requirements, the power modules used nowadays are typically oversized. The modules are either bigger than required, or smaller ones are used in parallel to reduce the thermal loads and fulfill the high lifetime demands. As a consequence, IGBT modules in typical traction inverters are operated with junction temperatures significantly lower than the specified maximum temperatures. Thus, the full potential in terms of current density is not utilized.

To achieve smarter, tailor-made solutions in the power converter, the typical end of life mechanisms must be significantly improved or even eliminated to extend the running times. If the end of life can be extended, the current derating due to lifetime constraints can be reduced, and the RMS current can be increased. To quantify this effect, an XHP with IGBT5 and .XT has been compared to an IHM module with IGBT4 and standard joining technologies. Figure 5 depicts the simplified result of a lifetime comparison using a metro mission profile. For the implementation of a 30-year lifetime, two 1700 V IGBT4 IHM modules in parallel are required. Using IGBT5 and .XT in XHP 2, only one 1200 A/1800 A 1700 V XHP 2 module can achieve a similar lifetime.

Urban propulsion converter designs based on XHP 2 modules will benefit from the significant advantages of using Infineon Technologies AG new XHP 2 equipped with the 1700 V IGBT5/.XT. Among other things, power density can be increased drastically using the new technologies.

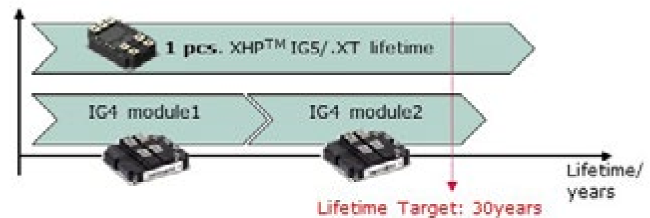


*Figure 5: Simplified lifetime estimation based on a metro mission profile in an air-cooled propulsion system*

**Summary**

Infineon Technologies AG has introduced a new XHP 2 with IGBT 5 and .XT. This combination provides system designers with the option of developing future-proof, scalable, low inductive systems with highest power density. Moreover, traction inverters can be harmonized with the XHP across various vehicle platforms and voltage classes. The field-proven IGBT5 and .XT technology is a key lever for increasing power density in applications, which demand long life cycles such as traction. The technology enables significant weight and volume reductions, and consequently, a reduction of system costs.

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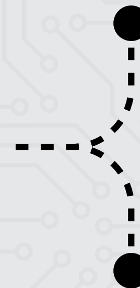

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# Scalability of SiC Near Chip-Scale Packages to Electric Vehicle & Locomotive Traction

## *µMaxPak packaging enables full SiC performance, efficiency & speed at high currents & voltages for traction applications*

*I shared with you previously that power WBG/SiC devices traditionally packaged in bulky DBC modules can be replaced with Near Chip-Scale SMD packages. The replacement is enabled by the WBG device's smaller die size (higher power density) and its higher efficiency. Near Chip-Scale packages like the µMaxPak can reduce package sizes & parasitics, enabling SiC devices to operate at their full performance, efficiency & speed.*

*By Courtney Furnival, Semiconductor Packaging Solutions, Lake Arrowhead, California*

These devices further enable higher density planar systems with enhanced system performance & efficiency. Power µMaxPak devices can be fully pre-tested before system assembly, reducing compound-yield losses and assembly costs. The µMaxPak is a proprietary power QFN package, using automated low cost QFN assembly technology, increasing throughput, and further reducing manufacturing cost. The requirements for µMaxPak type packages are explained in my July 2018 Bodo's Power Systems article, "Inevitability of Near Chip Scale SMD Packaging for Power GaN & SiC."

I am delighted to announce that SiC switches in µMaxPak Near Chip-Scale packages can power heavy-industrial equipment, and EV and locomotive traction. µMaxPak switches are described below with cross-sections of examples in Figures 1, 2 & 3. The higher power products are very thin, so thicknesses are not to scale and have been exaggerated to show key structural features.

**First Focus was on Light-Industrial Power Switches:**
The µMaxPak initial focus was up to 650V/400A & 1200V/200A industrial switches. Maximum die size was limited for solderability directly to power PCBs, DBC substrates, or even heavy copper leadframes, thereby limiting the maximum current. Initial µMaxPak designs, Types I & II, brought all thermal & electrical connections from the top & bottom of the SiC die to the bottom of the SMD packages. They accommodated both lateral GaN and vertical SiC die. Near Chip-Scale SMDs are a significantly advanced alternative to DBC Modules used to package 600-1200V IGBT switches. These modules were bulky, slow & expensive, and although their huge parasitics were acceptable for silicon power devices, they greatly limit the performance of power WBG (GaN & SiC) devices. Figure 1 shows the basic structure of the Industrial µMaxPak a) high-side, b) low-side & c) half-bridge switches.

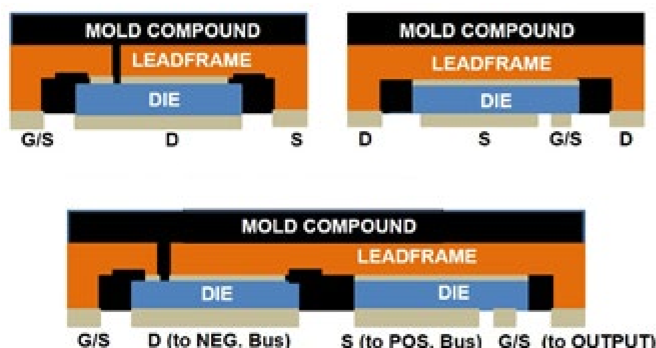


*Figure 1: Light-Industrial SiC 600-1200V µMaxPak Cross-Sections*
*Top/left: high-side switch Top/right: low-side switch*
*Bottom: half-bridge switches*

For Type I & II µMaxPak SMD packages, the pad area on the package bottom limits the available space and maximum current, and the available pad spacing limits the maximum voltage. As the new Type III µMaxPak's with top & bottom pads evolve, they can be used to extend the current range for industrial 600V-1200V products. It is advantageous for light-industrial µMaxPak to have all bottom-side pads for standard SMD assembly processes.

**Scalability to Electric Vehicle (EV) Traction Higher Currents:**
Type III or Thin µMaxPaks eliminate the over-molding on the top-side of the package, enabling electrical & thermal pads on both the bottom & top sides, which can accommodate higher currents like 750A & higher. The molding operation is essentially a filling of open spaces in the double-sided etched leadframe. This molding operation requires the leadframe & mold to be designed for molding compound fill & flow. The double-sided pads of the Type III µMaxPak also require both sides to be deflashed & plated.

Type III µMaxPak packages require vertical WBG die like the SiC MOSFET with drain (D) on one side and source/gate (S/G) on the opposite sides. (Today's lateral GaN on SiC substrates can be used if the D is brought to the back/opposite side of the die with via.) Larger top & bottom pads accommodate higher current for 600V-1200V EV Traction switches. Figure 2 shows the basic structure of the EV µMaxPak a) high-side (HS) & b) low-side (LS) switches.

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The higher EV currents increase the required die size, necessitating the µMaxPak can be soldered only to DBC substrate isolators to minimize the CTE expansion mismatch to the exposed bottom-side die. These substrates must provide the lowest thermal resistance with high-voltage isolation.

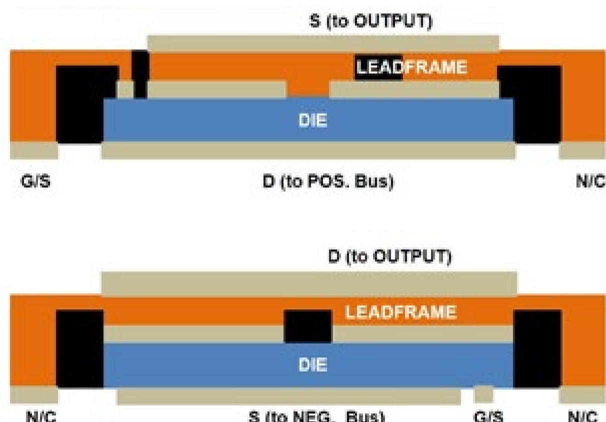


*Figure 2: EV Traction 650-1200V SiC µMaxPak Cross-Sections*
*Top: high-side switch Bottom: low-side switch*

The top of HS & LS µMaxPak switches will be soldered to an output bus, which again has CTE mismatch issues between the exposed SiC die and the copper output bus. Therefore, the high current contacts require multiple pads with stress relief features between the pads. Stress relief can be achieved with multiple thin and narrow connectors, and C-bends.

