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FEATURE STORY

Lightning Motorcycles deliver a smooth 'magical feeling' even at 215mph!

Innovative modular power system design delivers an unequalled riding experience.

More details on page 12.

APEC 2024 registration offers early bird discounts and access to technical content

Registration for APEC 2024 at the Long Beach Convention Center (25 to 29 February 2024) is now open, and includes access to a range of papers, seminars and events, such as peer-reviewed technical programme paper presentations, industry sessions and half-day professional education seminars presented by industry experts.

The annual event addresses issues of immediate and long-term interest to power electronics engineers, equipment OEMs using power supplies and DC/DC converters, designers of power supplies, DC/DC converters, motor drivers, uninterruptible power supplies, inverters and any other power electronic circuitry, equipment and systems as well as manufacturers and suppliers of components and assemblies used in power electronics. There is also material, presentations and companies relevant to manufacturing, quality and test engineers, compliance engineers, testing and qualifying power electronics equipment or equipment which uses power electronics and sales and marketing personnel across the power electronics market sector.

In addition to the conference programme, full registration includes admission to theb APEC 2024 Exposition that brings together nearly 300 leading manufacturers. Special events – including the MicroMouse contest, the FIRST Robotics event and the Wednesday evening Social Event are also part of this lively, interactive power electronics trade show.

APEC 2024 offers discounted rates at five hotels near the Long Beach Convention Center. Early bird registration ends on 29 December 2023.

https://apec-conf.org/registration

Productronica 2023 topics range from sustainability to efficiencies

This year's Productronica (14 to 17 November) will include power electronics topics including core components of a sustainable world, significantly higher efficiencies due to wide bandgap semiconductors and SiC frequency converters for electric vehicles.

Analysts from the Yole Group expect the global power electronics market to grow from $20.9 billion in 2022 to $33.3 billion by 2028, a CAGR of 8.1%. This growth will be driven by governmental regulations, the expansion of renewable energies and the demand for energy-efficient solutions.

The lengthier and more complex manufacturing processes required means that chips made from SiC and GaN are significantly more expensive than silicon counterparts, although manufacturers expect to reduce costs by switching to 300mm wafer technology. The choice between silicon, SiC and GaN ultimately depends on the specific requirements of the application, including power, switching frequency, temperature and cost.

Breuer-Motoren is presenting a SiC inverter power amplifier developed as part of the research project SiC-Mobil – SiC frequency converter for electromobility as a test platform for investigating the reliability, service life, EMC and efficiency of fast-switching SiC power semiconductors.

The growth in industrial automation is also an essential driver of the power electronic market. The industrial sector requires reliable and efficient power electronics to increase productivity, reduce energy consumption and optimise manufacturing processes.

Visitors will be able to see innovative test solutions from exhibitors Rohde & Schwarz, Viscom, Löhnert, CRS Prüftechnik and SPEA.

SEMICON Europa is once again taking place alongside productronica (14 to 17 November 2023 at Messe Munchen)

https://productronica.com/en/trade-fair/

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MEC2528A-UK-10-23

Exhibition space for PCIM grows

PCIM Europe 2024 Exhibition will occupy more space, with exhibition stands in four halls. The exhibition and conference takes place between 11 to 13 June 2024 at the Nuremberg Exhibition Center.

The additional hall for PCIM Europe 2024 reflects this increasing demand, says Messe Messago. The extra space will support the event's continuous growth, increase the variety of products and services presented, and drive further development of power electronics, says the show organiser.

Messe Messago adds that visitors to PCIM Europe can look forward to an even more extensive range of products and services as well as further networking opportunities.

www.pcim-europe.com

Research examines next-gen silicon anode technologies

According to Dr Alex Holland (pictured), Principal Technology Analyst at IDTechEx, the next generation of silicon anode materials is inching closer to commercialisation as energy density and rate capability improve.

There are contenders for the crown currently held by graphite, which has good overall performance and which is low in cost. While graphite is predicted to maintain its dominance in the Li-ion industry, there is also lithium metal and anode-free materials to consider. Other options, such as niobium oxides, have also garnered some interest for fast-charging batteries.

Graphite is expected to remain the most widely used anode material for the medium term and Li-ion graphite anodes will continue to grow and exceed 2m tonnes by 2029.

The graphite used for Li-ion anodes are either natural or synthetic. Each has its own advantages and disadvantages, says Holland. Natural graphite is generally a lower-cost option than synthetic with a higher initial capacity but also a lower cycle life, C-rate capability and initial coulombic efficiency. Synthetic graphite is more expensive and more difficult to mill into spherical particles. It also tends to offer longer cycle life and marginally higher initial coulombic efficiency.

The output of natural graphite has proven challenging. The US DoE and the European Commission have included natural graphite in their latest critical raw materials/minerals lists due in part to Li-ion batteries' important role in transport electrification and stationary storage applications. China's dominance of graphite anode production also presents a supply risk, though Li-ion graphite anode production outside of China is starting to develop from players such as Syrah Resources, Northern Graphite, and Nouveau Monde in North America, or Talga Resources, SGL Carbon and Vianode (synthetic) in Europe, amongst others.

www.IDTechEx.com/lithium

Nexperia and Kyocera AVX Components collaborate for 650V SiC rectifier module

The compact, power dense SiC modules 650V, 20ASiC rectifier module is designed for high frequency power applications ranging from 3.0 to 11kW power stack designs in industrial power supplies, EV charging stations, and on-board chargers.

The compact footprint will help to maximise power density, reducing the amount of required board space and lowering the overall system cost, say the partners. Thermal performance is optimised using a combination of top-side cooling (TSC) and an integrated negative temperature co-efficient (NTC) sensor which monitors the device temperature and provides real time feedback for device or system level prognosis and diagnosis.

The rectifier module has a low inductance package to enable high frequency operation and has been qualified to operate with a junction temperature of up to 175°C.

According to Katrin Feurle, Senior Director of the Product Group SiC at Nexperia, the collaboration combines the company's SiC semiconductors with module packaging for products which offer "exceptionally high levels of power density". The module is the first step in what is envisaged as a long-term SiC partnership between Nexperia and Kyocera AVX.

Nexperia expects samples of the new SiC rectifier modules to be available in Q1 2024.

http://www.nexperia.com

European distributor, Avnet Abacus announces distribution agreement with XP

The agreement covers the manufacturer's high reliability and mission-critical power products for medical and industrial applications, across EMEA markets.

The power products are designed and manufactured for integration into a selection of applications that require dependable and often mission-critical power sources, such as in industrial technology, healthcare and semiconductor manufacturing equipment. The manufacturer's extensive portfolio includes AC/DC power supplies from 3W to 50kW, DC/DC converters from 0.25W to 700W, and high voltage power supplies with outputs up to 500kV DC.

"This collaboration marks a significant milestone in our ongoing commitment to delivering high-quality power solutions to customers across various industries," said Gavin Griggs, CEO, XP Power. "By joining forces, we aim to streamline and enhance the availability of our products to a wider audience of design engineers and manufacturers."

Rudy Van Parijs, President at Avnet Abacus is delighted with the signing. "We are quickly ramping up stock availability of XP Power's diverse portfolio of power converters to provide our customers with fast access to these products."

www.avnet-abacus.eu

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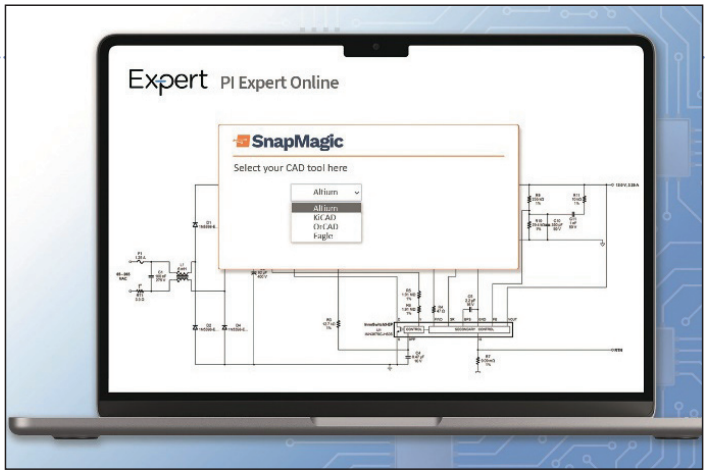
Streamlined design flow for power supplies



A collaboration between power conversion IC developer, Power Integrations, and AI driven electronics components search engine, SnapMagic (formerly SnapEDA) claims to reduce power supply specification to PCB layout time to just minutes.

SnapMagic announced that PI Expert, Power Integrations' online design tool, now features schematic and netlist export, through the use of its new schematic export technology.

Based on specifications input by the user, the design tool automatically generates a complete power supply schematic using Power Integrations' power conversion ICs, including a custom magnetics design. Before this innovation, the automated tool flow extended up to full circuit optimisation but required manual transcription into a CAD package to facilitate simulations and physical layout. This new export capability ensures a fast and seamless transfer of the design, including symbols, footprints, 3D models and electrical netlist into one of four popular PCB CAD tools currently supported, namely Cadence OrCAD, Altium, Autodesk Eagle / Fusion360 and KiCad.

Trevor Hiatt, director of channel marketing at Power Integrations said: "Eliminating the need to manually create or download symbols, draw a schematic and then port those files into a PCB layout tool will save time, reduce transcription errors and, importantly, assist with version control and traceability. The schematic is laid out in a consistent format and optimised for readability on the industry standard 0.1 inch format."

Natasha Baker, CEO and founder at SnapMagic added: "Power Integrations has created an extraordinary power supply design tool. By pairing it with SnapMagic's CAD expertise, we've made it possible to export schematics in real time . . . freeing engineers to do what they do best - innovate. We're not just saving engineers weeks; we're changing the game entirely."

PI Expert Online is a web-based program that takes designers' power supply specifications and automatically generates a power conversion solution, providing everything necessary to build and test a working prototype. It includes a ready-to-build Transformer Construction Report, winding instructions, electrical and mechanical diagrams, bill of materials and board layout recommendations.

No download or installation is required. PI Expert Schematic Export is compatible with user-defined custom components, and exported schematic files contain a readme text file providing step-by-step instructions for opening in the desired CAD tool.

SnapMagic created the schematic export capability within PI Expert. Engineers simply select File > Export Schematic and then the PCB format of choice. SnapMagic's schematic translator provides the completed schematic including schematic symbols and PCB footprints. In addition to the schematic export, CAD models for select Power Integrations components can also be downloaded on the main SnapMagic Search website.

TTI offers Mean Well's BIC-2200 series 2.2kW bi-directional power supplies costs and improve system reliability," she says.

European electronic component distributor, TTI, is now stocking the BIC-2200 bidirectional AC/DC power supplies from Mean Well.

The single, compact unit can deliver AC grid power to DC for charging and when it needs to be discharged converts the DC energy back to the AC grid. This bi-directional capability from a single, compact power supply fulfils SWaP-C (size, weight, performance and cost) needs for manufacturers of battery formation and test equipment, vehicle-to-grid (V2G) systems, EV charging stations, industrial laser equipment and kinetic recovery systems, said TTI.

The power supply's built-in functions include active current sharing, remote on/off control and CANBus mode. Timing of the discharge can be programmed to achieve peak-shaving and valley-filling, reducing electricity costs during the charging process.

TTI Europe is also able to assist customers in projects and design development, based on its close relationship with the manufacturer, its expert knowledge and experience in power supply integration in wide-ranging charge/discharge applications, said Ros Kruger, technical marketing director, TTI Europe. "The BIC-2200 bi-directional power supplies enable us to help our customers reduce overall costs and, more importantly, lower maintenance

Lightning Motorcycles deliver a smooth 'magical feeling' even at 215mph!

Innovative modular power system design delivers an unequalled riding experience

"After the first ride I took on Skyline Drive in Woodside, Calif., I became convinced that electric motorcycles should be a business. The bike gives you a feeling of limitless torque with no vibration, no noise and no heat – there is almost a magical feeling to it."

