POWER ELECTRONICS EUROPE

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TECHNOLOGIES TO HARNESS WIND POWER FOR NET ZERO

Support from sea to shore

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FEATURE STORY

Technologies to harness wind power for net zero

The offshore wind industry has a major role to play in reducing carbon emissions, but the industry faces a number of challenges. ABB Energy Industries discusses some technology developments which are being increasingly used to tackle these for a reliable sustainable renewable source.

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Prototype to practice power charging

Is it possible to prototype a power bank charger application without building dedicated hardware? Yes! An application can be developed using existing evaluation boards. This articles discusses some of the challenges and outlines some recommendations for revisions and improvements.

Diarmuid Carey, Staff Applications Engineer, Central Applications, Analog Devices

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SiC soars to meet demand for small, lightweight power solutions

Using SiC can improve both efficiency and reliability of aerospace applications. As the industry strives for lightweight, compact, high density efficient power, SiC is being propelled into the spotlight.

Alain Calmels, Design Engineer, Microchip Technology

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Ecofriendly choices shine through for clean energy

As the world moves towards making more eco-friendly responsible choices, the demand for sustainable and renewable energy has driven consistent high growth in the solar inverter market.

By Panasonic Industry

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IoT call for a different approach to backup circuitry design

Two backup options are compared and new backup circuitry is proposed to meet a 15ms holdup time for a 12V/60W flyback converter with a 9V to 60V wide input range. **By Tiger Zhou, Applications Engineer Battery Charging Products, Texas Instruments**

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Infineon invests €5billion in “world’s largest 200mm SiC power fab”

The company is staking its claim in the role of SiC in wide bandgap materials for decarbonisation with expansion plans for a Malaysian fab.

The Kulim fab, built in February 2022, will be expanded in the second phase of development announced last month. The planned expansion, depicted in the artist’s rendering, is backed by customer commitments covering about €5billion worth of new design wins in automotive and industrial applications as well as about €1billion in pre-payments.

The planned expansion is backed by customer commitments covering about €5billion of new design wins in automotive and industrial applications as well as about €1billion in pre-payments. Infineon says it expects the 200mm SiC power fab will lead to a total revenue potential of more over €7billion by 2030 with the planned 200mm SiC conversion of Villach and Kulim.

The company has announced a SiC market share target of 30% towards the end of the decade. Infineon is confident that the company’s SiC revenue in the fiscal year 2025 will come in ahead of the target of €1billion.

Infineon has been awarded new design wins of about €5billion and around €1billion in prepayments from existing and new customers, including six automotive OEMs, three of which are from China and include Ford, SAIC and Chery. Renewable energies customers include SolarEdge and three Chinese photovoltaic and energy storage systems companies. In addition, Infineon and Schneider Electric agreed on a capacity reservation including prepayments for power products based on silicon and SiC.

The Right Honourable Dato’ Seri Anwar bin Ibrahim, Prime Minister of Malaysia, comments: “Malaysia is putting in maximum efforts to meet its national target to decarbonise its economy and achieve net zero by 2050. Malaysia’s continued appeal as a preferred investment destination comes with a well-established landscape for developing innovative and sustainable technologies”.

Infineon adds that sustainability is a key element in the planning, construction and operation of the fab, which is designed to make responsible use of resources such as electricity and water.

www.infineon.com

Kraken and Cosworth partnership has lift-off for battery development

The Kraken Technology Group, a design and engineering company for maritime security, has partnered with powertrain and electronics engineering company, Cosworth to develop advanced batteries for Kraken’s littoral defence and security range.

Initially, the development will focus on the Kraken Manta range (pictured) of autonomous, uncrewed surface, sub-surface vessels designed for ISR (intelligence, surveillance and reconnaissance) missions.

In 2018, Kraken’s electric propulsion technology broke the UIM (Union Internationale Motonautique) Outright Maritime Electric Speed World Record with an average speed of 88.61mph (142kph) at Coniston Water in the UK’s Lake District.

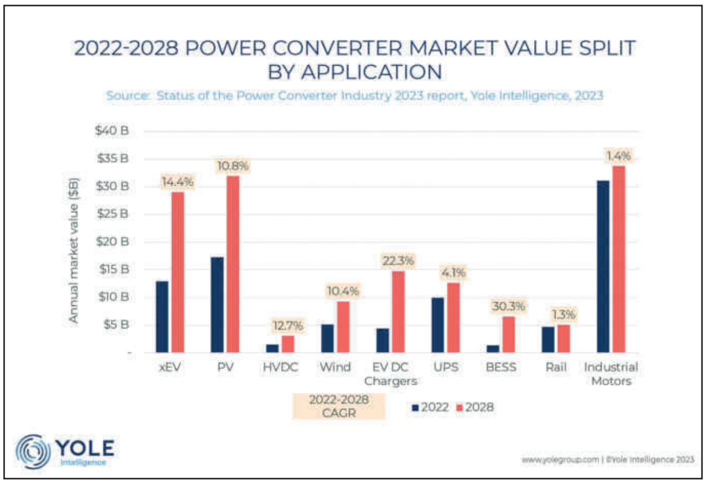
Simon Dowson, Cosworth Managing Director, High Performance Battery Systems, comments: “The alternative propulsion arm of Cosworth has been developing high performance batteries for well over a decade. We believe that partnering with Kraken is a perfect showcase of our capabilities in boundary pushing applications such as the advanced vessels for which Kraken is known. The learnings from this partnership will also prove to be essential for our marine offering moving forward.”