A secondary forming or coining operation to the etched leadframe strips can create both stress-relief & HV clearance features. This operation enables the one-piece power QFN leadframe, which is a key feature of the µMaxPak cavity architecture described in U. S. patent 9,214,416.

Higher power Near Chip-Scale packages with power-pads on both top & bottom are built using fundamental QFN technology and proprietary µMaxPak cavity architectures. However, leadframe designs require enhanced molding compound flow & locking features with thinner packages. The basic concepts for higher current SiC µMaxPak traction switch configurations are shown in Figure 2 a & b.

**Scalability to HV Locomotive Traction Higher Currents & Voltages:**
The Locomotive Traction switches are also TYPE III µMaxPak with both top & bottom external pads to accommodate the large die & high currents. The Locomotive traction also requires even higher voltage capabilities like 3.3kV-6.5kV. Although the Locomotive µMaxPak leadframe strips contain the same proprietary bottom-side cavities for the SiC die, the walls of the cavities are removed after molding during the QFN singulation operation. This singulation operation conveniently leaves the high-voltage drain on one side of the package, and the low-voltage source & gate on the opposite side. This can provide pollution degree 1 minimum creepage paths on the outside of the µMaxPak package when potted or coated in the Power-Train system.

Within the µMaxPak, the high-voltage drain on the die edge approaches the low voltage G/S plane on the opposite side of the die. So, isolation requires thicker molding compound between the HV die edge on the G/S side and the soldered leadframe or DBC copper pads. This is accomplished in the HS switch by deeper leadframe coining or forming. On the LS switch, the G/S leads are soldered to the bottom-side DBC copper pads, so the die edge must be separated by raising the die with solder and plating to increase separation. The separation is filled with both package molding compound and below the package with the system potting material. Details can be seen in Figures 3a & 3b.

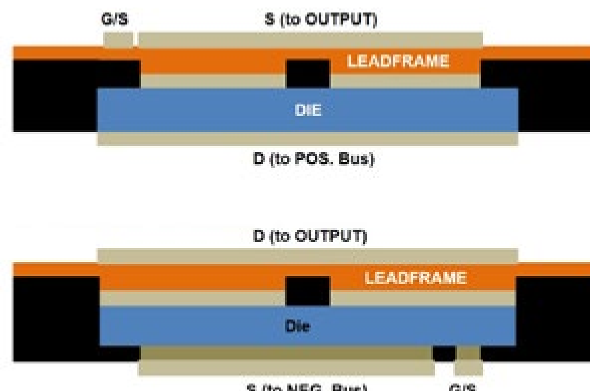


*Figure 3: Locomotive Traction SiC µMaxPak Cross-Sections*
*Top: high-side switch Bottom: low-side switch*

The scalability of µMaxPak to currents like 1000A and voltages of 3.3kV & higher are required for power Locomotive traction applications. The EV & Locomotive applications are in urgent need of such power SiC device performance & efficiency today, and the µMaxPak enables the SiC to provide their full inherent performance & efficiency.

**µMaxPak Images & Perspective**
The µMaxPak Near Chip-Scale SMD packages are typically about 1mm thick, and only slightly larger than the total power die area. See 3-D View of a µMaxPak Single-Switch ( SS) & Half-Bridge (HB) below. Figure 4a shows the top of an HS-SS µMaxPak with a SiC MOSFET & diode die, and Figure 4b shows the top of an HB µMaxPak with a MOSFET & diode die in both HS & LS switches. The HS-SS can be flipped over to become the LS-SS with anode (A) & drain (D) pads at top.

A size perspective for a 3.3kV 750A SiC µMaxPak single-switch is illustrated in Figure 4c relative to a typical credit card. This is an excellent comparison since both the µMaxPak package and credit card are about 1 mm thick.

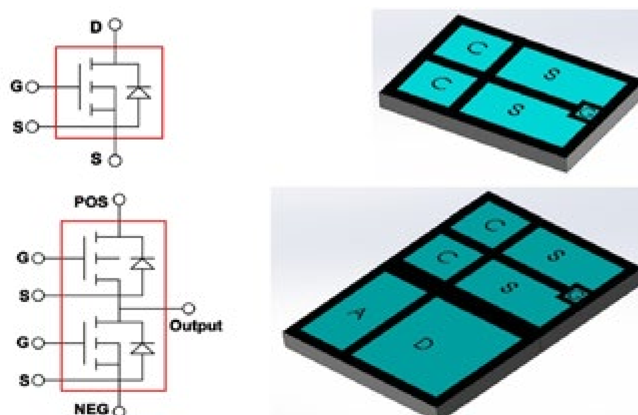


*Figure 4: EV µMaxPak Switch & Half-Bridge Illustrations*
*Top: Hi-Side SS Co-Pak*
*Bottom: Hi-Side & Lo-Side Half-Bridge Co-Pak*

**Using the µMaxPak SiC Switches for EV & Locomotive Traction:**
The EV and Locomotive traction Power-Train or Motor-Drive architecture must and should evolve to enable full SiC performance, efficiency & speeds. It does no good to eliminate the wire bonds, leads & terminals of the obsolete IGBT DBC modules, if you put all that

inductance back in the Power-Train structure & internal connections. The Near Chip-Scale SMD packages virtually eliminate the switch package parasitics and nearly maintained the unpackaged die power density. They provide pre-tested & yielded switches with multiple die (MOSFETs & diodes), which can be handled and assembled without damaging.

*Figure 4c: Locomotive 3.3kV_750 A SiC µMaxPak Switch*

The Power-Train Inverter can now be a planar SMD assembly, again with no bulky terminals and minimal interconnects. Furthermore, planar leads can also provide inductance canceling. Ideally, all other power components can eliminate or minimize interconnects and only uses terminals to exit the Drive System. Designing Drive System structure is beyond the scope of this article. The focus herein is limited to illustrating SMD/Planar Three-Phase Inverters using µMaxPak SMD packaged switches. The Inverter example addresses µMaxPak electrical & thermal interface issues, and it demonstrates how other power Drive components can be simplified for overall system higher power density, performance, and efficiency in the future.

See Figure 5, a Planar/SMD Inverter with Six µMaxPak Switches, on a bottom side cold-plate. The Three output busses are shown as copper strips soldered to each of the three HS & LS pairs of switches. This approach is simple and easy to visualize, but this configuration only takes heat from the bottom side of the µMaxPak switches. It is possible also to remove heat from the three output busses, if they are made using DBC substrates for isolation. This configuration increases SiC cooling and performance, but may also increase electrical & thermal interconnect complexity.

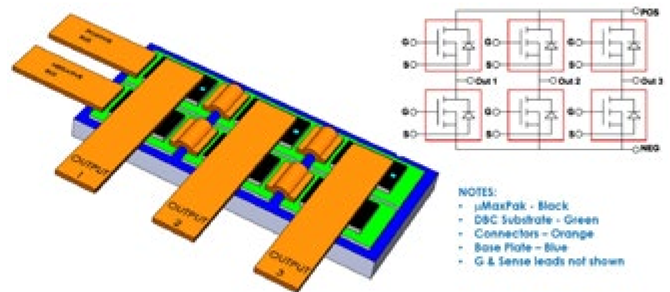


*Figure 5: Illustration of a Planar/SMD EV Inverter with Six µMaxPak Switches*

Although the µMaxPak packages are driven by the performance, efficiency & speed of the SiC switches, they also make extreme reductions to EV & Locomotive Drive size, weight & cooling systems.

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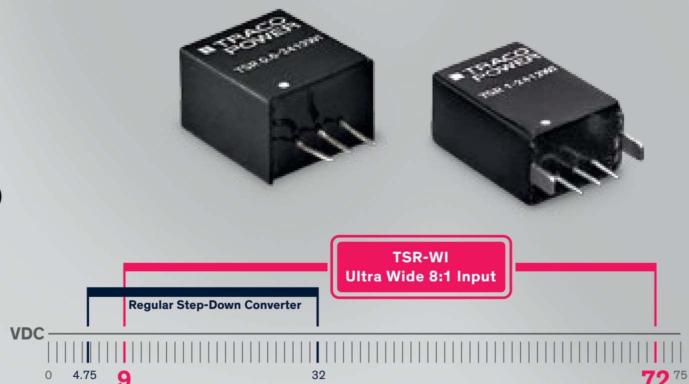

# Versatile IGBT Power Module for Demanding Industrial and Automotive Applications

*The SKiM63/93 power semiconductor module was launched in 2011 and, owing to its versatility, has become an important IGBT module platform for many applications. Initially the SKiM63/93 module platform used silicon IGBT and diode chips, employing sintering die attach to deliver excellent power cycling capability.*

*By Marco Honsberg and Anastasia Schiller, SEMIKRON INTERNATIONAL GmbH*

Indeed, with the introduction of AlCu bonding for the top side contacts, reliability was further increased and the SKiM63/93 is now a well-established solution for demanding power and load cycling applications that employ the latest technologies. The unique design of the SKiM63/93, based on a laminated busbar structure and multiple connections between the DC-link and the substrate, delivers a very low stray inductance, making the SKiM63/93 suitable for high-speed switching operations utilising SiC chipsets, as required for DC-DC converters, e.g. EV charging stations. This article provides an overview of the versatile combinations of chipsets and packaging and the resulting performance.