That was the experience of Richard Hatfield, founder and CEO of Lightning Motorcycles Corp., which holds the land speed record for electric motorcycles: over 215mph. The San Carlos, California company was founded in 2007, just a few streets over from another electric vehicle pioneer – Tesla. San Carlos at that time was ground zero for electric vehicle development and collaboration.

Figure 2 Minimally, electric motorcycles need to deliver 100 miles at 70 miles an hour per charge. Today Lightning's bikes range more than 170 miles/charge with the capacity to recharge to 80 percent in 10 minutes.

Lightning strikes and breaks land speed record

Having cut his teeth on EVs in the late 1990s helping develop an electric Porsche for a U.S. race series, Hatfield, a lifelong motorcyclist, set his sights on creating a motorcycle that leverages the same technology. In the early days, lithium batteries were a scarce luxury item, but by 2005 he was able to source some of the first iron-phosphate lithium cells, together with an industrial variable-frequency-drive inverter and an induction motor.

After developing early prototypes with his original EV motorcycle design, Hatfield equipped his next bike with a Tesla motor, and Lightning was born.

Figure 1 Lightning Motorcycles Corp. holds the land speed record for electric motorcycles, exceeding 215mph.

"We took it to the Bonneville Salt Flats and broke a speed record that had stood for 35 years," Hatfield said. "We still hold the Bonneville record – an SCTA (Southern California Timing Association) sanctioned 215.962mph – in addition to 211.7 at the El Mirage dry lake bed. Then we raced it in the inaugural AMA (American Motorcyclist Association) zero-emission road racing series and won the North American championship."

Soon after, Hatfield produced Lightning's first production bike, the LS-218. As the speed and road racing trophies piled up, Hatfield used the momentum to bulk up Lightning's engineering prowess.

"That was our model," he said. "From the beginning we thought that, for electric motorcycles to be a compelling business, we had to provide performance and an experience that equaled or exceeded the best internal combustion bikes."

And exceed he did. In 2013, Lightning ran in the open class of the Race to the Clouds at the Pike's Peak International Hill

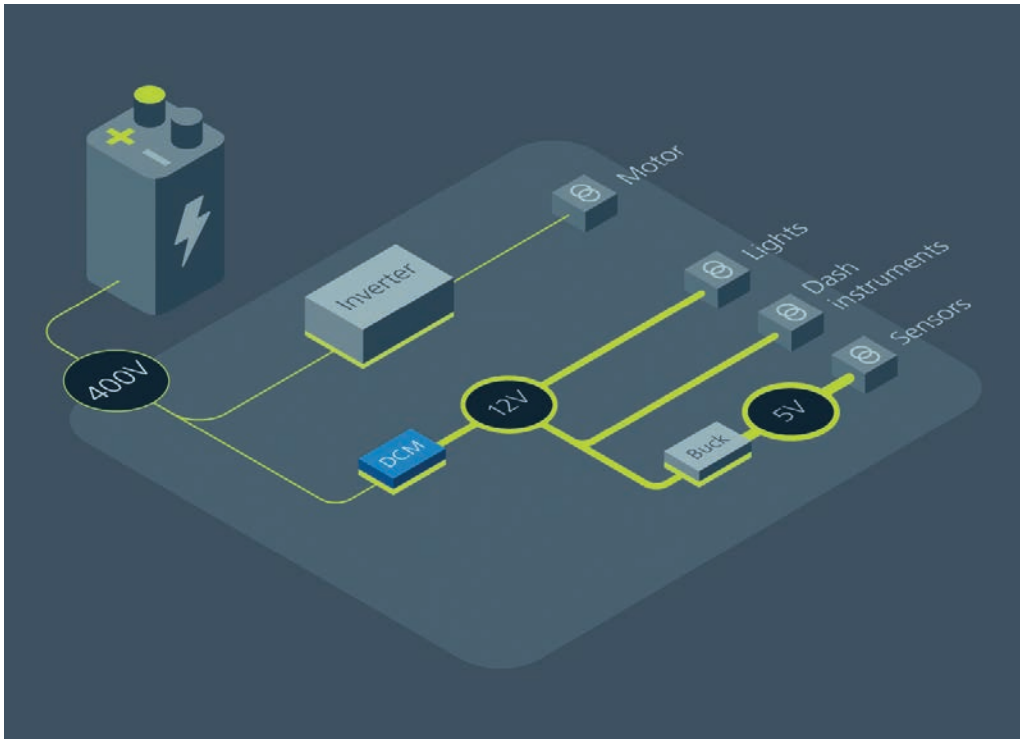


Figure 3 Lightning uses Vicor DCM power modules to convert the high voltage battery down to 12V to power the bike's control electronics including dash instrumentation, lighting, and sensors. The DCM4623 is a power-dense, lightweight and cost-effective DC-DC converter that generates a clean 12V supply from a very wide high voltage input range.

Climb. Hatfield's LS-218 EV motorcycle out-scrambled the entire field, winning the event by more than 20 seconds over the fastest gas bikes.

Honing a world class riding experience

Lightning's goal from day one was to deliver a one-of-a-kind electric riding experience. To a large extent, that came down to assuaging two customer concerns: range and charging time. Initially, Hatfield confided, it was a challenge to build a bike that could deliver 100 miles at 70 miles an hour. Lightning's bikes now range more than 170 miles with the capacity to recharge to 80 percent in 10 minutes.

Lightning's latest battery packs replace the typical graphite anode with silicon anodes, which have energy density in the 300-watt-hour-per-kilogram range – higher than most automotive EV OEMs can achieve, according to Hatfield. Silicon anode cells also charge exceptionally quickly and are able to charge sustainably over 100 kilowatts, whereas competing EV bikes push to get to 20 kilowatts even for a brief time.

The cell battery pack lifespan also generally exceeds that of most EV motorcycles. Even shorter-life cells pull about 800 to 1,000 zero-to-100 cycles. Lightning batteries are also modular and upgradeable, meaning that as better technology becomes available, new batteries can be swapped onto the bike.

Power modules the easy choice for top performance

As Lightning's bikes became more sophisticated, the electronics onboard demanded more power, but not weight. Managing electrical noise in a vehicle that's extremely compact and lightweight is always a challenge. From the early stage, Lightning adopted Vicor DC-DC power modules in all its products, a decision Hatfield attributed to their superior reliability, low noise, high power density and easy thermal management.

Lightning uses Vicor DC-DC converters to power the bike's 12V control electronics as well as lighting, dash instrumentation and sensors. Lightning began commercial production using the DCM4623TC8G16F0T00, which is power-dense, lightweight and a very cost-effective solution.

The input range of the DCM4623 is wide enough to support different voltages from commonly used battery chemistries. For example, it offers flexibility to switch between Lithium-Iron-Phosphate packs, which provide 200 – 400V, and Nickel-Manganese-Cobalt or Nickel-Cobalt-Aluminum Oxide chemistries, which typically range between 250 – 420V.

One early issue was how to connect the battery and apply its voltage to the DCM. The problem is one that all DC-DC converters face: the transient voltage step (V/µs) from a battery when turning on and off is so fast that it's not actually possible to connect and immediately apply the battery's 400V. There were also mechanical relays that connect the battery to the loads such as actuators and the motor, where noise can damage the DC-DC converter and other electronics. To address both problems, Vicor designed a pre-charge circuit and input filter to allow stable operation when turning ON and OFF.

Vicor was instrumental in supporting Lightning's technical needs as the power systems evolved.

What's down the road for Lightning

Hatfield is planning to return to the El Mirage dry lake beds in southern California to see if his team can break its own record. They also have aspirations of racing at Bolivia's Salar de Uyuni, which is the largest salt flat in the world and covers almost 4,000 square miles at 12,000 feet. So far, 15 of the world's elite teams have been invited to compete in what is the world's premiere land-speed event.

For Hatfield, while the records are important, it's the poetry of riding an EV motorcycle that is most satisfying.

"It's just a more advanced feeling," he said. "You don't need a transmission, you don't have to shift, and you have limitless torque all the way across the power band. We hear that a lot from our customers. Most of them are lifelong motorcyclists, but they don't ride their gas bikes so much anymore because of the experience they get from the Lightning."

DCM™ is a trademark of Vicor Corporation.

Battery management systems and the role of the sensor in EV driving range and safety

The latest sensors used in electric vehicles (EVs) not only help to prevent on-board fires but also contribute to tackling the driving range challenges, says **Jérémie Piro, Global Product Manager BMS at LEM**

Whenever EVs are discussed, the number one topic raised is range - the distance that they are capable of travelling on a single charge. Even though distance travelled on a full tank is usually a long way down the list of criteria for most people buying a petrol or diesel vehicle, for EVs it is at the very top.

Despite the average car journey being around 10 miles, drivers insisted in a recent survey that what they expected from an EV was the ability to drive around 375 miles on a single charge. Of course, the reality (at the time of writing) is that most drivers will not be able to travel anywhere near that distance on a fully charged EV lithium-ion (Li-Ion) battery.

This highlights a clear dilemma for the automotive sector. The technology used in EVs is completely different to what customers are familiar with and comparisons with the internal combustion engine (ICE) are erroneous.

There is another criterion that is increasingly governing people's choice of electric vehicles – safety, in particular from the risk of fire. This topic is expected to take on even greater importance in the coming years.

Why has safety become such a major issue? Simply because as modern EVs need to be designed to charge faster in order to satisfy the demands described earlier, on-board systems are going to have to deal with higher current and higher voltage and this will require greater isolation. There is a genuine concern in the automotive sector – whether among OEMs, manufacturers of EV chargers or charge point operators – that while it is vital to deliver all the benefits drivers are looking for, there has to be an absolute priority given to avoiding any possibility of leakage or fire within vehicles.

State of charge, state of health

The battery management system (BMS) installed in every EV is the main component of a vehicle's battery pack. It fulfils two essential requirements for the driver. Firstly, it evaluates the state of charge (SoC), which is the level of charge of an EV battery relative to its capacity. This dictates the driving range that the vehicle can achieve. Secondly, the BMS manages the battery pack's state of health (SoH) with an on-board safety function designed to prevent leakage or fire. The more accurate these evaluations are, the happier motorists will be in terms of addressing driving range anxiety as well as concerns over safety.

For a BMS to deliver these vital functions, it has to incorporate reliable sensing elements. Not surprisingly current sensors are key components of any BMS and these devices have gone through significant changes as demands increase from the EV sector.