Kraken develops and manufactures composite materials, prototype vessels, autonomous technologies and advanced powering solutions for maritime, defence and security industries.

Cosworth is a British engineering company, specialising in powertrain development, electronics and alternative propulsion solutions (hybrid or EV) as well as data connectivity and automation technology for the automotive, marine and aerospace sectors.

https://www.cosworth.com

High hopes for converter renewable energy and electrification



The xEV power converter market is growing substantially according to the latest research by analyst, Yole Group. It reports that the market value for power converters will reach US$146.1 billion by 2028, with an 8.7% CAGR between 2022 and 2028.

In 2022, the industrial motor segment represented the largest power converter market but the xEV power converter segment is growing substantially and is expected to become the third largest market by 2028.

Driven by the worldwide transition to renewable energy sources, such as solar PV and wind power, there is a growing need for power converters that can convert energy from these sources efficiently and easier their integration with the electricity grid.

China dominates in most end markets, particularly in converter suppliers and the ultimate target is increasing power density.

Hassan Cheaito, PhD.Technology & Market Analyst at Yole Intelligence, commented: "Power converters for battery energy storage systems will feature the fastest growth in the coming five years, with a 2022-2028 CAGR of 30.3%".

Dr. Milan Rosina, PhD. Principal Analyst for the power electronics and battery division, added: "Automotive OEMs are increasingly involved in converter manufacturing to save costs and are leveraging their vertical integration".

Yole Intelligence's report highlights China's dominant position in most end markets analysed, particularly in converter supply for xEV, wind and PV converter markets. This increase is attributed to the large domestic market for end systems (wind turbines, electric vehicles and PV inverters), the competitive advantage in terms of cost compared to regions like the USA and Europe and the dominant position regarding the supply and the cost of raw materials.

This has spurred innovation and alternative business approaches from non-Chinese players.

There has also been consolidation of the supply chain for high power converters, with the supply chain more secured compared to the one dedicated to low power solutions.

One trend in terms of vertical integration is that automotive OEMs are increasingly involved in converter manufacturing. OEMs and Tier 1s are moving towards manufacturing power modules and, in some cases, even power device bare dies, particularly in the xEV segment, where power modules and traction inverters play a crucial role in achieving technological differentiation.

A second shift is the move from solely system manufacturing and sales towards service-oriented businesses, with services such as project consulting, operation and maintenance. This trend is particularly noticeable in established markets with a significant number of existing installations, such as rail, wind, and PV. It is also present in relatively new segments like BESS (battery energy storage systems) and EV DC chargers.

http://www.yolegroup.com.

Rohm opens up the Solar Frontier in Japan as a main production base

Rohm has agreed the acquisition of the Solar Frontier plant in Kunitomi, Japan and with it comes an expansion of its production facilities.

The Kunitomi site is approximately 400,000m^2 with a total floor area of approximately 230,000m^2 and will be one of the Rohm Group's main production bases.

"This acquisition enables a fast production expansion by utilising existing infrastructure. This way, Rohm will continue to quickly and reliably supply its customers," says Wolfram Harnack, President at Rohm Semiconductor Europe. The company has scheduled operation at the plant for the end of 2024.

Commenting on the move, the company said that semiconductors are increasingly important in achieving a decarbonised society. Both automotive and industrial equipment markets are undergoing technological innovation, such as electrification, in order to reduce environmental impact and achieve carbon neutrality, explains Rohm. With this, the demand is increasing especially for power and analogue semiconductors. The company also says as further expansion of the semiconductor market is expected, the Rohm Group intends to expand its production capacity continuously, particularly for SiC power devices, and ensure a stable supply to customers

The acquisition is scheduled to take place in October 2023.

www.rohm.com

MOSFET's mixed fortunes

Written by Luke Gear, principal technology analyst, the report looks into EV power electronics and the evolving semiconductor and package materials industry. It includes data on Si, SiC and GaN semiconductors, die-attach materials, wire bonding and thermal management. It also includes granular forecasts detailing unit sales, GW and US$ demand for inverters, onboard chargers (OBC) and DC/DC converters segmented by voltage (600V, 1200V) and semiconductor type (Si, SiC, GaN).