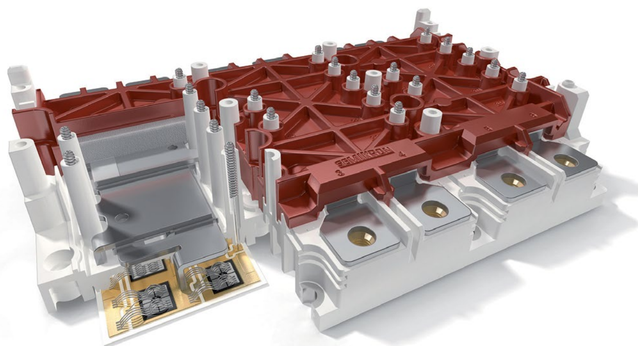

*Figure 1: Model design and structure*

An image of the SKiM63/93 module is shown in Figure 1. The module design allows the user to simply assemble the driver PCB on top of the SKiM63/93 and secure the IGBT driver printed circuit board (PCB) with a well-positioned set of screws. These screws connect the IGBT driver with the SKiM63/93 without the use of solder, instead employing SEMIKRON's tried and tested unique spring technology. This solderless assembly simplifies overall inverter design and enables the driver to be accessed easily in the event of repair and maintenance, even in the field. The internal structure of the SKiM93 is shown in Figure 2. Image A on the left side shows the structure of the low-inductance laminated busbar and its multiple connections to the substrate. By connecting the power terminals to the Al2O3 ceramic substrate using three individual solid busbars, both static loss and stray inductance from terminal to the power semiconductors is reduced.

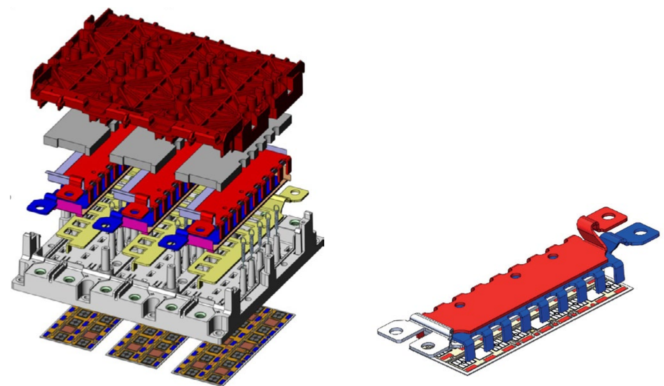

*Figure 2: The internal structure of the SKiM93*

**Thermal performance**

Another important focus during the design stage of the actual SKiM63/93 is the thermal performance. Besides the internal structure, a high performance thermal interface material has been applied, creating an evenly distributed layer of optimal thickness. Furthermore, the choice of a low-inductance dedicated internal busbar structure provides a certain degree of freedom in IGBT and diode chip positioning. Utilising this flexibility, the IGBT and diode chips are positioned such that the thermal losses are distributed more homogeneously across the substrate. This avoids concentration of local loss density on the ceramic substrate, creating hot spots that can potentially limit performance. The simulated loss generated in IGBT and free-wheeling diode chips and the resulting peak junction temperature distribution over the entire ceramic substrate results in fewer hot spots and allows for the development of more powerful inverter systems that utilise inexpensive heatsink designs.

The overall design of the baseplate-less SKiM63/93, which features pre-applied high-performance thermal interface material on an optimised water-based heatsink-eliminating the additional thermal resistance of a dedicated baseplate found in many off-the-shelf products-delivers unprecedented power density that can be yielded from the chipset employed. The performance achieved in an optimised configuration such as this is equivalent to the capability of pin-fin IGBT modules found mainly in automotive applications, but avoids the potential risks of water leakages that are inherent in pin-fin constructions as part of a pin-fin IGBT module mounted with a gasket into the designated hole of a water-based heat sink.

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**Chip technology**

Today, the SKiM63/93 IGBT module platform is compatible with a variety of chips. The voltage ranges from 650V to 1200V and 1700V blocking voltage. The IGBTs utilised are produced by leading chip suppliers and achieve different trade-offs between static and turn-off losses, enabling the user to design the module in line with the specific application conditions. The diodes employed are predominantly state-of-the-art SEMIKRON CAL4 diodes that deliver unprecedented performance with regard to static and dynamic losses. Silicon carbide diode populated SKiMs as a part of the portfolio are ideal for high frequency switching applications.

Owing to the variety of available chips and chip combinations, the SKiM module can be tailored to meet the needs of the given application, delivering superior performance in certain applications than off-the shelf modules. The figures below compare the performance of modules that use standard types of silicon chips with those with dedicated chipsets based on different Hybrid Silicon Carbide (HSiC) chip selections. The main differences under identical application conditions are shown accordingly.

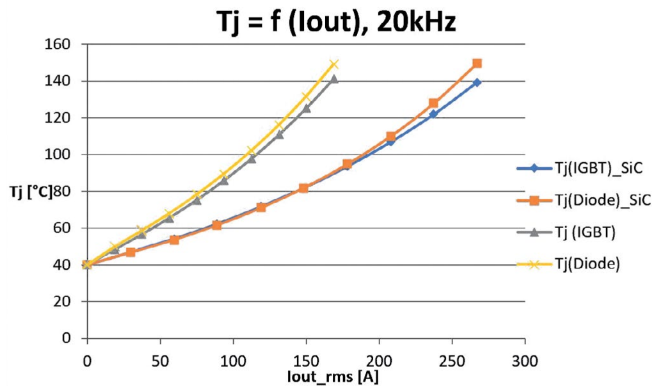


*Figure 3: Standard silicon IGBT/ silicon diode chipset versus the same converter utilising a SKiM93*

Figure 3 shows a performance comparison between a converter operating at fc=20kHz, $V_{DC}$=600V, cos phi = 0.8, using a SKiM93 based on a standard silicon IGBT/ silicon diode chipset and the same converter utilising a SKiM93 equipped with silicon IGBT and SiC diode on the substrate.

For more demanding application conditions such as operation at cos(φ) of -1, the SKiM63/93 provides the flexibility to optimise the populated diode space accordingly. The result of optimisation for operation at $f_c$=20kHz, $V_{DC}$=600V is shown in Figure 4.

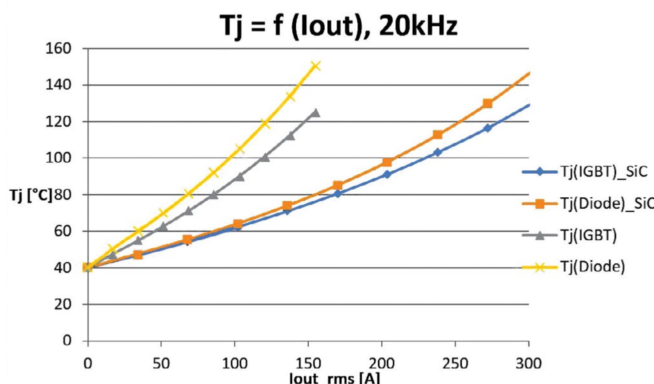


*Figure 4: The result of optimisation for operation at $f_c$=20kHz, $V_{DC}$=600V*

**Reliability**

The effect of thermal cycling is frequently mentioned in connection with base plate IGBT modules and addresses the aging effect of the connection between the baseplate of the module itself and the ceramic substrate. Over time, the stresses resulting from changes in temperature produced by the substantially different coefficients of thermal expansion of the metal base plate and the ceramic substrate will deteriorate the quality of the thermal connection. This is caused by the interconnection material used, in many cases solder. For a module family such as the SKiM63/93 that has been designed without baseplate, this failure mode has been eliminated entirely.

Furthermore, any reliability enhancing technology developed for SEMIKRON IGBT modules can be adopted in the SKiM63/93. The sintering process introduced to SEMIKRON's process portfolio more than 10 years ago, for example, offers huge potential to significantly improve the reliability of the connection between the back side of the chip and the substrate. For most IGBT modules based on an Al2O3 substrate, this connection is one of the common causes of premature module failure.