LEM has recently developed the third generation CAB series of transducers for delivering SoC figures with optimum accuracy. The premium CAB range was first developed for battery management systems 12 years ago and has evolved as customer requirements have altered. The first model represented a breakthrough technology that made it possible to achieve more accurate current measurements by eliminating magnetic offset and delivered contactless current

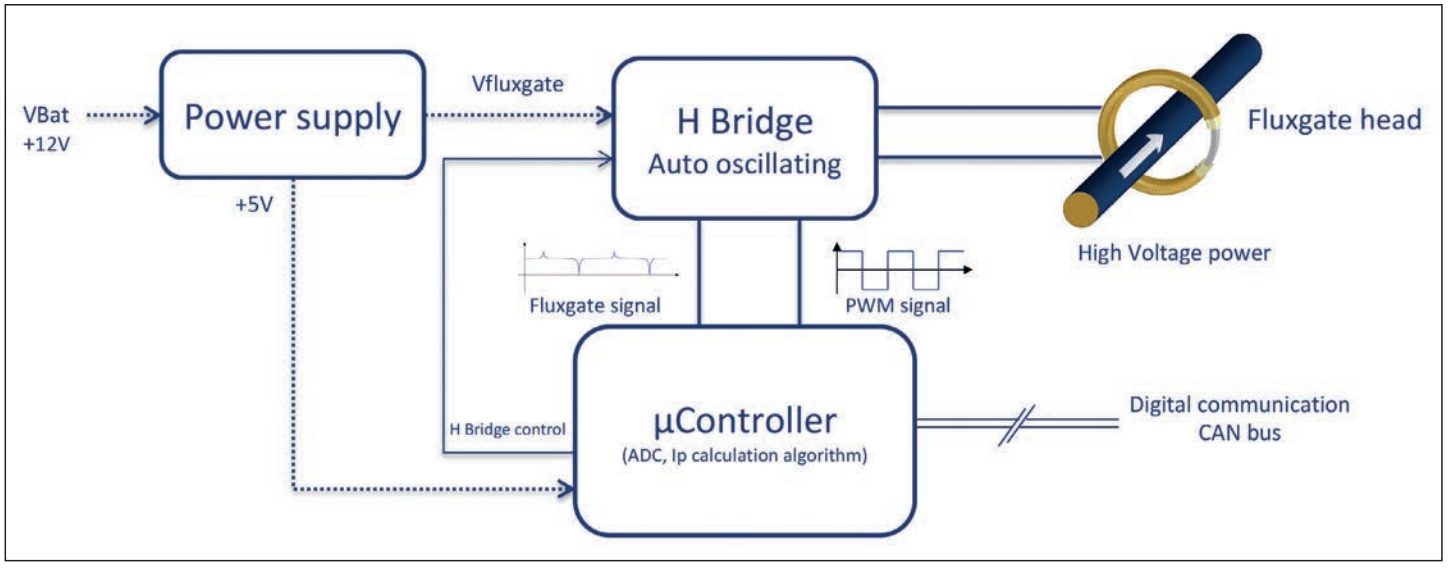


Figure 1: **In the CAB 1500, the fluxgate sensing head's induction coil ensures rapid transition between linear and saturated state.**

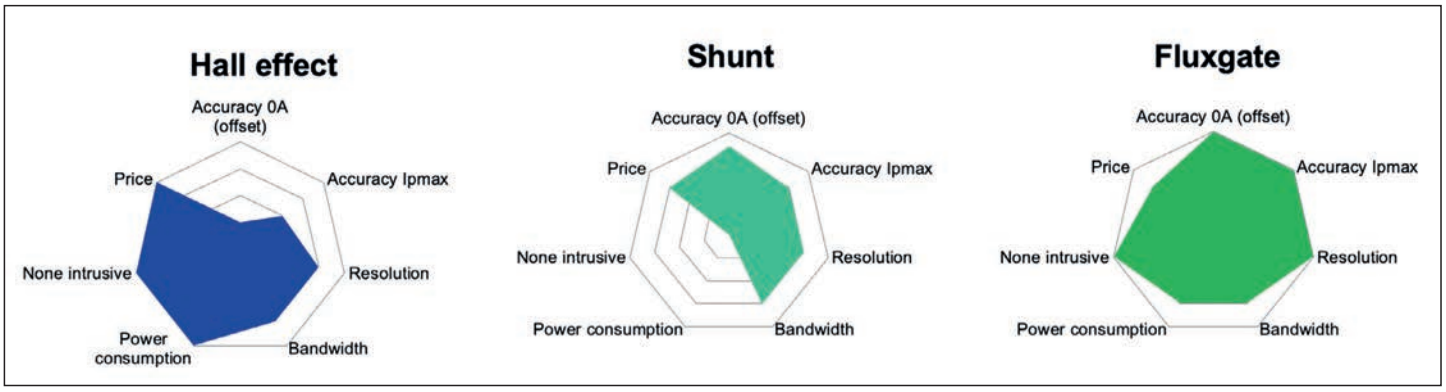


Figure 2: Fluxgate technology offers resolution up to 0.1%, Ip max accuracy and offset, non-intrusive measurement and isolation up to 2.5kV combined with lower power consumption than shunt technology.

measurement. The next model had a higher current range (from 300A to 500A) and improved safety levels.

The latest iteration of the transducer is the CAB 1500 with an extended current range of up to ±1500A. In terms of functional safety, this ASIL (automotive safety integrity level) C device complies with ISO26262. Additionally, it makes redundant current measurement possible using just a single current sensor in the BMS instead of a pair, due to two internal independent channels. Integral electrical features for safety management include over-current detection, with an internal error flag set to one when current is above 1600A, a safety goal violation flag set to one (depending on plausibility check results between the analogue and digital channels), a sequence counter and a CRC (cyclic redundancy check) for end-to-end communication protection.

The CAB 1500 has the ability to treble the current range within the same footprint as earlier models. It is also claimed to deliver best-in-class accuracy of 0.5% over a temperature range of −40°C to +85°C. As well as its extremely low offset, which enables accurate coulomb counting for SoC estimations, the sensor uses the non-intrusive measuring principle while offering full galvanic isolation and compatibility with 800V applications.

Other key features include the option to be busbar or panel mounted and a unipolar +12V battery power supply. The fluxgate sensing head is made of an induction coil which combines very high permeability with low remanence (Hc), ensuring rapid transition between linear and saturated state. Fluxgate technology is particularly suitable for battery management systems because it offers resolution up to 0.1%, best in class accuracy Ip max and offset, non-intrusive measurement and isolation up to 2.5kV, and low power consumption when compared to shunt technology.

Sensors take to the road

Incorporating the most advanced current sensors into new battery management system designs, engineers can differentiate products in a competitive market. With sensors becoming smarter, developers are able to incorporate more advanced software which makes it easier to collect and process greater amounts of data in a single device. At the same time, designers will be enabling automotive manufacturer customers to put the EVs they offer at the forefront of the marketplace in terms of performance, cost and safety.

Anticipating the need for higher safety levels, LEM is working actively on two new concepts. The first is to increase features as the sensor become multi-functional and take on the role of sensing a wider range of different factors within the battery disconnect unit. For instance, while a current sensor would traditionally sense the battery pack current only, it is now also expected to monitor the pack voltage at different locations as well as detect any hot spots. Additional features such as triggering the pyrofuse in case of any over-current or monitoring the high voltage pack insulation to ensure there is true isolation between the battery pack and the mass of the car's chassis is also becoming popular. These reflect a trend to turn the current sensor into a sensing hub to service the BMS.

The second concept is based on two different technologies to sense the current. Putting 'shunt + Hall' in a single package may not be revolutionary but it represents a very competitive solution. The company claims that by combining its 50 years' of sensing experience based on the open loop technology with a new ASIC, makes it possible to reach very high accuracy levels for the redundant path. This concept can be used as a standalone module or in addition to a multi-point sensing module and offers an optimised and robust sensing head which is easily compatible with the highest rank of safety level, ASIL D.

Mapping the route ahead

In summary, demands within the automotive sector are pushing the technological advances required to satisfy them. It may be sobering news for those 'playing catch up' that the demands are only going to get stronger and more challenging. The only way to 'get ahead of the game' is to embrace the kind of technology that will enable them to achieve a quantum leap in the market. At the very core of these advances in the EV sector will be current sensors operating as part of sophisticated BMS that will take EVs to new levels for range and safety.

Looking to the future, the current sensor is set to become a crucial part of the intelligence of a BMS where data will need to be transferred to the BMS simultaneously. Cost and mechanical integration will also be key factors as the market moves forward, because the BMS and battery pack will have to become smaller and lighter.

www.lem.com

Low power Wi-Fi opens doors in smart buildings and industry

Adding Wi-Fi 6 enhances current IoT applications while enabling many new ones.

By **Finn Boetius, Product Marketing Engineer, Nordic Semiconductor**

The proliferation of protocols enables many new applications in cities, buildings and vehicles.

According to the Wi-Fi Alliance, the organisation that promotes the use of Wi-Fi, the economic value derived from the technology is $3.5 trillion. (Global Economic Value of Wi-Fi 2021 - 2025.)

The alliance says there are 18 billion Wi-Fi devices in use and 4.4 billion annual shipments, of which 2.3 billion meet the latest Wi-Fi 6 standard. That makes Wi-Fi seriously big business, with much of its huge popularity down to Wi-Fi's internet protocol (IP) interoperability. This allows a Wi-Fi device to connect directly to the cloud using any of the millions of already-installed access points (AP).

Public Wi-Fi access will benefit from the new standard's high bandwidth and speed, for example allowing large numbers of users in malls or at airports to make quick purchases and stream videos or music.

Moreover, the adoption of Wi-Fi 6 has made the technology better suited to the IoT (internet of things), where it complements existing IoT technologies used for low power networks, for example, Bluetooth LE and Thread. Wi-Fi 6 offers higher throughput and longer range than these other protocols, allowing it to enhance existing IoT applications while enabling new ones.

Building Wi-Fi 6 for the IoT

Wi-Fi 6 introduced many enhancements to the specification but those most useful for IoT solutions are OFDMA (orthogonal frequency division multiple access), beamforming, longer symbol duration, target wake time or TWT, a new power saving mode (PSM) and basic service set (BSS) colouring (a method of differentiating between APs broadcasting on the same channel).

TWT and OFDMA make the most significant contribution to power saving and enable energy-constrained devices to use the benefits of Wi-Fi where it might not have previously been possible.

Earlier versions of the Wi-Fi standard do include PSM, but these are controlled by the AP and offer limited flexibility to the end device. Generally the end device has to remain awake to receive the AP's beacon ahead of any data exchange, which effects battery life.

By contrast, the TWT PSM included in Wi-Fi 6 enables the end device to individually negotiate a wake-up schedule with the AP. This allows it to sleep for defined periods, helping cut power consumption significantly and allowing data exchange to happen at the agreed wake-up time. A further benefit of TWT is that it enables interference mitigation by letting the AP allocate dedicated time slots for each end device's data transfer.

More sub-carriers allow larger sensor networks

The OFDMA employed in Wi-Fi 6 allows for a higher number of sub-carriers within a single Wi-Fi channel. For example, a 20MHz channel can be further divided into 117 sub-carriers each side of the channel's central frequency. Groups of sub-carriers can then be allocated to a certain end device while other groups can be allocated to different end devices depending on the data traffic requirement.

This technique is called multi-user uplink/downlink. It does add complexity to AP side of the link but not to the IoT end device because that only needs to operate with its dedicated sub-carrier frequencies. OFDMA is particularly useful for large IoT sensor networks with many end devices, but with each needing to send only a small amount of data, because it enables dynamic, flexible and highly efficient division of the available spectrum bandwidth. Using full specification Wi-Fi 6, up to 1,500 devices can be connected using a single AP. This can make Wi-Fi 6 particularly useful in, for example, airport applications, resolving the current challenges of sporadic coverage and time lags that hinder legacy services.

Without OFDMA, a large sensor network would typically generate a lot of channel congestion, as Wi-Fi client devices attempt to access the medium without much co-ordination, causing higher interference levels and resulting in reduced throughput.

The multi-user uplink/downlink feature will allow Wi-Fi 6 routers to improve wireless performance in the home, allowing greater use of smart home devices as well as resolving streaming difficulties with neighbouring users.

Nordic Semiconductor has introduced a Wi-Fi companion IC, the nRF7002, that will add low power Wi-Fi capabilities to embedded IoT systems. It can be used to enhance existing applications. For example, the high throughput is useful for scenarios when an IoT end device must transmit occasional high volumes of data – such as when the device performs over-the-air (OTA) updates for complex firmware.

New uses in home and industry

The companion IC is designed to complement the company's multi-protocol SoCs (system on chips) and cellular IoT SiPs (system in packages) and is controlled by the SoC or SiP's embedded Arm microprocessor. The companion IC incorporates co-existence technology to ensure it doesn't try to transmit on the 2.4GHz frequency at the same time as a Bluetooth LE SoC.

The combination of multi-protocol SoC or cellular IoT SiP and Wi-Fi 6 companion IC enables many new applications. For example, the companion IC boosts throughput to support applications such as security cameras. It also allows the addition of Wi-Fi location services to GPS asset tracking devices.

In the smart home, Wi-Fi's native IP interoperability is being leveraged by the Connectivity Standard Alliance's recently introduced Matter standard. This protocol works by building on top of existing smart home wireless technologies (Thread, Bluetooth LE and the Ethernet wired protocol) by providing a unifying application layer. Wireless Matter devices will use either Thread or Wi-Fi for transport (and Bluetooth LE for commissioning). The Matter application layer makes it simpler for Thread devices to communicate with a Wi-Fi network and from there to the cloud. Wi-Fi also boosts range and offers higher security for sensitive data transfers than Bluetooth LE.