SiC improves powertrain efficiency (EV range), operates at higher voltages for faster charging, and creates new materials opportunities, such as Ag or Cu sintering, as power densities and operational temperatures increase. SiC MOSFETs will feature in EV production in the next 10 years, says the report.

The IDTechEx report "" provides a deep-dive into EV power electronics with technology insights into the evolving semiconductor and package materials, including Si, SiC and GaN semiconductors, die-attach materials, wire bonding, thermal management, and more. IDTechEx presents

Infineon and ST Microelectronics both supply automotive power semiconductors, and both expanded major OEM partnerships recently.

Infineon has a deal to supply Stellantis' Tier 1 partners from 2025, potentially worth over one billion euros. Infineon also has a ten-year supply deal with VW, supplies into Hyundai's 800V E-GMP platform, and has a historic relationship with BMW for the original i3, as well as Renault.

STMicroelectronics has a major supply relationship with Tesla which commands around 14% market share of all BEV PHEV cars sold globally in 2022 according to the "Electric Cars 2023-2043" report from IDTechEx. the company has recently developed ACEPACK SiC modules as drop-in modules, which will help expand its customer base. It is also expanding production capacity in Italy and Hyundai has already chosen to use the modules in upcoming E-GMP models.

SiC adoption is gathering pace as other players release products, such as onsemi's EliteSiC SiC MOSFETs. It will supply VW and Hyundai. Tier 1 Borgwarner announced it would invest US$500 million in Wolfspeed, with Wolfspeed supplying SiC semiconductors to future Mercedes-Benz models and JLR's next generation of electric cars from 2024.

It is not all fast-paced acceleration, however. Tesla announced it was aiming for a 75% reduction in SiC utilisation for the cyber truck and future model releases. IDTechEx expects all Tesla's vehicles will continue to use SiC MOSFETs in most of their power electronics, however.

It was Tesla's 2018 Model 3 whic introduced SiC MOSFETs to the automotive sector at scale. The inverter design currently in use across Tesla's line-up is similar to this original inverter. IDTechEx expects that the announced reduction is being driven by smaller and more advanced SiC chips reaching commercialisation at a time when five years of real-world experience and understanding of SiC chip thermal management comes to fruitiion. It is also likely that Tesla's initial SiC inverter design was optimised for redundancy - extra chips - with the design now being optimised for cost and efficiency.

IDTechEx predicts a 27% CAGR for the period 2023 to 2033 for 600V to 1200V SiC MOSFETs in inverters, allowing the technology to capture more than half the market.

Asahi Kasei licenses doping method for improved Li-ion capacitor performance

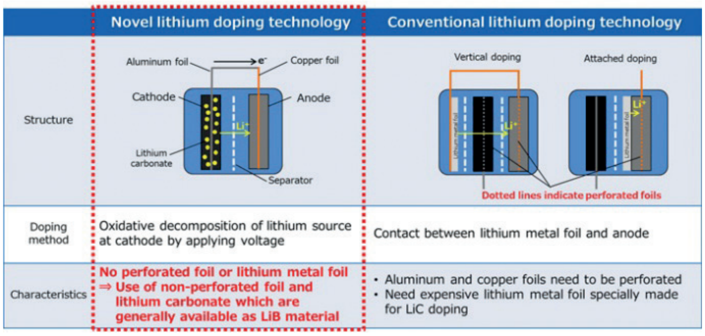
The proprietary doping method enables Li-ion capacitors (LiCs) to be manufactured at lower cost with generally available materials and equipment which are used for manufacturing lithium-ion batteries, says the company. At the same time, it enables the design and manufacture of capacitors with increased capacity and improved I/O performance.

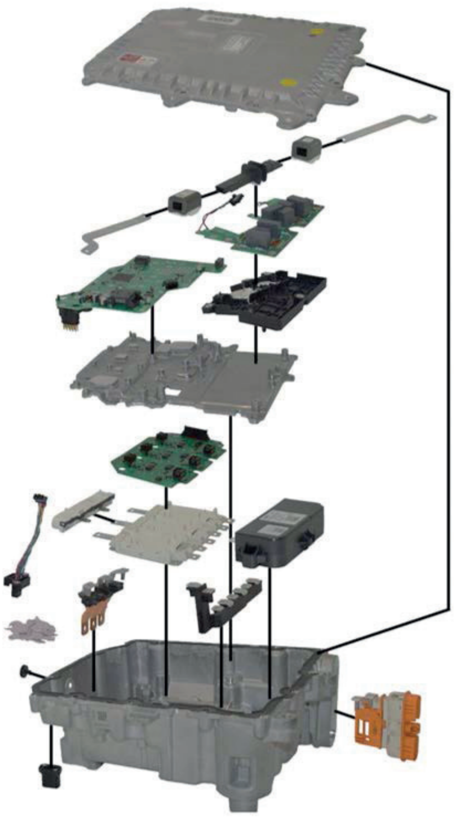
Asahi Kasei developed a low-cost, pre-doping method using inexpensive lithium carbonate as the source of lithium ions, eliminating the need for perforated foil and lithium metal foil. Lithium carbonate is included in the cathode and pre-doping is performed at initial charging, when nearly all of the lithium carbonate decomposes, and lithium ions transfer to the anode. This allows the manufacture of LiCs using materials and equipment similar to those used in the manufacture of Li-ion batteries (LiBs), but also enables capacity and I/O performance to be raised by a factor of 1.3 or more (compared to Asahi Kasei's conventional LiCs).