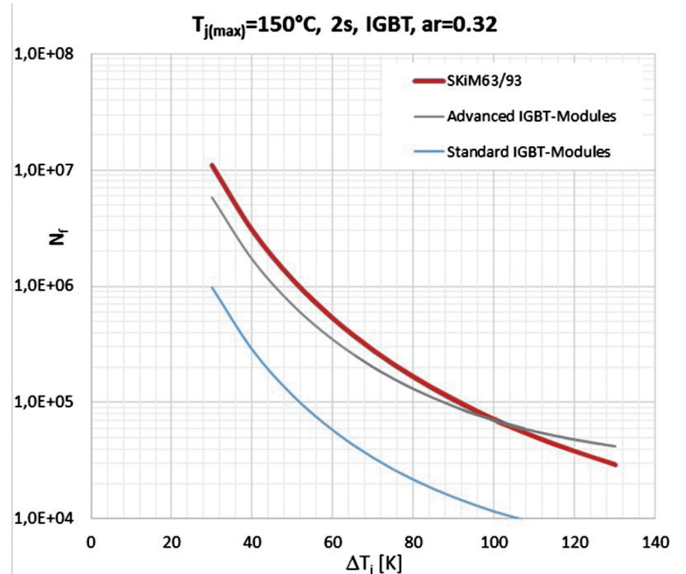


*Figure 5: Sintered modules are approximately six times more robust than soldered modules*

Figure 5 shows that sintered SKiM63/93 modules are approximately six times more robust than soldered modules for a temperature swing of 80K. This optional sinter technology thus makes the SKiM63/93 far more robust to load cycles than industry standard modules, making it the preferred choice for large servo motor applications, lift and eleva-

*Figure 6: Cross-section of an AlCu bond wire*

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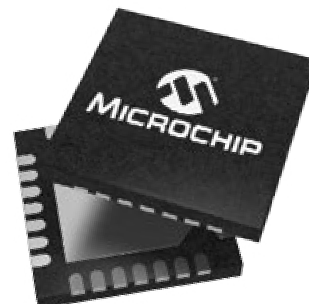


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tor applications, electric vehicle (EV) applications as well as for wind turbine generator converter applications.

The SKiM63/93 is also available with AlCu bonding for applications with increased power cycling stresses where more robust components are required.

Figure 6 shows a cross-section of an AlCu bond wire where the inner copper wire is covered entirely by an outer aluminium sheath. Such aluminium cladded copper wiring along with carefully chosen wire bonding process parameters has proven to be 4 times more robust under power cycling at ΔT =80K, as shown in Figure 7.

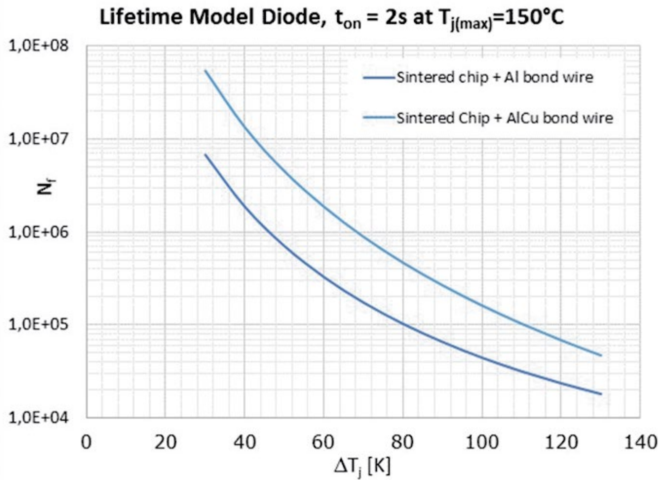


*Figure 7: State-of-the-art robustness and ruggedness*

Combining these core technologies, the SKiM63/93 platform delivers state-of-the-art robustness and ruggedness under demanding changes in load conditions, outperforming industry standard modules.

**Product overview:**
A wide range of chip technologies and processes are available for the SKiM63/93 platform. Figure 8 shows the standard options for this platform:

| | 650 V | 1200 V | 1700 V |
|---|---|---|---|
| SKiM 63 | 600A<br>SKiM606GD07<br>– Sintered<br>– Soldered | 300A<br>SKiM306GD12<br>– Sintered<br>– Soldered | 280A<br>SKiM286GD17<br>– Sintered<br>– AlCu bonded diodes |
| SKiM 93 | 900A<br>SKiM909GD07<br>– Sintered<br>– Soldered | 450A<br>SKiM459GD12<br>– Sintered<br>– Soldered<br>– SiC<br>– AlCu bonded diodes | 420A<br>SKiM429GD17<br>– Sintered<br>– AlCu bonded diodes |

*Figure 8: Standard options for this platform*

**Accessories:**
A gate drive adapter board developed for the SKiM63 and the SKiM93 is shown in Figure 9.

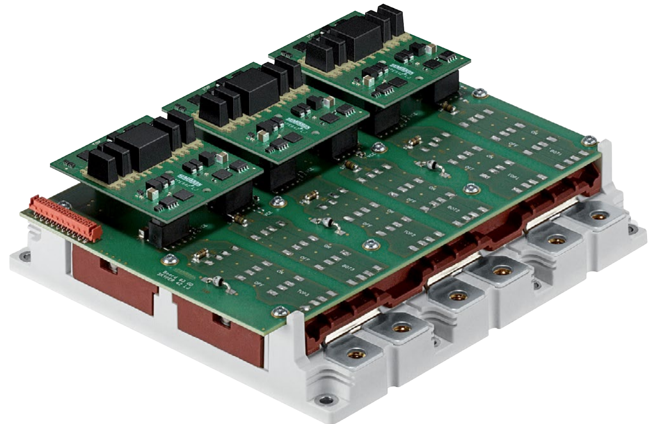

*Figure 9: Gate drive adapter board developed for the SKiM63 and the SKiM93*

The SKiM63/93 housing concept features a main PCB, which is screwed on to supporting plastic domes, providing the electrical connections between the contact spring system in the module and the driver PCB. Indeed the main PCB holds the IGBT drivers in place and provides mounting space for gate resistors. Matching with the required gate driving performance of the IGBT utilised in the SKiM63/93 the industrial standard SKYPER42 LJ driver employing state-of-the-art mixed signal ASICs to reduce the number of overall components is well suited to safely control and protect the SKiM modules in typical applications. This SKYPER42 LJ is shown in Figure 9 on top of the main PCB.

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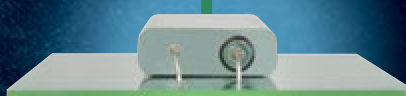

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## 300 W Adapter Reference Design Highlights GaN Innovation

GaN Systems and ON Semiconductor announced the availability of the world's highest power density 300 watt AC Adapter Reference Design using GaN Systems' 650 V, 15 A GaN E-HEMTs and multiple award-winning ON Semiconductor Controller and Driver ICs: NCP51820, NCP13992, NCP1616, and NCP4306. This complete system reference design is highly versatile and low cost, allowing designers to easily develop and bring to market ultra-high power density adapters for various applications in HDTV power supplies, gaming notebook and console adapters as well as ultra-small power supplies for industrial and medical devices.
The kit and application note provide detailed technical information including schematic, PCB layout, and BOM (bill of material) files, and EMI and efficiency data. The kit hardware has complete PFC, LLC, and secondary stages, and features a high-efficiency synchronous PFC which meets CoC T2 benchmark, a highly-versatile low-cost 2-Layer design, and universal input with 19 V Output at 340 W peak. System designers using this GaN-based reference design can reach power densities up to 32 watts per cubic inch. "Fast-switching GaN works effectively with our advanced controller and drivers to optimize system designs for high power density, removing design barriers and enabling designers to take advantage of the numerous benefits provided by GaN E-HEMTs," stated Ryan Zahn, Director of Marketing at ON Semiconductor.

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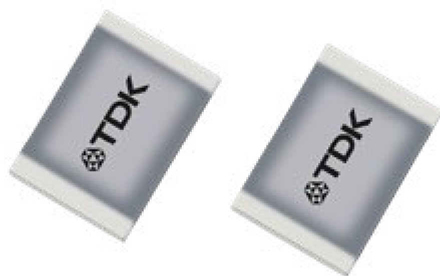
## Surface-Mountable Rechargeable Batteries

The surface-mountable, rechargeable solid-state battery produced by TDK Corporation is now available from TTI, Inc. The TDK CeraCharge range merges aspects of lithium-ion battery and multilayer ceramic capacitor technologies to produce an all-ceramic, solid-state rechargeable cell suitable for reflow soldering. The parts can be used as backup batteries for real-time clock circuits, to store energy for Internet of Things (IoT) devices such as beacons and energy-harvesting systems, and as sub-batteries that smooth out voltage and current variations in wearable devices.