The single band (2.4GHz) nRF7001 is for use in cost-optimised designs.

The nRF7002 Wi-Fi companion IC will add low power Wi-Fi capabilities to embedded IoT systems.

In industrial automation or warehouse applications, the companion IC will play a vital role in making it easy to build a gateway between low power Bluetooth LE or IEEE 802.15.4 -based networks and the cloud.

A dual band device

The nRF7002 is a dual band (2.4 and 5GHz) device which features a low power capable Wi-Fi radio, advanced security features and the 2.4GHz co-existence mechanism. The IC is compatible with earlier Wi-Fi standards (IEEE 802.11a/b/g/n/ac) in addition to Wi-Fi 6 (IEEE 802.11ax) and supports one spatial stream, 20MHz channel bandwidth, 64 QAM (quadrature amplitude modulation) and 86Mbit/s PHY throughput, OFDMA (downlink and uplink), TWT, BSS colouring and beamforming (on the receiver side). A 2.4GHz-only companion IC is also available.

When powered from a 2.9 to 4.5V supply, the companion IC's radio operates with a peak transmit current (2.4/5GHz) of 191/260mA and a peak receive current of 60/56mA. Sleep current, with real time clock (RTC) is 15µA and shutdown current is 1.7µA. With TWT (2.4GHz, 60s interval), the average current is 29.5µA, reducing to 18.2µA for one day intervals. Sensitivity (1DSSS, 2.4GHz) is -98.6dBm and TX (max) (2.4/5GHz) is 21/15dBm.

The device supports the Wi-Fi Protected Access (WPA)3 security protocol which features increased cryptographic strength and more robust authentication. This support for WPA3 removes some of the security burden from the host side.

The companion IC implements the IEEE802.11 physical layer (PHY) and medium access control (MAC) firmware only. The Wi-Fi driver and Wi-Fi and TCP/IP (transmission control protocol/IP) stack are held on the host processor. Communication between the MAC and the other parts of the stack is via the IC's SPI (serial peripheral interface) or quad SPI (QSPI). There is a development kit to introduce developers to a multi-protocol SoC and Wi-Fi companion IC.

The company also offer the nRF7001, which is a single band connectivity of 2.4GHz intended for use in cost-optimised designs.

Extending location services

The Wi-Fi companion ICs make it straightforward to add Wi-Fi SSID location services to existing products such as asset trackers.

For example, one can be used with a cellular IoT SiP to enhance location accuracy. Together with the company's nRF Cloud Location Services, the SiP can use cell-based (single- or multi-cell) and/or GPS-based (assisted- or predictive-GPS) location features. Wi-Fi SSID locationing is more accurate than cell-based location features and less power hungry than GPS.

Wi-Fi excels where GPS struggles. For example, among a city's high buildings, the GPS signal can be patchy, yet there is typically a high density of Wi-Fi APs. Wi-Fi is also good indoors where GPS fails. The Wi-Fi companion looks for a nearby AP and obtains its SSID. The cellular IoT SiP then sends the SSID to nRF Cloud, which in turn checks a Wi-Fi AP database. nRF Cloud then returns the location, with the degree of uncertainty, to the SiP, or elsewhere.

With its higher throughput, longer range and power saving features, Wi-Fi 6 is set to boost the capabilities of embedded IoT systems - opening new applications for wireless technology in virtually every market.

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Emerging high frequency, high power applications need a rethink on capacitors to maintain power integrity

There is an alternative to using traditional multi-layer ceramic capacitors (MLCCs) to fulfill high frequency power demands in IoT devices, mobile phones and high performance computing applications. By **Mukund Krishna, Senior Manager, Product Marketing and Luca Vassalli, Customer Applications Engineering Director, Empower Semiconductor**

As one of the most fundamental components in electronics, capacitors are used in large numbers across a variety of designs to maintain power integrity. They are a key requirement for applications such as mobile phones, IoT devices and HPC (high performance computing) applications and address last mile power delivery challenges, such as high frequency power demands for the high performance processors. While traditional MLCCs have fulfilled the requirements thus far, stricter constraints on power density are challenging the continued usage of the existing model.

As system engineers look to deliver the promised and expected performance in smaller form factors, provision of the most efficient power de-coupling solution is a critical design consideration.

It is currently estimated that over one trillion capacitors are produced every year, of which 800 billion are surface mount MLCCs or chip capacitors.

These are used to address requirements across the complete power and voltage range in applications, including energy storage, filtering and decoupling of power rails to filter out unwanted ripple and noise. The exponential growth in the creation of HPC has been led by the rapid advent of artificial intelligence and machine learning (AI and ML).

The magnitude and frequency of instantaneous power demands are growing in steps of 100% for subsequent generations, placing stress on power integrity solutions.

When it comes to the latest data-intensive systems built around high performance, high speed processors and multiple power domains that operate with fast transients and low voltages, designers are finding a growing number of challenges with conventional MLCC capacitors.

These processors are increasingly used on highly dynamic workloads, such as running AI algorithms and neural network models for ML and inference. For such applications, the peak current swings become significant, with instantaneous peak processor currents of 800A to 1000A in tens of nanoseconds becoming the norm. This results in extremely challenging current transients (di/dt). These high-performance devices usually require multiple low voltage (0.4V DC to 1.0V DC) power rails and tight adherence to voltage regulation specifications, typically within ±1.0%.

Board-mounted switching DC/DC converters offer a viable method of provisioning high power direct to computational devices such as FPGAs, GPUs, and neural network processors (NPUs).

While the DC/DC converters mounted on the PCB provide adequate DC power to these workloads, their frequency of operation, and hence bandwidth (which is the ability to respond to ultra-fast current transients), is orders of magnitude lower than required. The sheer volume of such solutions render them being located at distances far enough away that any ability to service fast transients is rendered useless by the high impedance to the processor.

The electrical noise generated from transients, power supply ripple and other noise artefacts can significantly impact the performance of the computational ICs and other circuit functions. Signal integrity is tightly associated with power integrity in any complex application, and such artefacts can create 'ringing' oscillations across the whole system. Digital processors made with advanced process nodes such as 5nm have extremely tight tolerances on voltage supply to avoid brown-out at the lower end and over-voltage at the upper end. Analogue ICs used in data conversion signal chains are particularly vulnerable to PDN (power delivery network) noise, with its power supply rejection ratio as a critical indicator of susceptibility. As any analogue IC's datasheet will highlight, small variations of supply voltage can upset the function's operation. For example, the introduction of jitter on clock signals or the reduction of analogue conversion accuracy.

Decoupling power rails

Minimising transient, ripple and noise artefacts from the PDN in high frequency, high performance applications is paramount. To decoupe PDN noise artefacts, multiple capacitors, typically MLCCs of different values and case sizes, are placed across the supply rails. The aim is to provide a low impedance return path across a wide frequency range. To provide the most effective noise cancellation, the capacitors are placed closest to the noise sources and the power pins of sensitive ICs. Board layout will influence MLCC placement, but this situation is exacerbated by larger processor ICs requiring tens of capacitors. At higher switching and computational frequencies, PCB trace parasitics and the equivalent circuit characteristics of the MLCCs also become significant.

As high frequency processing

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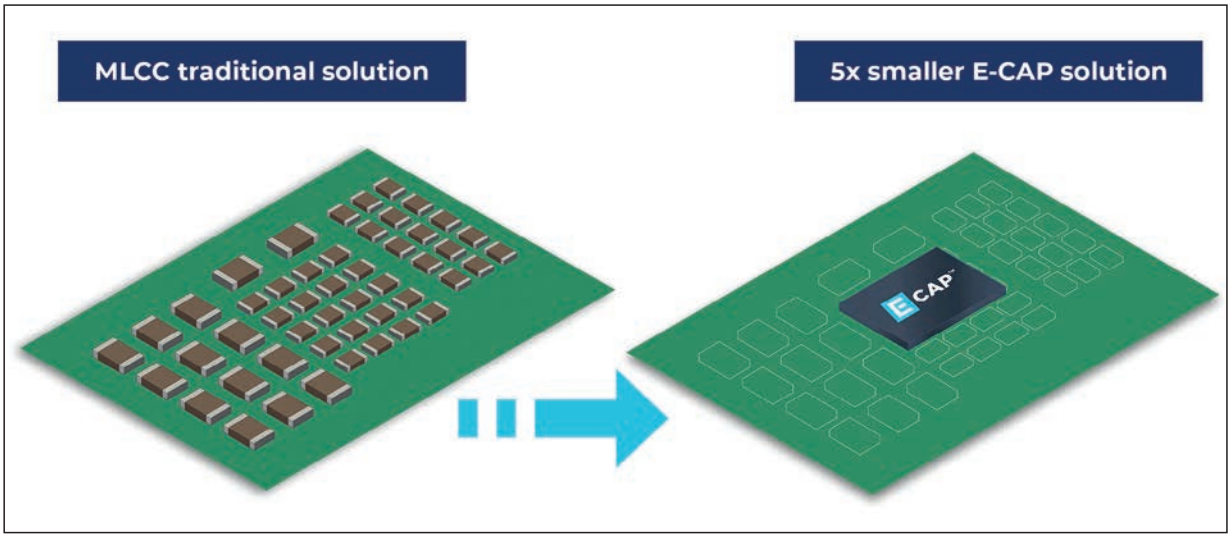
applications become the norm, several factors will limit MLCCs' abilities for specific applications. There are several parasitic factors that will cause a capacitor's impedance to change across frequency. The equivalent circuit of a capacitor includes a series resistor (ESR) and series inductance (ESL). For example, the metal electrodes and end caps contribute to an equivalent series inductance or ESL that impacts the capacitor's resonant frequency. All things being equal, the lower the ESL, the higher the resonant frequency. Above its resonant frequency, a capacitor's effective impedance becomes inductive in nature, i.e., increases with frequency. There is an imperative to keep ESL as low as possible for capacitors used in high performance, high frequency applications.

Another critical issue is capacitor de-rating. Key de-rating factors that impact MLCCs are voltage, temperature and age.

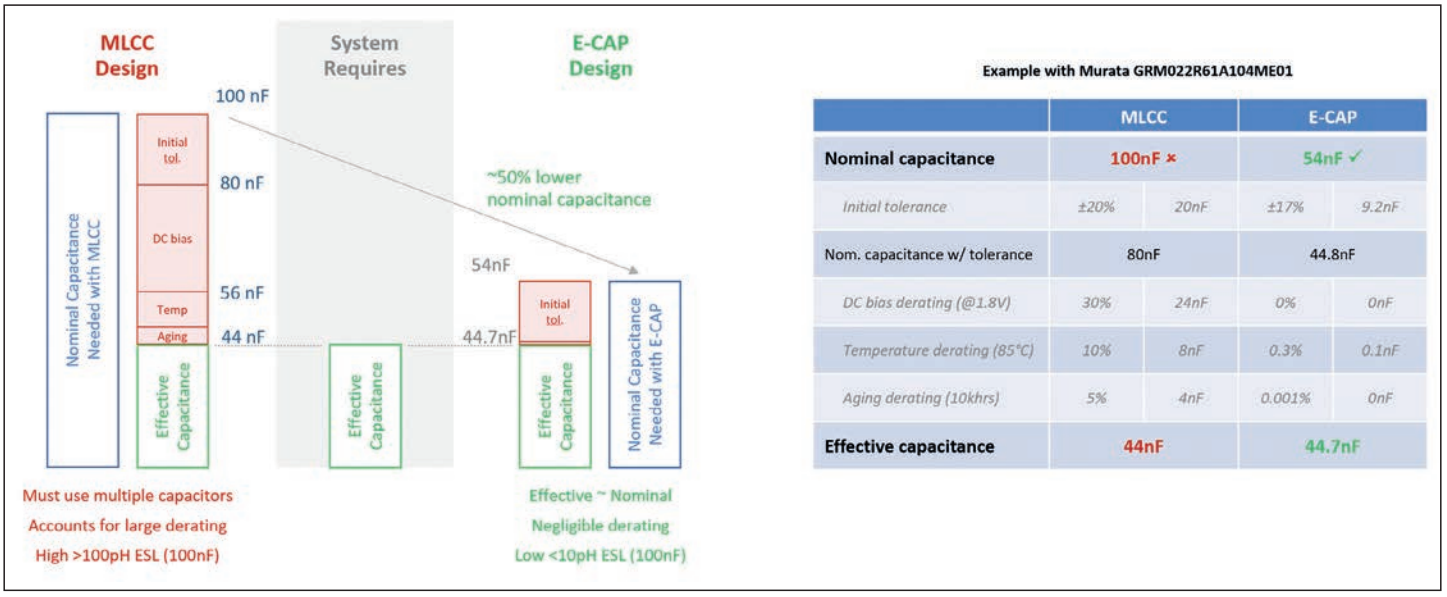
An average MLCC will see its capacitance value reduce as the DC bias voltage increases. Capacitance also reduces as the temperature increases, with the degree of change dictated by EIA (American Electronic Industries Alliance) code used to classify the temperature co-efficient. AC or DC bias voltage has an impact on ageing characteristics that produce a decrease in capacitance over time due to changes in the dielectric's crystal structure. Increasing the number of MLCCs to address these characteristics ensures that the necessary decoupling capacitance is provided over the product's lifetime and across the entire anticipated range of operating conditions. Accommodating the many MLCCs, however, effects the product's mechanical design attributes, from form factor and power density to PCB layout flexibility, reliability, and cost. In general, the more capacitors that are deployed, the further away the capacitor network is likely to be from the processor, increasing the series inductance and introducing further opportunities for parasitics, especially at high frequencies. The product's calculated reliability metric will also be lower because the overall component count negatively influences reliability.