The licensing includes Asahi Kasei's IP (intellectual property) related to LiC technology, but also technical expertise such as cell design and manufacturing with pilot equipment. Asahi Kasei expects to support licensees around the world to significantly reduce LiC development times and achieve low-cost LiC manufacture using existing equipment.

The LiC is a next generation energy storage device that uses the same material as an electric double layer capacitor (EDLC) for the cathode and the same material used as a LiB for the anode. As LiCs have higher I/O characteristics than LiBs, they are suitable for where instantaneous power is needed, and can be quickly recharged. The long cycle life and high safety LiCs are expected to be used in mobility applications such as electric trams and buses to charge at each stop instead of using power from overhead lines.

In the growing field of energy storage systems for renewable energy such as solar and wind, it is possible to extend the service life of LiBs by using with the LiCs to reduce the LiB charge/discharge load. The company says this is expected to reduce both running costs and environmental impact through less frequent replacement of LiBs, generating less waste. The conventional LiC manufacturing process requires expensive materials for pre-doping, such as perforated foil and lithium metal foil. In addition, lithium metal is highly reactive and hazardous, which incurs additional costs to maintain a safe working environment.





Magna and onsemi agree SiC investment to secure long term supply

The two compnaies have signed a long-term supply agreement for Magna to integrate onsemi's EliteSiC intelligent power solutions into its eDrive systems.

According to Magna, integrating onsemi's EliteSiC technology will offer better cooling performance and faster acceleration and charging rates to improve efficiency and increase the range of electric vehicles (EVs). onsemi's end-to-end SiC manufacturing capability and ability to ramp production quickly, improves Magna's vertical integration and simplifies Magna supply chain, added the company.

Asif Jakwani, Senior Vice President and General Manager, Advanced Power Division, onsemi, said the latest EliteSiC MOSFET technology enables increased power density and higher efficiency in traction inverters to incease range "without compromising driving dynamics and safety".

Magna will also invest approximately $40 million for new SiC equipment at onsemi's New Hampshire and Czech Republic facilities. Although SiC is a proven substrate for high temperature, high power applications such as EVs, it is difficult to produce and there are only a limited number of manufacturers, leaving OEMs and automotive suppliers increasingly looking to secure a long-term, reliable supply.

"As the electric vehicle market continues to grow, we are taking proactive steps to secure Diba Ilunga.

Technologies to harness wind power for net zero

The offshore wind industry has a major role to play in reducing carbon emissions, but the industry faces a number of challenges. ABB Energy Industries discusses some technology developments which are being increasingly used to tackle these for a reliable sustainable renewable source.

A combination of environmental, economic, and geopolitical factors is leading many countries to consider new forms of power generation. Combined with a growing awareness of the need for energy security and greater sustainability, there is a steadily increasing shift towards renewable sources as a means of providing the power needed for everyday life.

One such source is wind power. The world's second biggest renewable energy source after hydropower, wind power accounted for over 6% of global electricity generation in 2022, providing 837 GW of global capacity. That same year saw an extra 77.6 GW of capacity added. This is projected to rise as more countries strive towards achieving net zero carbon emissions.

A sector of the industry that has seen considerable growth has been offshore wind. Since the first units were introduced in 1991, improved performance combined with lower technology costs have seen a massive growth offshore turbine projects. The Global Wind Energy Council (GWEC) estimates that the global market for offshore wind grew by almost 22% per year between 2010 and 2020, while an additional 235 GW of new capacity is expected by 20302.

Tackling the challenges of wind

Although wind offers significant opportunities for improving both environmental performance and reducing reliance on fossil fuels, companies hoping to harness its full potential face some key challenges.

The first is wind's intermittent nature. Variability in wind conditions and the inherent unpredictability of seasonal weather means that turbines may be operating at peak efficiency when there is less demand or at low efficiency when there is high demand. Periods with low wind speeds will mean that the power from offshore turbines will need to be supplemented by other energy sources.

The challenge is to find ways to maximise output and match demand, while also reducing capital investment in the construction of the windfarm and infrastructure, as well as the facility's operating costs.