The TDK CeraCharge parts use lithium-based ceramic oxides to form both the electrolyte and the inner electrode of the battery, and copper to collect the resultant charge and route it to the external electrodes. The parts therefore combine the benefits of lithium ion batteries with the safety and manufacturing advantages of ceramic multilayer components. The all ceramic-structure of the CeraCharge batteries means that they cannot leak, burn or explode, and will work over wide operating temperature ranges and even in a vacuum. The parts are compatible with reflow soldering processes, surface mountable, and embeddable. They are available in EIA case sizes.
The CeraCharge 1812 is just 4.5 x 3.2 x 1.1 mm, and weighs 40 mg. It has a nominal operating voltage of 1.5 V, a nominal capacity of 100 µAh, and a nominal discharge current of 20 µA.

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## Cooling Solutions

The Power Electronics Solutions (PES) Group of the Rogers Corporation is presenting two product expansions from the curamik® cooler product family. The two water-cooled laser diode coolers efficiently derive the heat from powerful laser diodes on the smallest surfaces, improve performance efficiency and extend the lifespan. curamik CoolPerformance Plus coolers are manufactured for outstanding cooling performance from OFHC copper and a highly conductive ceramic substrate, which, in combination, produces a precisely controllable coefficient of thermal expansion (CTE).

In addition to curamik CoolPerformance / Plus, the material-based laser and photonics cooling solutions curamik CoolPower / Plus and curamik CoolEasy will also be shown. curamik CoolPower / Plus coolers are produced from several layers of pure copper. The coolers are manufactured in the unique curamik bonding process in order to achieve hermetic, multi-layer structures without solder or additional adhesive layers. The curamik cooling solutions are also used for cooling high-performance LED and Lidar applications.

www.rogerscorp.com

Automotive Home Appliances Industrial Power Transmission Renewables Railway

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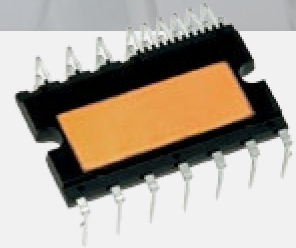
key products:
Trust.

# Power Devices from Mitsubishi Electric.

Home appliances are becoming more and more demanding regarding functionality, reliability and efficiency. In the field of Power Semiconductors Mitsubishi Electric had created the necessary basis over 20 years ago as the pioneer of the DIPIPM™ transfer molded package intelligent power modules, followed by the continuous development and expansion of this series. Consequently, with the new SLIMDIP™-W a new Intelligent Power Module in the well-established SLIMDIP™ package has been added to the line-up to enable low losses with high switching frequencies, while keeping the electromagnetic noise low. The versatile integrated features give, for various applications in the industry and residential field, the benefit of reduced development time for the complete inverter system.

**New IPM in SLIMDIP™ package with latest RC-IGBT chip technology**



**The high-switching speed SLIMDIP™-W**

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- Integrated bootstrap diodes and capacitors
- Short circuit protection through external shunt resistor
- Power supply under-voltage protection: Fo output on N-side
- Over temperature protection
- Analog temperature voltage signal output
- Low electromagnetic emissions

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More Information:
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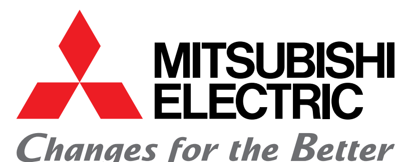
**Scan and learn more about our Power Semiconductors on YouTube.**



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# 3W AC/DC Converter with Transient Output Power

MORNSUN first high-transmission power product, the 3W AC/DC converter LDE03-20Bxx-O Series, supports 12W output and lasts for 10 seconds, which firstly solve the power redundancy requiring high transient power in systems.
Why is it forced to choose? In some applications where high transient communication or drive power is required, such as electrical control systems, automatic meter reading, anti-theft alarms, and access electric lock applications, large amounts of power are outputted in a short time at transmitting and receiving data or driving relays. Therefore, the system usually has to use a higher steady output converter to meet the demand in the case of no high transient converter, resulting in power redundancy. Not only that, High power converter can result in larger system dimension or layout difficulties, as well as increasing purchase cost.
For solving industrial difficulties, by comprehensively optimizing circuit design, material platform and other R&D platforms, MORNSUN researched and firstly launched 3W high transient power AC/DC converter LDE03-20Bxx-O series, assisting the demand of high transient power system, which the 3W power supply reliably replaces the 12W steady output power supply, and optimizing system dimension and cost. In addition, the series has high isolation voltage (4000VAC), wide operating temperature (-40 to 80°C), low no-load power consumption (0.3W), and complete protection functions (output short circuit, over current, over voltage, over temperature protection), the dimension is 37.0*24.5*18.0mm (compatible with our LDE03-20Bxx), which saves system application space and ensures reliable system application.

**www.mornsun-power.com**

# Time-of-Flight (ToF) Demonstration Board



EPC announces the availability of the EPC9144, a 15 V, 28 A high current pulsed laser diode driver demonstration board. In time-of-flight systems, speed and accuracy of object detection is critical. As demonstrated on this board, the rapid transition capability of the AEC Q101-qualified EPC2216 provides power pulses to drive laser diodes, VCSELs or LEDs up to ten times faster than an equivalent MOSFET, in a small fraction of the area, energy, and cost.
eGaN® FETs and integrated circuits provide the high current pulses, extremely narrow pulse widths, and small size that make affordable, high performance lidar possible. The short pulse width lead to higher resolution, and the tiny size and low cost make eGaN FETs ideal for time-of-flight applications from automotive to industrial, healthcare to smart advertising, gaming, and security.
The EPC9144 ships with an interposer board. The interposer board is a collection of break-away 5 mm x 5 mm square interposer PCBs with footprints to accommodate different lasers, RF connectors, and a collection of other footprints designed for experimentation with different loads. The use of the interposers allows many different lasers or other loads to be mounted, allowing users to test the performance with the load requirements that are appropriate to their application.

**www.epc-co.com**

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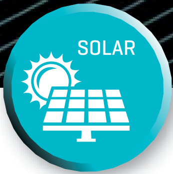
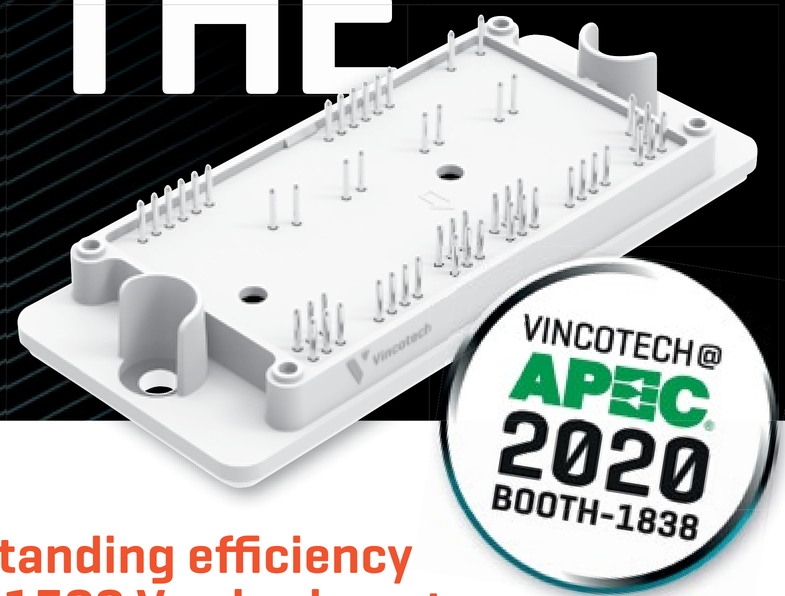


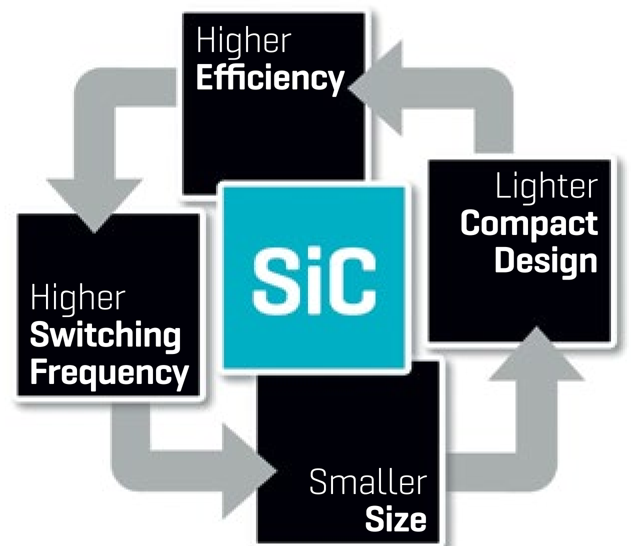




## Max power density, outstanding efficiency with hybrid modules for 1500 V solar inverters

Featuring a combination of SiC diodes with the latest 950 V IGBTs, the new *flow*NPC 2 for 1500 V multi-string inverters supports 200 kVA and higher output power. Higher efficiency and better power handling – that adds up to maximum return on your and your customers' investment.