Differences between MLCCs and silicon capacitors

MLCCs are formed by alternating plates of metal (electrodes) with a dielectric material in between. The long plates connect to the terminals on either side providing contacts to the outside world. Since parasitic inductance is proportional to length of the metal path that current or charge must travel along, the long electrodes within MLCCs lead to inherently higher ESL.



Silicon capacitors, like E-CAP, can improve layout density compared to standard MLCCs.



	MLCC		E-CAP	
Nominal capacitance	100nF ×		54nF ✓	
Initial tolerance	*±20%*	*20nF*	*±17%*	*9.2nF*
Nom. capacitance w/ tolerance	80nF		44.8nF	
DC bias derating (@1.8V)	*30%*	*24nF*	*0%*	*0nF*
Temperature derating (85°C)	*10%*	*8nF*	*0.3%*	*0.1nF*
Aging derating (10khrs)	*5%*	*4nF*	*0.001%*	*0nF*
Effective capacitance	44nF		44.7nF	

Figure 2: **Comparison of MLCC nominal capacitance values to achieve a desired effective capacitance goal. (Source: Empower)**

Silicon capacitors are relatively new, created by vertical trenches in silicon using an ultra-fine lithography process. This allows many capacitors to be formed in a very small space where electrodes are orders of magnitude shorter than MLCCs, providing the same order of magnitude reduction in ESL. A large number of such capacitor cells (100s or 1000s) are connected in parallel to form a single capacitor further reducing effective ESL. Standard metal layers available in silicon-based semiconductor processes can connect to the electrodes anywhere on the silicon die, enabling termination flexibility and performance. Using silicon-based semiconductor processes also provides an inherent stability against variations in voltage, temperature and ageing that MLCCs struggle with, resulting in a much more stable and reliable product.

There is an immediate density improvement for silicon capacitors compared to MLCCs for the same effective capacitance and decoupling requirements. Empower's E-CAP silicon capacitor portfolio, for example, features a single capacitor of 220nF that fits standard 0201 footprints, up to an array of 17 single capacitors (4,800nF) in a single, low profile, surface mount, chip scale package (Figure 1).

The combined impact of an MLCC's ageing and de-rating factors is illustrated in Figure 2. The table in Figure 2 showcases a 54nF E-CAP compared to an example 100nF MLCC. The effective capacitance achieves the required 44nF, but the E-CAP achieves this with only the initial tolerance specification added. It is also more resistant to ageing. In this example, double the number of MLCCs would be required, effecting board space and layout.

Impedance versus frequency

Figure 3 illustrates how the low ESL attributes of an E-CAP offer high frequency impedance characteristics above 50MHz. For example, an average MLCC may have an ESL of 200pH compared to an E-CAP's 15pH. Even a commonly used network of MLCCs with reducing values and case sizes features more than two times the impedance at many 100s of MHz than a solution using E-CAPs which uses 40% fewer components.

An examination of the physical placement of capacitors is warranted to ensure their effective utilisation. When series inductances in the order of pH start to make an impact on the de-coupling capability, the inductance of the traces connecting the capacitors to their de-coupling points start to feature the same order of magnitude as the capacitor's ESL. Placing such capacitors too far away will render them useless and the benefits versus MLCCs may not be apparent.

High performance processors are typically mounted as die on silicon substrates that are then moulded over to form a package. The packages house multiple die, i.e., the processor, memory, communications chips, as well fan out the fine pitch of the die (e.g., 150µm) made in deep sub-micron processes to a manageable I/O pitch for PCB mounting (e.g., 500µm). There are multiple levels of

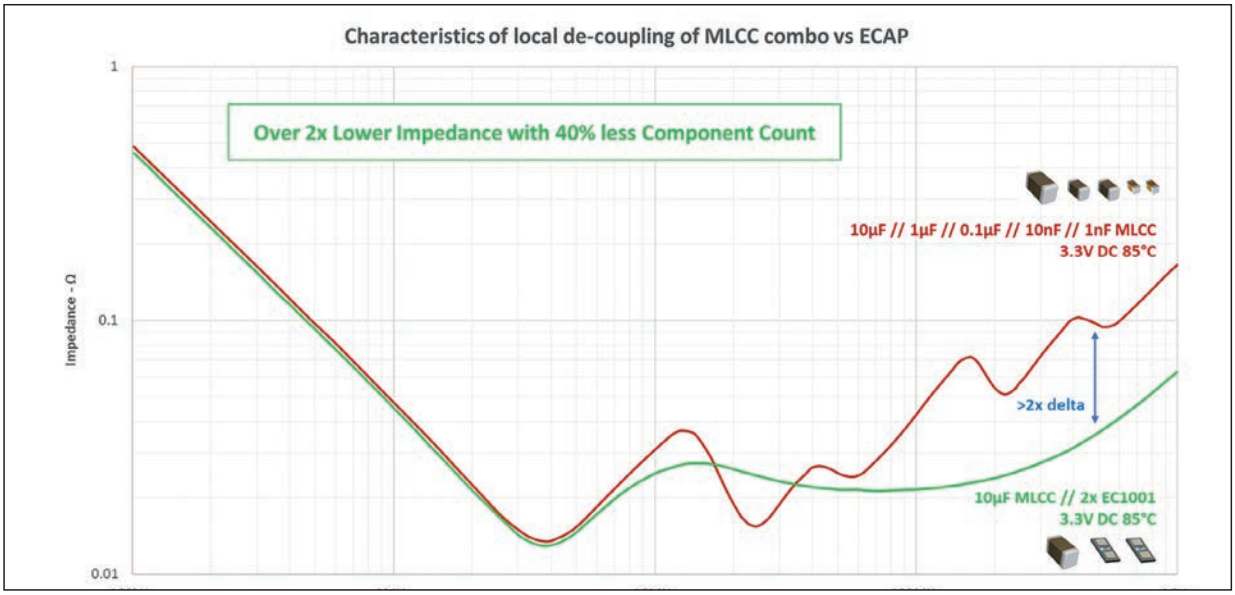


Figure 3: **Impedance versus frequency curves comparison of MLCCs and E-CAPs. (Source: Empower)**

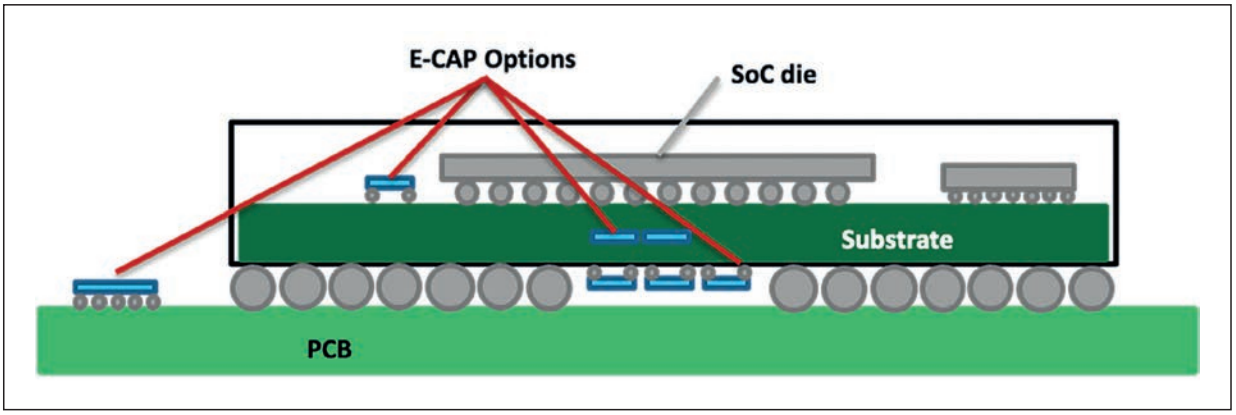


Figure 4: **E-CAP mounting locations.**

layers separating the processor die pins and the PCB (see figure 4).

A de-coupling capacitor located on the PCB is thus separated by impedance contributed by the many steps to reach the processor die pins.

De-coupling capacitors on the processor die are limited in capacitance and are meant to de-couple the transients with signatures exceeding 1GHz. Capacitors placed on the PCB will see at least two levels of RL impedances to get to the pins of the die. Since E-CAPs demonstrate low ESL and superior de-coupling capability up to many 100s of MHz, their ideal location should be on the SoC package, so that they see minimal impedance to the processor die pins.

Silicon capacitors can be realised in profiles down to 50µm and therefore capable of being located within the processor package in tight spaces such as the ball-height of the package, or even embedded within a package substrate which would provide the lowest possible impedance to the processor pins (apart from the on-chip capacitance themselves).

High frequency integrated voltage regulators

Another notable trend for DC/DC converters used in high performance applications are integrated voltage regulators (IVRs). IVRs leverage high switching frequency techniques in DC/DC converters, enabling orders of magnitude higher bandwidth, and fast response to load steps with minimal droop and recovery. Often neglected at low frequencies, the ESR and ESL of the output capacitor become critical design elements for IVRs that operate at high frequencies, in order to minimise noise and ripple.

IVRs are meant for PoL (point of load) power, targeting output voltages from 0.4V to 2.0V. Figure 5 illustrates the difference in ripple of solutions that use MLCC vs E-CAPs on the output ripple signature of a DC/DC converter operating at 10MHz. In addition, the ripple waveform is smoother, resulting in fewer harmonics limiting the EMI signature of the design.

Growth in demand

Over the last decade, the demand for high power applications has grown considerably. Use cases such as compute-intensive server boards used for cloud computing, machine learning deployments, the rise of electric vehicles (EVs) and the need for fast, energy-efficient charging stations are just some examples. There is also the need for ever-faster computing and highly dynamic computational workloads in high frequency, high bandwidth systems and in power conversion applications, high frequency switching topologies yield fewer energy losses while reducing the size of the critical supporting inductors and capacitors. With these game-changing technological innovations, power rail decoupling is even more critical than before. The availability of silicon-based capacitors significantly aids the development of these high frequency, high power applications.