A number of technologies are helping operators meet these challenges. Improvements in offshore turbine design, including both efficiency and size and the availability of floating designs that enable

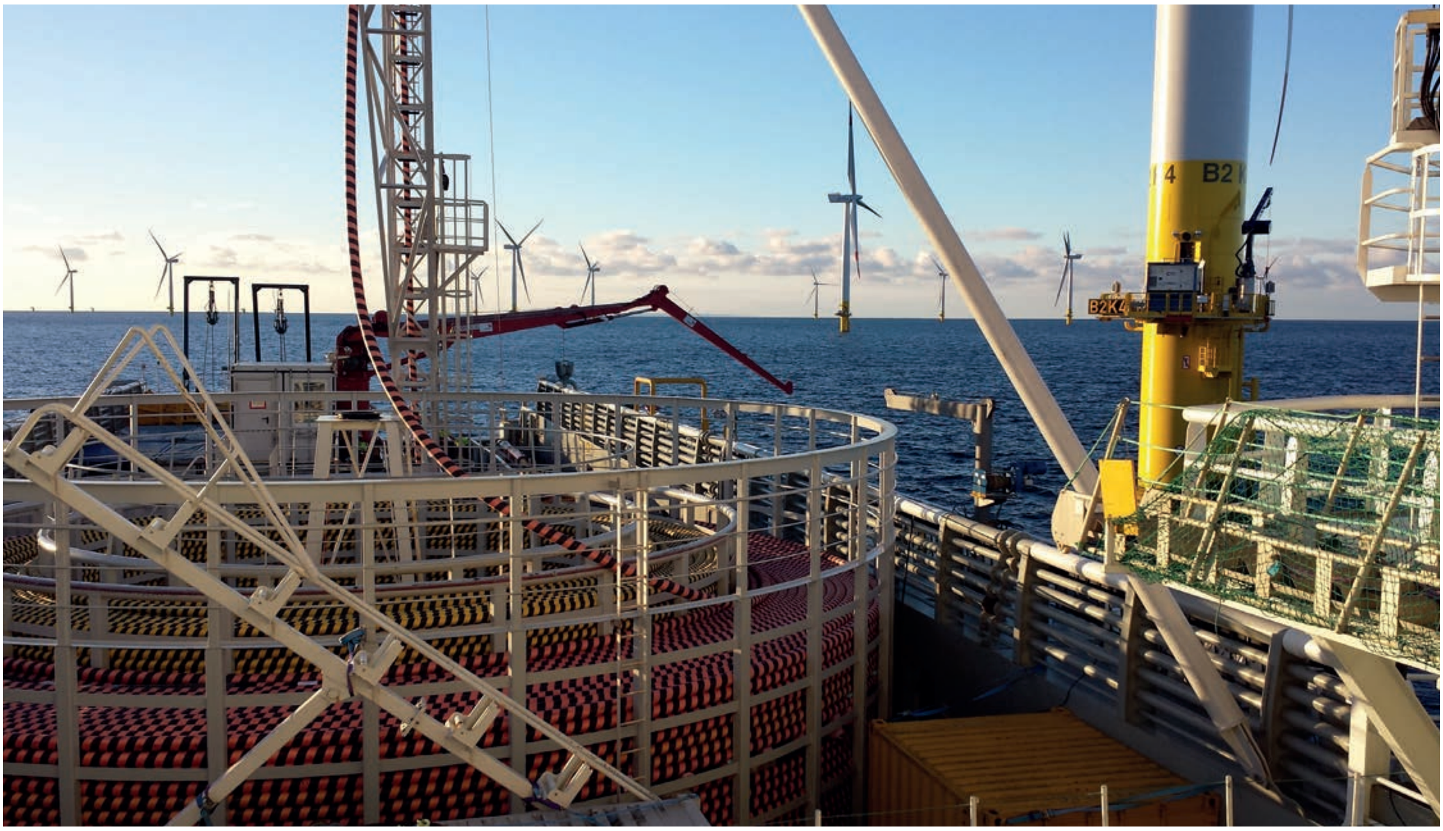


Figure 1: Using subsea power distribution and conversion technology from the oil and gas industry is helping address the cost and practicality challenges involved in transmitting power from wind turbines back to shore.

Figure 2: **Increasing numbers of offshore windfarms coming online require people and facilities to deliver and maintain them.**

wind farms to be situated further offshore to take advantage of higher quality wind conditions, are helping achieve steady increases in capacity of 40 to 50% and more. This improved efficiency is seeing offshore turbines exceeding the capacity performance of other renewables such as onshore wind and solar power.

Developments in energy storage are also helping to provide added stability. Various technologies can be used, including batteries and thermal storage.

Other concepts include bladders on the seabed. Here, excess power is used to pump water from underground reservoirs into the bladders. When demand for power rises, water from the bladders is routed through hydro turbines to generate electricity.

Another technique is to use power from wind to help produce hydrogen, a low carbon power source that can be used widely for anything from electric vehicles and shipping through to heavy industries. With around 70 million tonnes of hydrogen currently produced using fossil fuels, offshore wind offers huge potential to make significant savings in CO_2 emissions.