### Your benefits:

- **Maximized ROI**
  Chips optimized for efficiency with SiC diodes and 950 V IGBTs
- **More secured supply chain**
  Multi-sourced components ensure flexibility
- **Light compact design**
  No bulky passive components
- **Lower production costs**
  Press-fit pins and pre-applied TIM

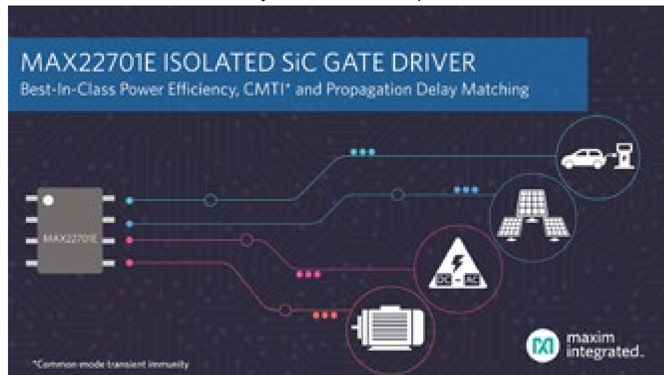



www.vincotech.com/npc-2-1500V

EMPOWERING **YOUR IDEAS**

# Isolated Silicon Carbide Gate Driver

With the MAX22701E isolated gate driver from Maxim Integrated designers of high-voltage/high-power systems can improve power supply efficiency by up to 4 percentage points over competitive solutions, reducing power loss and the resulting carbon footprint by 30 percent. The driver IC is intended for use in switch-mode power supplies within industrial communication systems for solar power inverters, motor drives, electric cars, energy storage systems, uninterrupted power supplies, data farms and high-power/high-efficiency power supplies. Many switch-mode power supply applications are adopting wide-bandgap silicon carbide (SiC) transistors to improve power efficiency and transistor reliability. However, the high switching frequency incurs transients that generate noise, which either disrupts operations or requires extensive mitigation. The MAX22701E offers the industry's highest common-mode transient immunity (CMTI) of 300kV/µs typical to deliver industry-leading reliability. CMTI is up to 3x higher than the closest competitor, which results in increased system uptime. Best-in-class driver propagation specs (35ns typical which is 2x lower propagation delay than the closest competitor) and propagation delay matching between the high-side and low-side gate drivers (5ns maximum which is 5x lower than the closest competitor) helps to reduce the transistor's dead time. This, in turn, improves power efficiency up to 4 percentage points.




www.maximintegrated.com

# Current Transducers Packaged with Power Analyzers

Danisense has announced that HBM Test and Measurement will offer customers a packaged solution of its power analyzer together with a Danisense current transducer. The combination will make it more convenient and simpler for customers to use the best available equipment. HBM will label the current sensors included in the package, 'powered by Danisense'. Its eDrive power analyzer acquires mechanical signals (e.g. torque, vibration, temperatures) and electrical signals (current, voltage) simultaneously, helping designers to better understand the electric drive and its losses in minutes rather than days, which is important for the optimisation of the drive as well as the increase in efficiency. In contrast to conventional power analyzers, HBM´s eDrive offers data acquisition and analysis capabilities in addition to power measurement. When paired with a high-accuracy, high reliability, wide-bandwidth Danisense current transducer (compatible models range from 50A to 1200A), the solution is a perfect fit for the electric vehicle market. Comments Loic Moreau, Sales & Marketing Director, Danisense A/S: "The HBM solution is a powerful tool for the automotive market, enabling the collection and analysis of lots of data from diverse sensors. We are excited to partner with HBM to deliver a convenient, high-performance T&M solution, available from one source."

www.danisense.com

# IGBT for 900 A Power Rating

Infineon introduced the IGBT7 chip for its Easy housing platform in March. Now it is taking the state-of-the-art TRENCHSTOP™ IGBT7 to the arena of medium power: in the standard industry package EconoDUAL™ 3. In this chip technology, the 1200 V module provides a leading nominal current of 900 A enabling a 30 percent higher inverter output current for the same frame size compared with the former technology. While specific improvements of the module's chip and housing directly aim at industrial drive applications, it can also be very well implemented in designs for commercial, construction and agricultural vehicles (CAV), servo drives, as well as solar and UPS inverters.

Based on the new micro-pattern trench technology, the TRENCHSTOP IGBT7 chip performs with much lower static losses compared to the IGBT4. Its on-state voltage is reduced by up to 30 percent for the same chip area. This brings significant loss reduction in the application, especially for industrial drives, which usually operate at moderate switching frequencies. Additionally, the oscillation behavior and the controllability of the IGBT have been improved. The power modules feature a maximum allowed overload junction temperature of 175°C.

www.infineon.com

# XHP™ 2 – Maximum power density and reliability for urban transportation systems

## Up to 1800 A at 1700 V with IGBT5 and .XT technology

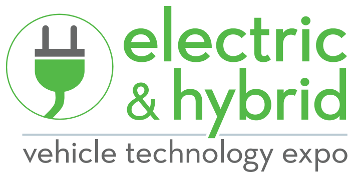
Infineon is offering two new IGBT modules for demanding applications: XHP™ 2 with 1200 A or 1800 A nominal current at 1700 V blocking voltage.

**Features**
- IGBT5 chip technology
- .XT joining technology
- Low stray inductance (<10 nH)

**Benefits**
- Highest RMS current per module
- More robust against cyclic loads
- Superb switching behavior

www.infineon.com/xhp

infineon

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*CEO*
*Paraclete Energy*

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# Accelerometer with Built-In Noise Filtering Function

ROHM Group company Kionix announced the availability of accelerometers, KX132-1211 and KX134-1211, ideal for high accuracy, low power motion sensing applications in the industrial equipment and consumer wearable markets. In recent years, as factories have begun to save labor costs and increase efficiency, the concept of predictive maintenance for detecting abnormalities before equipment malfunctions has gained broad acceptance. This has increased the need for machine health monitoring along using sensors to detect equipment conditions (i.e. motor vibration).

The KX134-1211 is a 3-axis accelerometer optimized for machine condition monitoring. Advanced Data Path (ADP) technology allows noise filtering and sensor signal processing normally carried out by the MCU to be performed by the accelerometer. They contribute to reducing MCU load and power consumption together with improved application performance. In addition, to meet industrial requirements, the sensing frequency and acceleration detection ranges have been increased to 8,500Hz and ±64g, respectively, while supporting operating temperatures up to 105°C. At the same time, the sensor itself consumes less than half the current (0.67μA in low power mode) compared to conventional products. Additional features include Wake Up and Back to Sleep functions that contribute to lower power consumption, enabling sensing operation in battery-equipped wearable devices.

**www.rohm.com**

# AC/DC Modules Meet Ecodesign Specifications

Dengrove Electronic Components is now stocking the smallest 3-Watt AC/DC power modules on the market, the RECOM RAC3 series meeting the latest European ErP Lot 6 ecodesign specifications for standby and off mode. With a footprint only 28.5mm x 23.5mm, and 17.9mm high, the RAC3 series delivers full-load power from -40°C to 60°C, and 2 Watts up to 80°C. in addition to their small size, ErP Lot 6 compliance makes the modules suitable for automation, industry 4.0, IoT, household, and home-automation applications worldwide. International safety certifications include UL/IEC/EN62368-1 and IEC/EN60335-1, easing approval of industrial, domestic, and IT equipment. An IECEE CB Report is also available, which simplifies conformity assessment in CB Scheme member countries.

The RAC03 series also simplifies equipment design, with features including reinforced insulation that meets IEC Class-II protection requirements and electromagnetic emissions significantly inside the class-B limits without the addition of an external filter. The family comprises six single-output models that feature a universal 85V-264V AC input and present a choice of 3.3V, 5V, 12V, 15V, 18V, or 24V output. All units come with a 5-year manufacturer's warranty.