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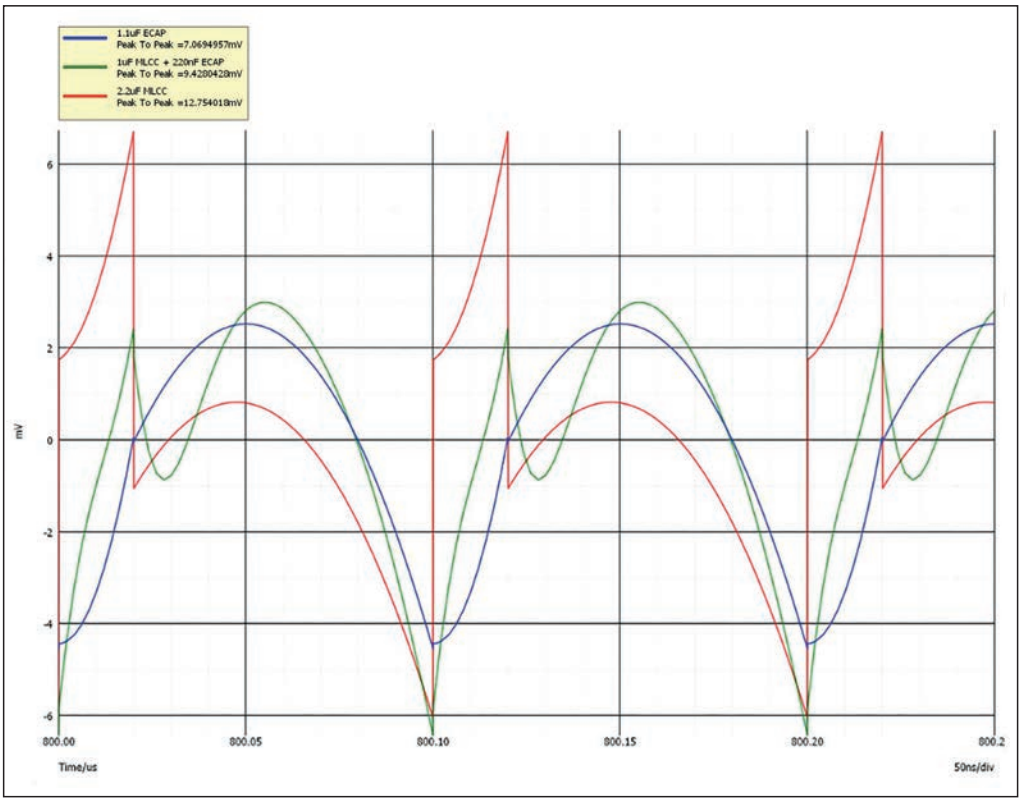

Figure 5: MLCC / E-CAP output ripple comparison at 10MHz, showing the MLCC at 12mV and E-CAP at 7mV.

Parameter	Standard MLCC	ECAP
DC bias de-rating	*44% @ 3 V*	*None*
Temp de-rating	*-11% up to 85°C*	*Negligible - ~0.3% (measured in ppm / K) – equivalent to C0G*
Aging	*~5-10% / 10k hrs*	*<0.001% / 10k hrs*
ESL	*>100pH (100nF)*	*<10pH (100nF)*

Table 1: Summary of technical differences between a conventional MLCC and a silicon E-CAP.

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How GaN-based power can smooth the road ahead for smaller, more efficient, cost-effective automotive infotainment systems

In-vehicle infotainment systems poses a challenge to vehicle power design, explains **Renee Yawger, Marketing Director at Efficient Power Conversion (EPC)**

In the rapidly evolving landscape of automotive technology, in-vehicle infotainment systems have become more than just a luxury – they are an integral part of the driving experience and becoming increasingly critical as the demand for connected and autonomous vehicles increases. In-vehicle infotainment systems are tasked with providing better connectivity solutions, improved vehicle safety and enhanced in-vehicle user experiences. Modern infotainment systems offer a plethora of advanced features, ranging from touch screen capabilities and Bluetooth communication to digital and high-definition TV, satellite radio, GPS navigation and even gaming. The integration of these features poses a challenge to the vehicle's power system, demanding more efficient and compact power solutions. Gallium nitride (GaN)-based solutions can provide the higher power density, higher efficiency and lower cost designs that these systems require.

The combination of GaN devices and analogue controllers that are optimised to extract the peak performance of GaN are addressing this challenge by providing designers with high power density and cost-effective solutions.

FET selection

GaN devices are characterised by their smaller size and lower capacitance compared to conventional silicon MOSFETs. This characteristic has significant implications for power efficiency and performance. The figure of merit (FoM) of GaN transistors compared to silicon (Si) MOSFETs enables the design of systems that can operate at much higher efficiency levels, leading to smaller, more efficient, cooler-running, and cost-effective solutions. All these features are critical to in-vehicle infotainment systems.

To illustrate the practical implications of this improvement in FoM for the design of an in-vehicle infotainment system, consider the example of the EPC9160. This design is a dual output synchronous buck converter that operates at a 2MHz switching frequency, converting an input voltage of 9.0 to 24V to either a 3.3 or 5V output voltage, delivering up to 15A continuous current for both outputs. The design's high switching frequency contributes to its compact size; measuring

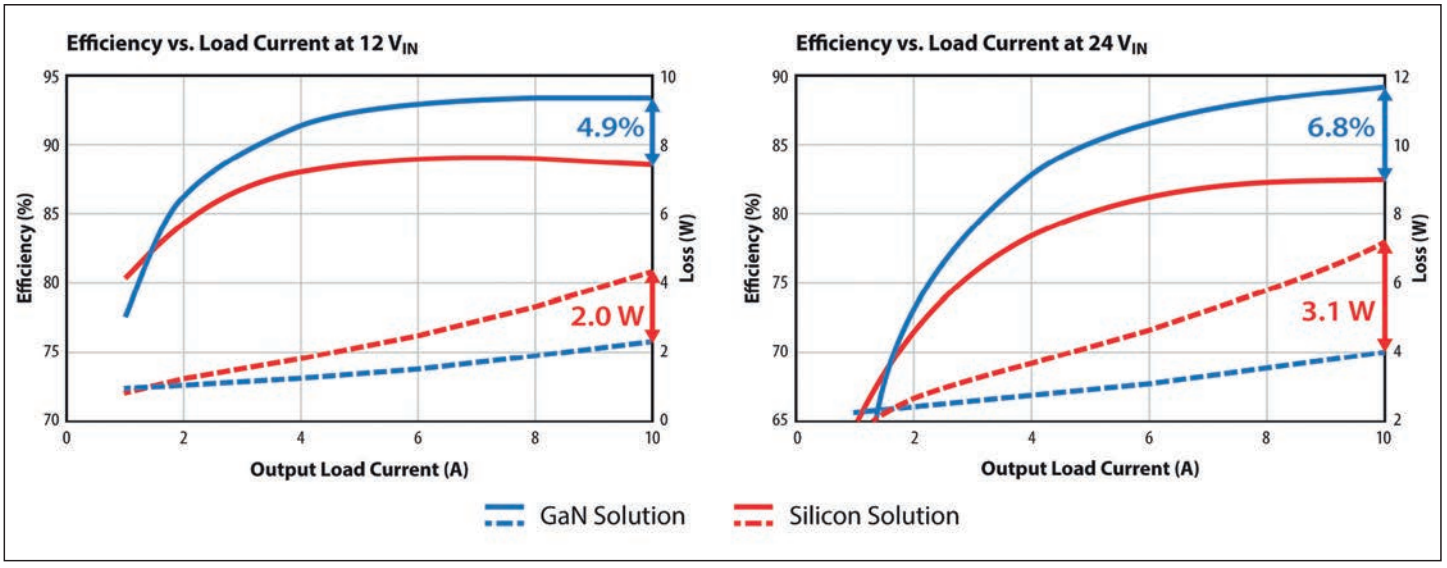

Figure 1: **Efficiency and power loss comparison of GaN FET vs Si MOSFET**

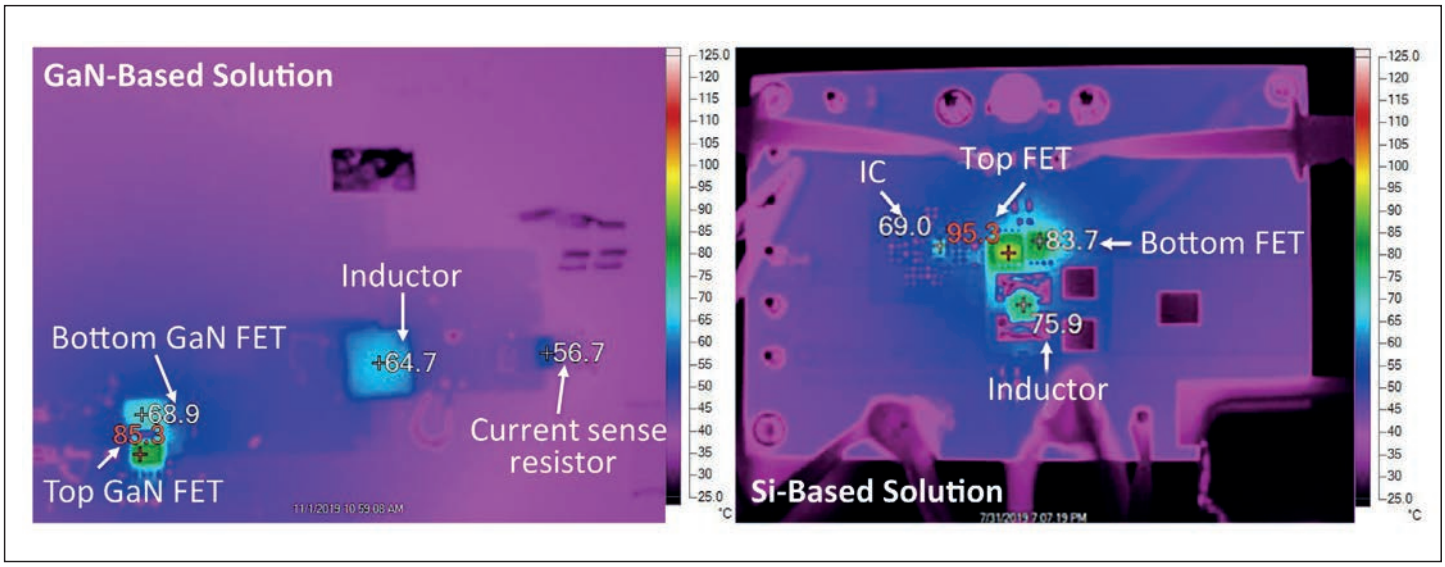

Figure 2: **Thermal performance comparison of GaN FET vs Si MOSFET**

23 x 22mm for both outputs with an inductor height of just 3mm.

The GaN FET chosen for this design is the EPC2055 40V, 3mΩ max RDS(on), 6.6nC QG, 0.7nC QGD, and 1.3nC QOSS, in a small 2.5 x 1.5mm footprint. It can deliver up to 29A continuous current and 161A peak current. It also exhibits very small switching losses at 2MHz switching frequency.

Controller selection

Conventional MOSFET analogue controller ICs are not fully compatible with GaN FETs because of the specific driving needs. For example, there is no over-voltage management for the bootstrap supply in the event where the lower FET reverse conducts, and high negative voltage spikes on the switch node during dead time can lead to unpredictable timing behaviour. As a result, digital controllers such as DSPs have been used for GaN FET-based designs but require additional support ICs such as a current sense amplifier, housekeeping power supply and a GaN FET-compatible gate driver. This approach adds to the overall bill of materials (BoM) and increases design complexity. In contrast, the LTC7890 controller from Analog Devices is a 100V, low quiescent current, dual two-phase synchronous step-down controller with dedicated driver feature for GaN FETs. The small 6.0 x 6.0mm QFN package is fully optimised to drive GaN FETs. The LTC7890 integrates a half-bridge driver and smart bootstrap diode and offers optimised near-zero deadtime or programmable deadtime and programmable switching frequencies up to 3 MHz. It also has low standby power consumption. The integration of GaN-compatible analogue controllers with integrated gate drivers eliminates the need for additional support ICs, simplifying designs and reducing the overall BoM.