Yet another challenge is how to get the power produced from the turbine back to shore efficiently. Depending on the distance involved, this has been achieved using either HVAC or HVDC connections. For both techniques, subsea power distribution and conversion technology originally developed for the oil and gas industry have substantially reduced the cost and eased the practicalities of transmission. By eliminating the need for surface infrastructure, this technology is opening new opportunities for transmitting power over long distances whilst simultaneously reducing emissions. It also offers scope for improved control and operation through digitalisation and the use of remote monitoring.

Other techniques are also becoming increasingly viable, including floating substations that share design and assembly ideas from the buoyant platform structures being deployed for floating offshore wind turbines.

Matching supply to demand

As more offshore wind farms come online, there is a growing requirement for the people and facilities needed to deliver and maintain them.

The high initial capital costs involved in building sea-based wind farms and their associated transmission networks means there are currently a limited number of operators in the market with the ability and resources to build, operate and maintain large scale wind farms.

Engineering resources are becoming increasingly stretched as more wind farm programmes get underway. Companies across the power generation value chain, from operators through to suppliers, have had to find ways to make best use of existing resources.

This can mean using tools to help get more out of available engineering hours. One of the key tools is remote operation, which allows operators to understand what is happening and then using the data to make decisions to improve performance. Advances in smart digital technology are delivering expanded possibilities for remote and unmanned assets. As well as making them easier and more efficient to deploy and operate, they increase the speed and quality of information sharing, allowing better decision making and faster rollout of modifications.

Getting practical data from remote assets is important for safe functioning of remote assets – the greater autonomy made possible by digitalisation also reduces the need for manpower at the asset sites.

Do more with less

Digitalisation allows engineers to do more whilst making better use of available time. Some of the tasks made easier include condition monitoring, fault tracing, incident handling, cybersecurity patching and modifications.

Many maintenance and inspection tasks, for example, can now be performed remotely. These can be done either via real-time control and communications networks or using technologies such as drones to inspect components at height or in otherwise hard to reach areas.

Developments in predictive maintenance technologies especially are also helping to improve turbine performance. Identifying problems in advance allows operators to decide how best to rectify them, either deploying engineers to the turbine or, if possible, applying the fix remotely.

Digital simulation has also helped to reduce a lot of the work involved in planning new offshore installations. These tools can allow operators to assess turbine performance and potential electrical output before installation. By testing a turbine installation under multiple conditions, operators can use the data produced to help develop the best real-world solution, reducing risks and speeding up deployment.

Partnerships in power

Another way to address the limitations of the available skills base is to work in partnership with other players in the supply chain.

This approach offers several advantages. Foremost amongst these is the exchange of new ideas. For example, ABB has an extensive portfolio of electrical solutions and has developed expertise from delivering hundreds of offshore applications, including projects located in some of the world's harshest waters. This means it can offer new perspectives on meeting many of the challenges inherent in offshore wind projects. As an example, its experience gained in building subsea transformers for oil and gas since the 1990s is now being used to provide the building blocks for subsea networks that collect, convert, and distribute power from floating wind turbines.

This expertise can be used to create networks that can help to ensure grids can meet peak demand whilst also delivering peak reliability by finding ways to supplement wind power during periods of low demand. Experience can also be used from a supplier's involvement in other forms of energy generation and distribution, such as hydrogen production, storage and transmission projects. This makes it well placed to advise operators on how to supplement generation networks using alternative power sources that are powered by offshore wind.

The same advances in digital maintenance technologies can also be used to help deliver remote service and support. This can range from digital simulation through to augmented reality tools that can be used by engineers to remotely guide colleagues on site to resolve problems.

The growing convergence between information (IT) and operational (OT) technologies allows new opportunities for collaboration. The huge variety of data from equipment, processes, plants and business systems can be integrated and shared between the different parties involved in building, running and maintaining offshore wind farms.

By sharing information about operational status and asset performance, including analysing varying performance between different wind assets and wind farms, allows better decision-making within the operating company. Sharing performance information among the vendors in the wind generator industry also allows new equipment and techniques to be developed that can benefit everyone.

Figure 3: **Improvements in offshore turbine design, in relation to size and efficiency and the availability of floating designs, enable wind farms to be situated further offshore to take advantage of higher quality wind conditions.**

Maximising potential

The growing need for affordable low carbon technologies will see all forms of renewable power being used to supplement and eventually replace fossil-fuel based power generation.

The potential of offshore wind as an effective power source has increasingly been recognised as technology has advanced and ways have been found to tackle issues such as variability and intermittency.

As the industry addresses issues through continued developments in electrical system design, offshore wind will increasingly take its place as a major enabler of the global transition from fossil fuels to renewable power.

Prototype a power bank charger without hardware headaches

Is it possible to prototype a power bank charger application without building dedicated hardware?