**www.dengrove.com**

**Thyristors**
Real power for heavy industries.

ABB Power Grids' new range of 8500 V high-power thyristors with 100 mm pole piece offers lowest on-state losses and highest blocking stability. The safe operation temperature up to $T_{jmax}$ = 125 °C assures reliable operation in demanding industrial applications. **abb.com/semiconductors**

ABB

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## Hybrid Surge Protective Device

Bourns, Inc. announced the Bourns® Model 1202 Series. This Type 1 hardwired hybrid surge protective device (SPD) is designed for AC infrastructure applications. Bourns engineers have combined the company's fast-responding Metal Oxide Varistor (MOV) technology with its low leakage Gas Discharge Tube (GDT) technology to deliver a device that provides consistent, long-life, reliable and enhanced protection performance. The Model 1202 Series employs a full multi-mode protection scheme that can be utilized in line-to-line, line-to-neutral and neutral-to-ground configurations.

The innovative hybrid design uses the GDT to isolate the MOV from the line voltage thus shielding it from transients and temporary overvoltage spikes that can potentially damage the MOV over time. The GDT's ultra-low leakage also helps to reduce damage due to watt loss heating.

The Model 1202 has a nominal current rating of 10 kA and a short circuit current rating of 25 kA. The device's LED indicators provide visual indication when the surge protector encounters any situation that requires its internal safety fusing to activate. In addition, the Series is IP66/NEMA 4x rated and can be used indoors or outdoors. As a Type-1 SPD, the Model 1202 requires no external line fusing or circuit breaker, and can be placed on the line side of the main service disconnect.

**www.bourns.com**

## DC Meters for Charging Infrastructure

Isabellenhütte presents the first shunt-based, calibration law-compliant DC energy reference meter IEM-DCC-500 for charging infrastructure following the successful completion of the type examination. The DC meters are now available for purchase by manufacturers of charging stations and can be integrated into the designs of their applications. The basis of the type examination certification was the successfully conducted metrological measurement series (accuracy class B), the operation of the software in compliance with calibration law, the corresponding documentation for the customers and institutes, as well as the positive completion of the EMC and environmental impact studies.

Andreas Prüfling, Director of the Business Unit Measurement at Isabellenhütte: “We thank PTB Braunschweig for this good collaboration, which has ultimately led us to achieving a solution for the market that complies with calibration law. Simultaneously, we have expanded series production so that the DC meter is now directly available to recharging station manufacturers.” The design features integrated current and voltage measurement (500 A and 1,000 V) as well as the calibration law-relevant periphery in a compact housing that is secured against manipulation.

**www.isabellenhuette.de**



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POWER SUPPLY
AC/DC LM/LMF Series

Active PFC function is available

Isolation up to 4000VAC

EMI meets CISPR32/ EN55032 Class B

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EN62368 approval meet IEC/UL62368/ EN60335

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MORNSUN®
www.mornsunpower.de

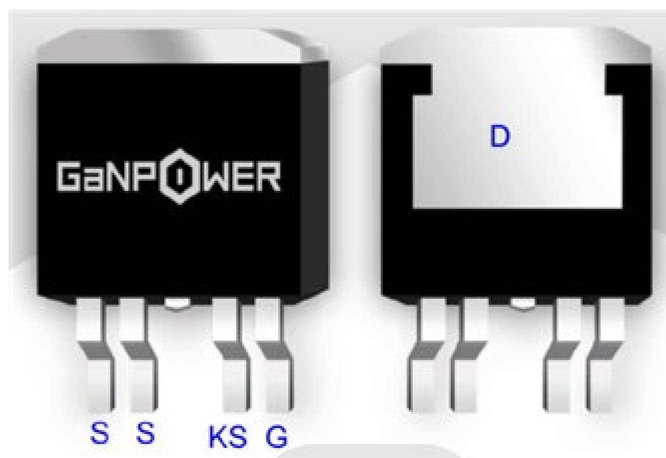
# Smart Driver IC for Battery Powered DC Motors

TRINAMIC Motion Control announces the TMC7300, a low-voltage driver for one DC motor up to 2A peak, or two DC motors up to 2.4A peak. Operating on a single or dual Li-Ion cell or at least 2 AA batteries, the TMC7300 is optimal for battery-operated equipment such as IoT and handheld devices, printers and POS applications, toys, cameras, and mobile medical devices.
Thanks to an integrated direct bridge, the chip can also be used to control solenoids, relays, and other actuators. Despite the small form factor – a QFN of 3x3 mm² with 20 pins in total, the TMC7300 scores with a high power density using integrated power MOSFETs and a complete integrated DC motor control logic. As such, it can control velocity and limit torque, or be used in torque-controlled operation.
Michael Randt, Founder, and CEO of the Hamburg, Germany based company, explains: "By rolling out our new family of driver ICs for battery-powered applications, we want to stimulate innovation. We want to fuel the imagination of engineers around the world by giving them the tools needed to develop new applications and turn proven concepts into portable devices that are convenient to use for both consumers and professionals."

www.trinamic.com

# 1200 V Single-Die E-Mode GaN Power Devices

GaN Power International has achieved an important milestone in the development of high-voltage GaN power devices. After introducing its first lateral EMODE GaN power transistor (GPIHV15DK), a 1200V/15A device in a TO252 package, this past summer, the company more recently released a second GaN FET (GPIHV30DDP5L) at 1200V/30A in a TO263-5. This latest development indicates that GaN Power's success in producing a 1200V GaNFET was no accident and that 1200V GaN can be scaled to higher current/power. With their excellent dV/dt handling capability, 1200V GaNFETs are suitable for PV, motor drive and automotive applications.




It was commonly believed that high voltage discrete power devices (> 1000V) were exclusive domains of silicon (Si) IGBT and silicon carbide (SiC) (both vertical devices) until GaNPower recently proved otherwise. All previous GaN devices with BV higher than 600V were made of a DMODE cascode with two or more chips copackaged, and with compromised switching performance. GaNPower International is the first company to offer devices rated at 1200V using single die enhancement mode technology. The lateral device has an actual breakdown at about 1500V and it is being rated at 1200V with sufficient safety margin. GaNPower is presently offering these 1200V engineering samples with 100mOhm (15A) and 60mOhm (30A) ratings.

www.iganpower.com

# Rack-Mount Programmable DC Load

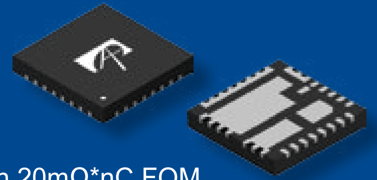
Elektro-Automatik announces the EA-ELR 10000 30 KW Programmable Electronic Load. The 4U rack-mounted ELR 10000 4U, engineered with advanced SiC power conversion devices, boasts the industry's best power density—requiring as little as half the rack space for the same power output as competing programmable loads. This latest generation ELR combines its high-efficiency programmable DC load with an equally efficient inverter (regenerative) output stage, returning up to 95% of the energy used in the test back to the ac grid. A master-slave bus provides for parallel connection of multiple ELR 10000 units to a maximum input power rating of 1080 KW.

The ELR 10000 provides a wide range of programmable functions to simulate complex testing such as electric vehicle traction motors, battery discharge testing, PV simulation per EN 50530 and MPP tracking and others. An FPGA-based function generator with a value table of up to 3,276 points enables creation and operation of load profiles that include sine wave, square wave, sawtooth and ramp functions. The device can easily reproduce non-linear internal resistances such as those of batteries or LED chains. Sequences can be loaded from and saved to a standard USB drive on the front panel.

www.elektroautomatik.us

# DrMOS Power Modules

## DrMOS



▶ (30A – 65A)

- Industry leading Trench MOSFETs with 20mΩ*nC FOM
- Wide range of package solutions from QFN3.5x4.5 to QFN5x5
- Compatible with many common VR controllers for various CPU and GPU platforms
- High peak current capability to handle challenging transient response

Our latest generation of DrMOS power stage products provides flexible, high efficiency, and easy-to-use solutions for computing CPU and graphic card GPU applications.

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# Fully Integrated Power-Management IC

With features including four DC/DC buck converters, a boost DC/DC converter, and six low-dropout regulators (LDOs), the STMicroelectronics STPMIC1 power-management IC (PMIC) satisfies the complex power demands of highly integrated application-processor based systems. The chip is optimized as a companion PMIC for ST's STM32MP1 heterogeneous multicore microprocessors, which target a broad range of applications by integrating single or dual Arm® Cortex®-A7 and Cortex-M4 cores, an optional 3D graphics processing unit, and rich digital and analog peripherals.