Optimising layout and thermal performance

One of the design challenges in leveraging GaN FETs lies in minimising parasitic inductances in both the gate and power loops. Power loop inductances, as well as gate loop inductances, impact switching behaviour and efficiency. The internal vertical loop layout is a technique that helps minimise switching losses and ringing. High- and low-side gate loop inductances must also be minimised to prevent gate over-voltage and ensure smooth operation.

Thermal management is another critical aspect of GaN FET design. Despite their efficiency, the compact size of non-packaged GaN FETs necessitates careful attention to heat dissipation. In the absence of a heatsink, maximising the number of vias beneath the GaN FETs becomes crucial. This approach enhances thermal heat-spreading from the FETs into the PCB's copper layers, ultimately improving overall thermal performance.

Design validation

The efficiency of the EPC9160 surpasses 93% for 5V output and 24V input. High switching frequency of 2MHz was chosen based on EMI requirements in automotive applications. It further demonstrates the fast switching speed of GaN FETs together with the smaller size of the inductor and capacitors. The EPC9160 power stage fits within an area of just 506mm^2 (W = 23mm, L = 22mm).

In a comparative analysis of systems built with GaN FETs vs systems built with Si MOSFETS, both operated at 2MHz and 10A, the GaN-based solution exhibited nearly 5% higher peak efficiency and 2W lower power loss at 12V input and nearly 7% higher peak efficiency and 3.1W lower power loss at 24V input (Figure 1). The superior efficiency and reduced power loss of GaN-based solutions also translates to cooler operation, as evidenced by a 10°C lower hotspot temperature than the silicon board in a thermal performance comparison (Figure 2). The vias underneath the FETs and the six-layer PCB with 2oz copper thickness help in reducing the temperature of the FETs by utilising heat spreading of the PCB copper layers.

In summary, the automotive industry is undergoing a transformative phase, and the demand for advanced in-vehicle infotainment systems that provide better connectivity, improved vehicle safety, and enhanced in-vehicle user experiences is on the rise. GaN-based power solutions that incorporate analogue controllers offer a path forward, allowing for smaller, more efficient, and cost-effective designs that meet the demands of these sophisticated systems.

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Addition to the RL78 family excels in performance stakes, says Renesas

The latest addition to Renesas Electronics' RL78 MCU family of eight- and 16-bit devices is the RL78/G24. It has the highest performance among all the devices in the RL78 family, says the company, enhanced by an application-specific flexible application accelerator (FAA) and a fast CPU that can achieve an operating frequency of 48MHz. Peripheral functions include analogue and timer capabilities, making the MCU suitable for motor control, power supply control and lighting control. Using the FAA enables the device to distribute tasks such as inverter control, encryption, sensing, and arithmetic operations independently of the CPU to "substantially" boost processing speed and shorten development time, says Renesas.

Developers can use MathWorks' model-based design to improve system performance and identify issues before implementing on the MCU, observes Brian McKay, Global Strategic Partner Manager, MathWorks. "Mutual customers can use RL78 virtual models in Simulink to gain a variety of capabilities, including generating production-quality code, processor-in-the-loop testing, and maintaining a digital thread," he adds.

The RL78/G24 also has a 12-bit ADC capable of simultaneous sampling three channels with a maximum conversion speed of 1µs. It also has a high speed comparator with a latency of 50ns (typical). It is also equipped with DALI-2 function for the lighting communication standard. Operating temperature is up to 125°C.

A standby function reduces power consumption, with the choice of Halt mode, which cuts power consumption by 60% compared to normal operation mode, and Stop mode, which reduces power consumption by 99% compared to Halt mode. These power-saving modes allow the device to use less power overall.

The MCU is supplied in a compact, 3.0 x 3.0mm package.

The Smart Configurator can be used to generate driver code for peripheral functions via a graphical user interface (GUI), similar to other RL78 devices. There is also a fast prototyping board, which comes with Arduino Uno and Pmod Type 6A interfaces and Grove connectors for access to all pins. The device can be debugged and programmed using only a USB cable. Evaluation kits for motor applications and power/lighting applications are also available.

AH39xxQ sensors detect speed and direction

A portfolio of high-sensitivity Hall-effect sensors make up theAH39xxQ. The robust sensors provide speed and directional data or two independent outputs. They are designed for industrial and automotive applications such as detecting rotational and linear speed/direction and determining the angular position of a rotating shaft.

To align with automotive battery requirements, the dual output Hall-effect sensors operate over a wide supply voltage range of 2.7 to 27V. They also have a 40V absolute maximum rating in order to safely handle 40V load

dumps. There is also -18V of reverse voltage protection to guard against incorrect battery connections. The electrostatic discharge (ESD) protection exceeds the automotive norms of 5kV human body model (HBM) and 2kV charge device model (CDM).

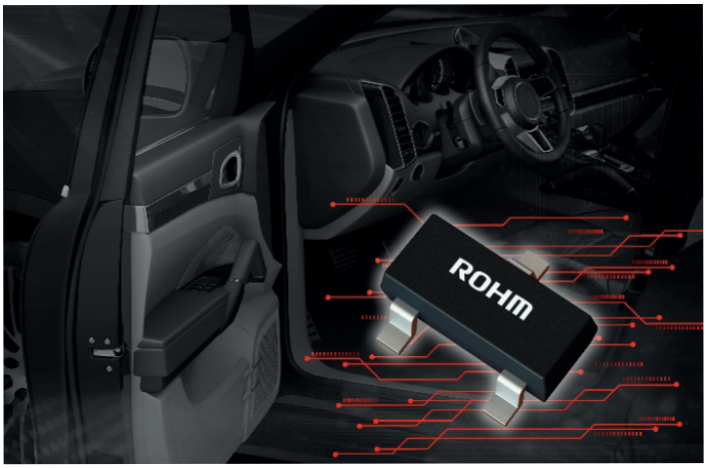
Three operating and release (BOP/BRP) options are available, with typical values of 10/-10 gauss, 25/-25 gauss and 75/-75 gauss. The narrow operating window ensures accurate and reliable switching points, says the company.

Dual-channel operation means the sensors can replace two latch switches, reducing PCB space and overall component costs. Combining chopper-stabilised amplifiers with an advanced Hall plate design mitigates switch point drift, says Diodes, to ensure accurate measurements over a broad temperature range.

There are also self-diagnostic features making them suitable for ISO 26262-compliant systems. The devices enter a safe operating mode if an error, such as over-temperature or under-voltage lockout, is detected.

The AH39xxQ series Hall-effect sensors from Diodes are AEC-Q100 Grade 0 qualified and manufactured in IATF 16949 certified facilities. They support PPAP (production part approval process) documentation and are supplied in TSOT25 packages.

Automotive HV ICs connect directly to 12V battery



The BD5310xG-CZ / BD5410xG-CZ series of Hall ICs have been designed for automotive applications which require magnetic detection. They are in response to the continuing computerisation of vehicle systems to meet demand for increasing electrification, comfort and safety, using additional

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electronic control units (ECUs) and sensors for control. Rohm notes that Hall ICs are one of the most adopted sensor types, with an ability to detect position and motor rotation in a non-contact manner that reduces the wear and tear suffered with mechanical switches. In addition, they are also compact and can be equipped with protection circuits.

Rohm explains that it has combined its Hall IC expertise, gained serving the mobile and consumer sectors, with original high withstand voltage processes. The resulting BD5310xG-CZ / BD5410xG-CZ series feature what is claimed to be an industry-leading 42V withstand voltage that enables direct connection to a primary (12V battery) power supply. This helps to improve reliability under battery power, which can fluctuate rapidly depending on the operating conditions.

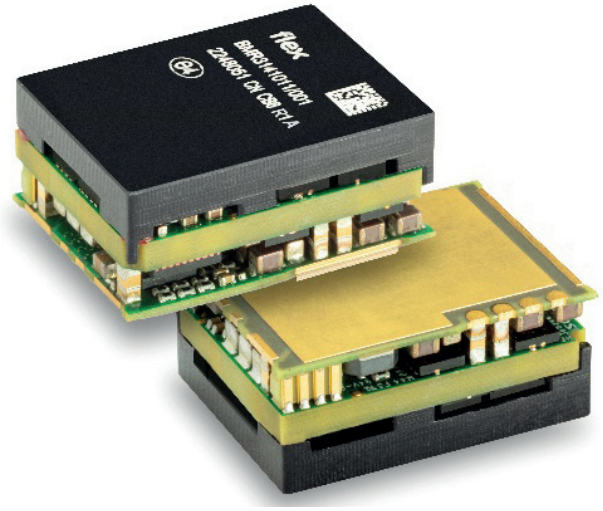
The wide operating supply voltage range of 2.7V to 38V enables support for a variety of applications for comfort and safety, including door locks, seat position, power windows.

The internal topology also reduces power consumption by approximately 20% compared with general products, to achieve an industry-leading current consumption of 1.9mA, claims Rohm.

Both series comply with the AEC-Q100 (Grade 1) automotive reliability standard while incorporating multiple protection circuits required for vehicle systems.

The BD5310xG-CZ series is a unipolar detection type and the BD5410xG-CZ series provides latch-type detection. There are 11 models in total, available in detection magnetic flux densities ranging from 2.0mT to 28.0mT. Unipolar detection can be used for detecting position in applications such as door open/close and door locks, whereas latch detection is suitable for rotation detection in various motors used in windows and sliding doors.

Digital non-isolated IBC has 4:1 conversion ratio



The non-isolated DC/DC converter has a fixed 4:1 down conversion ratio and provides 800W continuous, 1.5kW peak output from an industry standard package, measuring just 23.4 x 17.8 x 9.6mm.

Input range is 38 to 60V DC (68V DC peak) for an output of 9.5 to 15V DC.

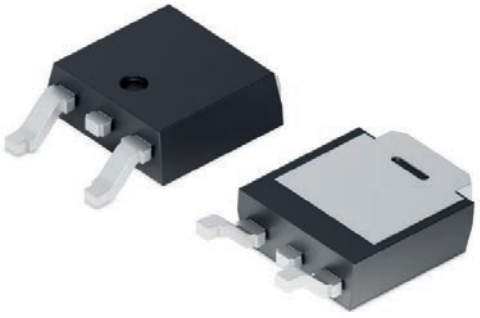
The BMR314 is targeted at applications such as powering point of load (PoL) converters in AI and datacomms centres where high peak loads can occur and where space is at a premium but energy saving is important. The converter has high efficiency of 97.4% peak in a low profile package optimised for cold wall cooling. Up to 70A output current is available and the device is protected against over-temperature, input under-voltage and output over-current, over-voltage and short circuits.

Control and monitoring are provided through a PMBus interface and MTBF is 7.47 million hours according to Telcordia SR-332 Issue 4 Method 1 at 40°C. Operating temperature range is -20°C and 125°C for a specified hot spot location. There is a timed warning and shutdown with over-temperature to minimise stress, particularly under peak loading conditions.

The DC/DC converter is available as a surface mount device with LGA terminations and meets the safety requirements of IEC/EN/UL 62368-1 for non-isolated converters and meets 'Class B' conducted EMI limits to standards EN 55032/CISPR 32/FCC part 15J with a simple external filter. It is supported by the company's Flex Power Designer software tool for configuration, performance simulation and monitoring.

BMR314 is now available for sampling and is planned to go into volume production in Q4 2023.

Littelfuse unveils first automotive grade P-channel MOSFET



The P-channel power MOSFET has low conduction loss and a maximum on-state resistance of 4.2Ω. It offers reduced power dissipation, decreasing heat generation and improving efficiency in the end applications. It also has a low gate charge of 11.9nC, for fast and efficient switching operation.

The MOSFET is rugged and has dynamic dv/dt and avalanche rating in order to withstand harsh conditions of automotive applications which require durability and reliability.

The IXTY2P50PA saves PCB space with a miniature TO-252 (DPAK) footprint in surface mount form factor. This allows for compact designs in applications such as automotive ECUs, sensor circuits, high side switches, push-pull amplifiers, automatic test equipment and current regulators, advises Littelfuse.

The automotive grade PolarP P-Channel Power MOSFET is available in reel packaging of 2500 pieces. Samples can be requested through authorised Littelfuse distributors worldwide.