Diarmuid Carey, Staff Applications Engineer, Central Applications, Analog Devices

The short answer to this question is yes. This article will review the process involved in developing an application using existing evaluation boards, discuss the challenges encountered and outline some recommendations for further revisions and improvements.

Ideally, any power supply design should start with some basic proof of concept tests, which often involve testing an existing demo board. This demo simply takes this pre-existing step (of testing single rails on the demo hardware) and expands on it to produce a working system using demo hardware. As this demo was needed within a relatively short time frame, the typical development process of design, layout, build, assemble, and test (plus any design iteration) was not possible, so the system was prototyped in its entirety using nothing but readily available hardware.

Application

It was necessary to choose a high level application as a starting point to prove it is possible to prototype a power bank charger application without building dedicated hardware. This led to the power bank charging application being selected as a proof of concept. As power management is a prerequisite for every electronic project, any other application could have been selected.

A power bank charger is a common application, which most consumers have encountered and used. For example, many travellers carry one to ensure their phone remains charged over a long journey. A power bank is essentially a battery pack (capacity varies depending on the price and range required), with one or more USB-A ports as well as a USB-C input port to charge it. It is possible of course to layer additional complexity on top of this basic functionality. For example, the addition of a wireless charging pad or an input to allow solar charging of the bank for outdoor enthusiasts.

For this application, the option to charge the battery via solar or to charge via a DC input from a standard 12V AC/DC wall wart was included. The outputs included some basic USB-A charging ports (two in total), producing 5V for use with mobile phones and a range of USB-powered electronics.

Hardware selection

In this example, the design will support two input power sources (a solar panel and an AC/DC wall wart, which is just a simple AC/DC power supply). For this reason, a clever device called a power path prioritiser is required not only to intelligently switch between the available sources depending on which was available but also to manage the situation where they both were available by assigning priority to one source or the other. A simple version of this implementation can be achieved by using some simple diodes, commonly connecting the two cathodes of the diodes and connecting the anodes to their respective sources. Unfortunately, this particular configuration is lossy due to the diode drop inherent in a typical diode (approximately 0.6V), but it also doesn't allow for any clever selection criteria to be

	E2	Operation Mode	IG(OFF)1	IG(OFF)2
1	0	Load sharing	Enabled	Enabled
1	Sense	V1 is less than V2	Enabled	
Sense	0	V1 is greater than V2		Enabled
0	X	Channel 1 disabled Do not use	Disabled	
X	1	Channel 2 disabled Do not use		Disabled
0	1	Both channels disabled	Disabled	Disabled

Table 1: Modes of Operation from the LTC4416 datasheet

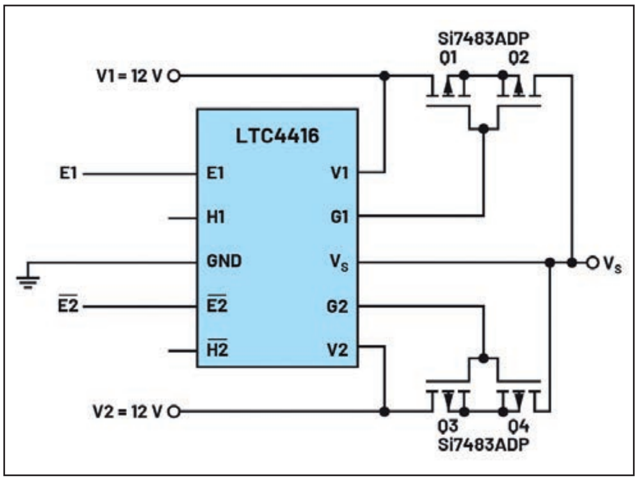


Figure 1: An LTC4416 typical application circuit.

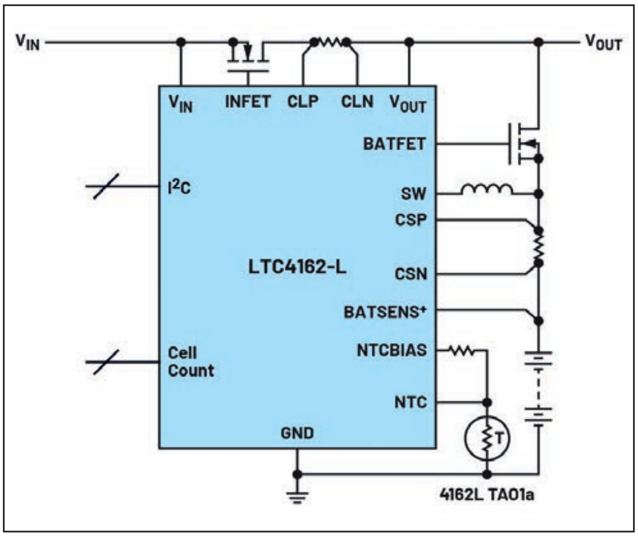


Figure 2: An LTC4162-L typical application circuit.

implemented, for example, priority selection. It simply allows the higher potential input to pass through.