Simplify power design and save space with STPMIC1
14-channel Power Management Integrated Circuit

- Integrated power management for embedded systems
- Enhances power efficiency
- Minimizes circuit area and BOM

More than simply saving board space and BOM cost, compared to arranging the same number of power rails using discrete components, the STPMIC1 also provides power-rail monitoring and protection, handles power-up/down sequencing, and meets the ST32MP1 accuracy and settling-time specifications. ST Authorized Partner Octavo Systems has utilized the STM32MP1 and STPMIC1 to create the OSD32MP1x family of microprocessor system-in-package (SiP) devices, which occupy a footprint up to 64% smaller than an equivalent system implemented with discrete components while also addressing engineering challenges such as power sequencing.
In addition to supplying power rails for the microprocessor unit (MPU) and external system components, the STPMIC1 also provides a DDR memory reference voltage, a 500mA USB OTG power switch, and a general-purpose power switch. An I2C interface and additional pins allow the MPU to manage the PMIC.

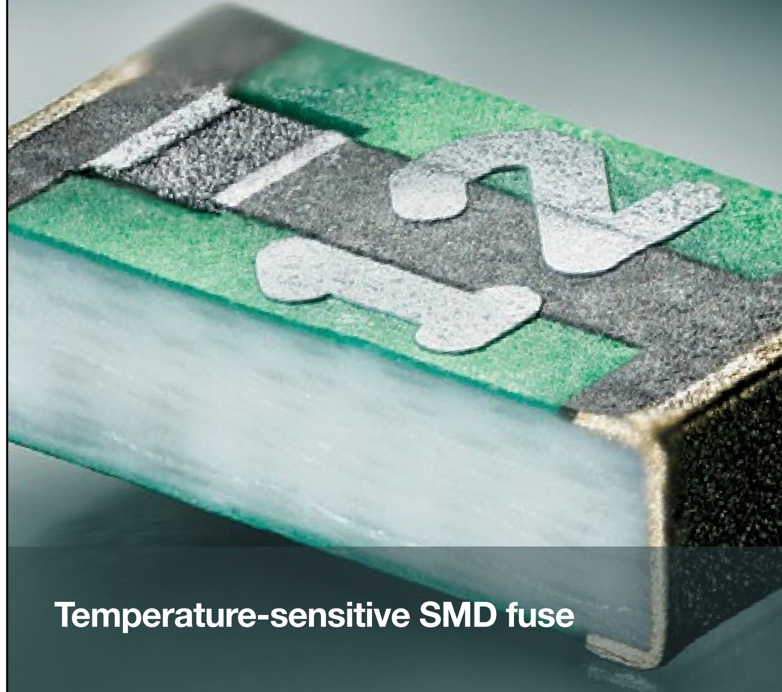
www.st.com

# GaN Used in Power Supplies for Airplanes

Transphorm confirmed that customer AES Aircraft Elektro/Elektronik System has released its first 650 V GaN-based power supplies.

Serving the aviation industry, AES supports customers with various products and services ranging from electrical engineering to certification and testing. The company's Switch Mode Power Supplies are currently used by large CS-25 airplane manufacturers (e.g., Airbus A318-A321, A330, A340, A380 and Boeing B767, B787 VIP aircraft) and use Transphorm's GaN FETs to increase overall system efficiency by more than 10 percent compared to competitive Silicon-based power supply unites (PSUs). The two GaN-based Switch Mode Power Supplies are the PS250X 500 W system and the PS6120 1200 W system. Both products support a 96-130 VAC/360 Hz – 800 Hz input voltage with a 28 VDC continuous power output at 15 amps for the 500 W system and 42 amps for the 1200 W system. Further, AES certified the PS250X and PS6120 as DO-160 compliant—meeting the more than 25-point stringent Standard of the Radio Technical Commission for Aeronautics (RTCA). This Standard assesses system impact and performance under various external and internal conditions on aircraft—ranging from pressure and temperature to voltage spikes and RF emissions.

www.transphormusa.com




- Combines a standard fuse characteristic with an additional ambient temperature sensitivity
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- Excellent inrush current withstand capability

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we energize electronics!

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RSG and P-DUKE Present:
High-isolation DC/DC Converters for Special Applications

Top Features:

- Range of DC/DC converters from 2W to 30W in DIP16 to 2"x1" cases
- Special reinforced high I/O isolation of 5kVAC
- Suitable for many applications like E-Mobility, PV, Medical, EES, Charging, etc.

15W and 20W in 1.6"x1" package with 5kVAC

Various wattages in cases from DIP16 to 2"x1"

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Or contact us via email sales@rsg-electronic.de or phone +49.69.984047-0

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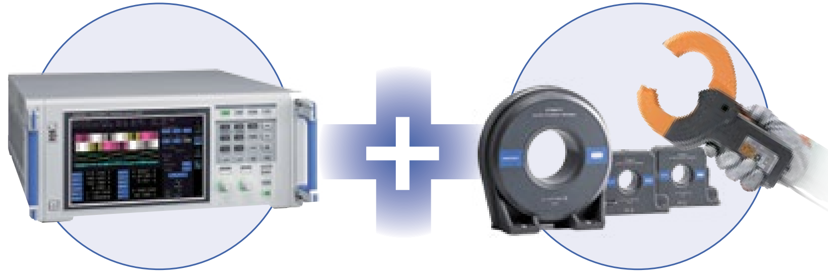
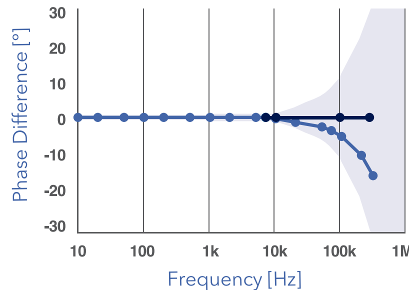


**HIOKI Power Analyzer PW6001**
- Harmonics, Motor & Inverter Analysis
- ±0.02% accuracy, 6 channels

**HIOKI High-Accuracy Sensors**

Pull-through sensor series *CT687x*
- DC to 2 MHZ, Up to 2000 A

Current clamp series *CT684x*
- DC to 1 MHZ, Up to 1000 A




HIOKI Power Analysis Solution

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# Power Supplies Suitable for Medical Applications

Components Bureau extends its range of Medical power supplies from Cosel, the PCA Series AC-DC Power Supplies are available. The PCA series comprises of 3 models offering power range from 300W - 1000W and meets 2MOPP, EN60601-1 certification. It comes packaged in 89mm x 41mm x 152mm (without terminal block and screw). Average efficiency up to 93% with an operating temperature of -20°C ~ 70°C. Input range 85-264V AC and output voltages 5V, 12V, 15V, 24V, 32V & 48V. The PCA series key features include -only 1U high full function power supply, remote on/off, various alarms, constant current operation, parallel/redundancy operation, EN & UL approved and comes with 5 years warranty. Other features include low leakage current (<0.5mA), Output voltage adjustable close to 0V, 1U High, Low Noise Fan and Communication Function.

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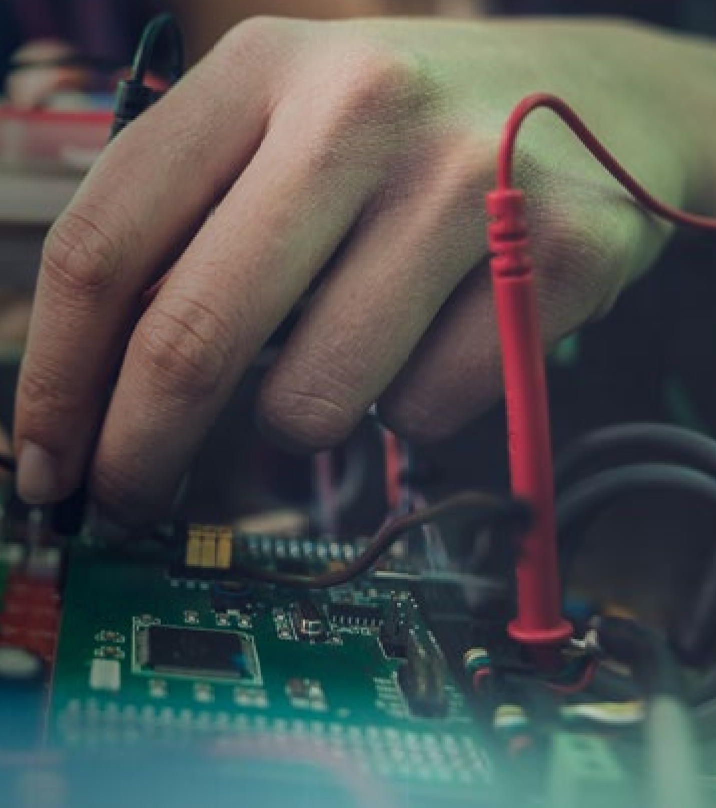

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