Low profile power supply meets industrial automation needs

The company has added a 3000W AC/DC enclosed power supply with an adjustable output voltage from 100 to 350V DC. The ETA3000BC is intended for industrial applications requiring a fast output voltage response and integrates Cosel's digital microprocessor technology. Active current sharing facilitates paralleling up to 10 units for extra power or redundancy. There is also an active filter for efficiency and the phase shift, full bridge topology offers efficiency up to 93%. The high response speed to adjustments of the output voltage across the full range is particularly suitable for demanding industrial applications.

Industrial applications such as laser, plasma processing and industrial heating require the output voltage of power supplies to adjust rapidly within 100 to 350V DC in less than two milliseconds to provide an accurate voltage to the emitting element. This requires very tight, specific power control. The FETA3000BC's response time across the full output voltage range is just 1.5ms.

With an input voltage range of 170 to 264V AC, the power supply delivers a

nominal output voltage of 250V DC, adjustable from 180 to 350V DC using the built-in potentiometer, or 100 to 350V DC when using the trimming analogue control function available at the interface connector. The nominal output current is 12A and efficiency is up to 93% at 230V AC input.

The use of the company's digital microprocessor technology results in voltage and current balance control. This simplifies system integrators' task when connecting units in parallel or series and allows up to 10 power supplies in parallel without adding any other external components. The digital control also controls switching parameters to optimise efficiency, reducing energy consumption.

To reduce audible noise the FETA3000BC series is equipped with a thermo-regulated fan whose speed is automatically adjusted to optimise cooling according to needs.

The FETA3000BC includes in-rush current limiting circuitry, over-current and over-voltage protection and thermal protection. Power Good and Alarm signals are available from the interface panel and highlighted by LEDs. The unit can be remotely controlled via RC pin.

The power supply series can be operated within a temperature range of -10 to 70°C, 20 to 90% RH (non condensing), and up to 3,000m (10,000 feet) maximum altitude. Depending on cooling and assembling methods, a power derating may apply.

The FETA3000BC includes an input filter and complies with FCC Part 15-A, CISPR32-A, EN55032-A, VCCI-A. In cases where a higher level of conducted noise attenuation is required, the company recommends use of the NAC-20-472 filter. The power supply has an input to output isolation of 3,000V AC, input to ground (FG) of 2,000V AC and output to ground (FG) of 2,000V AC. It is UL62368-1, C-UL (CSA62368-1), EN62368-1 safety approved.

The FETA3000BC measures 102 x 41 x 340mm [4.02 x 1.61 x 13.39 inches] and weighs 2.3kg maximum for integrated industrial applications in 1U height equipment.

Typical applications include measurement and analysis equipment, machine tools, semiconductor manufacturing equipment, battery chargers and power amplifiers. The power supplies comply with the RoHS directive and they are CE and UKCA marked in accordance with the Low Voltage Directive.

Medical-grade 6W AC/DC measures 25.6 x 25.6 x 16.6mm

The board-mount, through-hole 6W AC/DC converter can be used in a range of applications. It has input nominal voltages of 100 to 277V AC (80 to 305V AC, 120 to 430V DC) making it suitable for worldwide use. Isolation is reinforced/2xMOPP for any application, from household to patient-connect medical, says the company.

There is a range of outputs available (3.3V, 5.0V, 12V, 15V and 24V) with high efficiency, maintained down to light loads. Operating temperature is from -40 to 90 degrees C ambient with a full load rating up to 60 degrees C. Full protection is provided against over-temperature, output short-circuits, and over-voltage.

Safety certifications include those for IT/multimedia, medical, industrial and household equipment. It also meets Class B EMC specifications with good margin with a floating load.

For medical use, touch current is less than 0.1mA for body-floating patient-connect applications. No-load dissipation is 120mW maximum for compliance with eco-design requirements.

The RACM06E-K/277 operates at altitudes up to 5000m altitude in over-voltage category II (OVC II) environments to IEC/EN 62368-1 and to 3000m for OVC III according to IEC 61558-2-16.

The part is encapsulated with a plastic casingwhich measures 25.6 x 25.6 x 16.6mm. The AC/DC converter weighs just 20g.

Parts include a three-year warranty and samples, and OEM pricing is available from all authorised distributors, or directly from the company.

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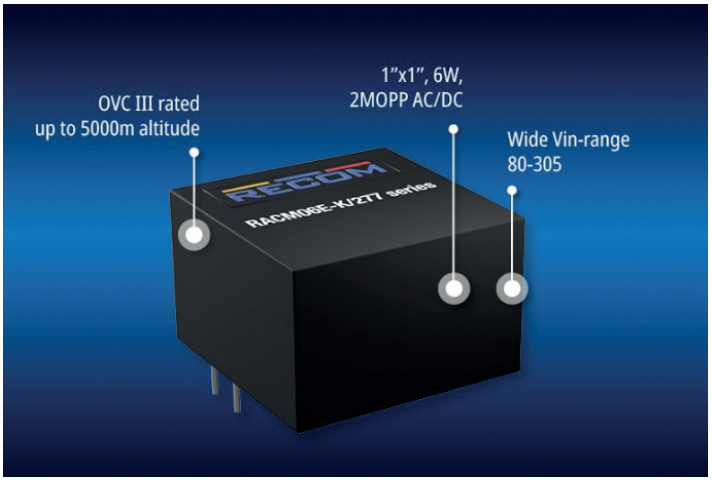


Nexperia and Kyocera AVX Components produce a 650V SiC rectifier module

The 650V, 20ASiC rectifier module for high frequency power applications ranging from 3.0 to 11kW power stack designs is for use in industrial power supplies, EV charging stations, and on-board chargers.

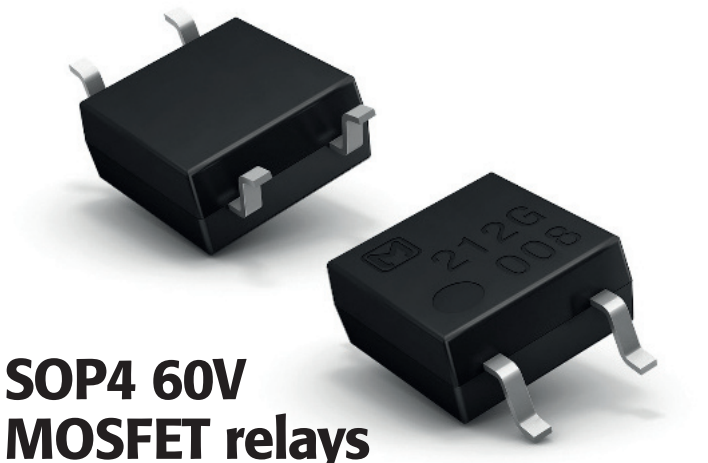
The pair says that the compact footprint of this new SiC rectifier module will

help to maximise power density, reducing the amount of required board space and lowering the overall system cost. Thermal performance is optimised using a combination of top-side cooling (TSC) and an integrated negative temperature co-efficient (NTC) sensor which monitors the device temperature and provides real time feedback for device or system level prognosis and diagnosis. The rectifier module has a low inductance package to enable high frequency operation and has been qualified to operate with a junction temperature of up to 175°C.

According to Katrin Feurle, Senior Director of the Product Group SiC at Nexperia, the collaboration combines the company's SiC semiconductors with module packaging for products which offer "exceptionally high levels of power density". The module is the first step in what is envisaged as a long-term SiC partnership between Nexperia and Kyocera AVX.

Thomas Rinschede, Deputy Vice President Sensing and Control Division at Kyocera AVX Components Sensing and Control Division, comments: "We are delighted to further extend our successful partnership with Nexperia into the production of silicon carbide modules for power electronics applications . . . Nexperia's manufacturing expertise combined with Kyocera module know-how make a compelling offering for customers looking to achieve higher power densities using wide bandgap semiconductor technology."

Nexperia expects samples of the new SiC rectifier modules to be available in Q1 2024.



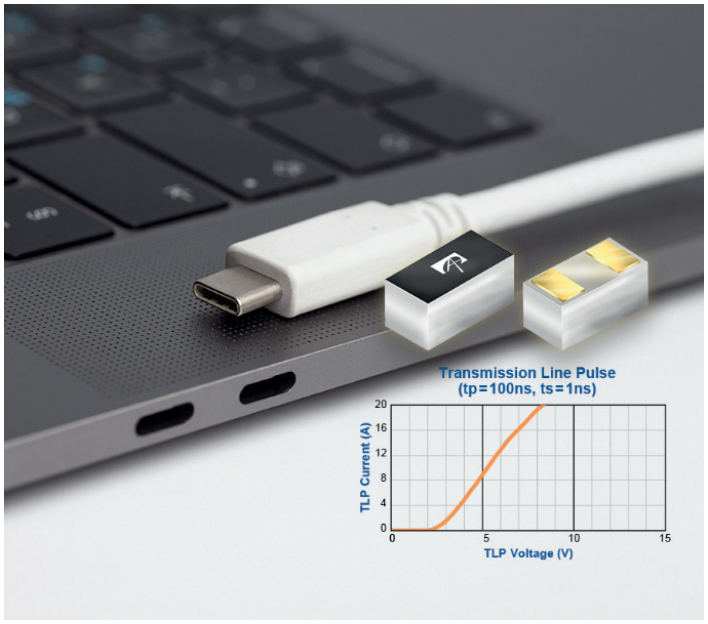
SOP4 60V MOSFET relays operate in high temperatures

The PhotoMOS SOP4 AQY212G3HS and AQY232G3HS relays operate at up to 105°C and 125°C respectively. They can be used in higher temperature environments including modern industrial equipment, testing, and measuring equipment as well as security and battery operating equipment.

The compact SOP4 package achieves an I/O withstand voltage of 3,750V rms, allowing for insulated equipment to be miniaturised. The AQY232G3HS components achieve high-capacity 2A load control and the AQY212G3HS relays have 1.8 A load control.

The AQY232G3HS components achieve a maximum LED current of 1mA, which is one third that of conventional models, says the company, enabling an LED current during use to be reduced by up to 40% to lower power consumption. The AQY232G3HS models achieve an average of 0.8ms, which is about 57% the time required for conventional models, says Panasonic Industry. The increased speed of the switching operation improves the tact time of equipment and systems.

Ultra-low VRWM TVS diode provides USB4 and Thunderbolt 4 ESD protection



The AOZ8S207BLS-01 ultra-low reverse working voltage (VRWM) transient voltage suppressor (TVS) diode. It is designed to deliver low capacitance and fast response times, with high speed data line protection based on AOS' Ultra-Low Breakdown Voltage (VBR) TVS platform and packaging. Together with the TVS diode's 0.15pf capacitance, it is suitable for USB4 and Thunderbolt 4 electrostatic discharge (ESD) protection.

Low breakdown voltage is essential for ESD protection devices, especially when protecting ICs manufactured with the finest process, explains the company. This TVS diode features an especially low breakdown voltage, and it can provide a faster response time compared to conventional snap-back devices, enabling it to absorb ESD energy extremely quickly to avoid damage to the IC and surrounding components.

The single-channel device is housed in a 0.6 x 0.3mm leadless surface-mounted device (SMD) package which makes it well-suited to meet the small footprint requirements of USB Type-C connectors, adds the company.

According to AOS' marketing director, Charles Chen, the AOZ8S207BLS-01 provides "a much better figure of merit (FOM) on clamping voltage times capacitance".

"In addition to low capacitance, having a lower clamping voltage and faster response during an ESD event is important to protect today's more ESD-sensitive chipsets," and help designers to "greatly reduce ESD failure rates in their electronic products".

The AOZ8S207BLS-01 TVS diode is immediately available in production quantities with a lead time of 16 weeks.

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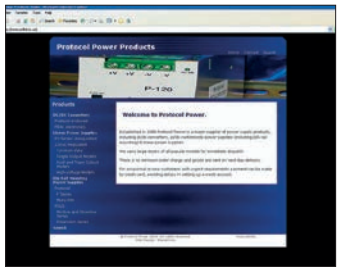

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