The LTC4416 not only replaces the lossy diodes with PFETs, which are far more efficient, but also allows for priority to be assigned. In this particular application, priority will always be assigned to the wall wart. This allows the design to take advantage of the available power (and higher current) when it is available. This device is exceptionally flexible, with many operational modes possible depending on the design requirements. Table 1 (sourced from the LTC4416 data sheet) displays the modes of operation.

Battery charger

For the battery charger, the LTC4162-L was selected due to its wide input voltage range (up to 35V) and 3.2A charging capability, as well as the integrated FET design, which results in a small solution size. This is a commonly used charger IC which has great application flexibility as it comes in many battery chemistry variants such as LiFePO4, Li-Ion, lead acid as well as an I²C interface to allow the user to extract telemetry information. It was selected for this particular application not only because of flexibility on the input and battery voltage but also because of the integrated nature, which helps to keep the solution size to a minimum. Another useful feature is maximum power point tracking (MPPT). If solar is one of the possible input sources for a design, MPPT is a must to ensure the design extracts as much available power as possible. The LTC4162 also has a built-in power path control that is useful in this application when the input source is removed, allowing the provision of the battery voltage to the output terminals for use downstream.

The board selected to provide the USB charging voltage for the connected device is from Analog Devices' Circuits from the Lab collection of reference designs and solutions. Typically, a single device is shown on an evaluation board to evaluate a specific device. Circuits from the Lab's boards make use of several Analog Devices' products from different product portfolios to solve a particular system requirement.

The CN0509 was designed to be a wide input range, dual USB power charger. It was developed for use in emergencies such as natural disasters or extended power outages. An example power source that many would have available to them is a car battery. This board can be powered by a car battery to provide two 5V ports, which are isolated from the primary voltage for safety. There is a range of alternative power sources that you may have available from stacks of loose batteries to motors to act as a simple generator.

The CN0509 has a wide input voltage range so it will be able to run from any supply in the range of 5V to 100V to pair up with the existing boards to provide the USB charging outputs required for the power bank charger.

Protection features

Reverse polarity protection is included to protect the circuit from an incorrectly connected supply and an isolated flyback converter is utilised to isolate the charger outputs from the input source. This is particularly useful if a -48V communication back up supply is used as a power source. This can result in a phone being charged to -48V and creating a hazardous situation. Isolated conversion prevents this from occurring. Another note here is that the CN0509 board is quite small, largely due to the highly efficient ICs selected and the no-opto flyback LT8302. A key differentiation is that the flyback converter LT8302 does not need an isolated optical feedback path.

There are two USB ports on this particular board: one is a standard USB port (without D+/D- connected) and the other port has a DCP controller to monitor the USB data line voltages so that it can enable fast charging and provide 5V at 2A max. Achieving this higher level of charge current is dependent on the input voltage utilised, 12V is optimal based on the

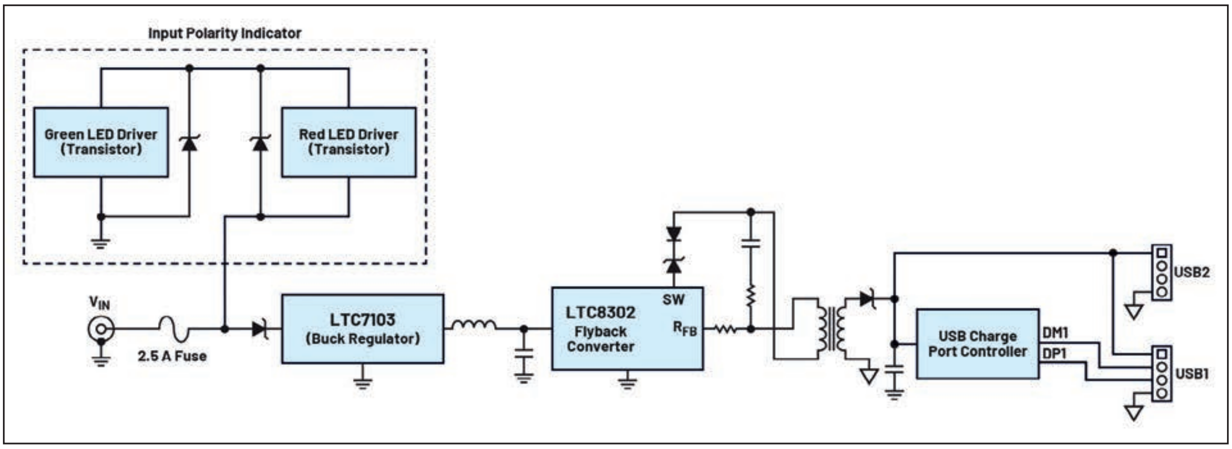


Figure 3: A CN0509 application circuit.

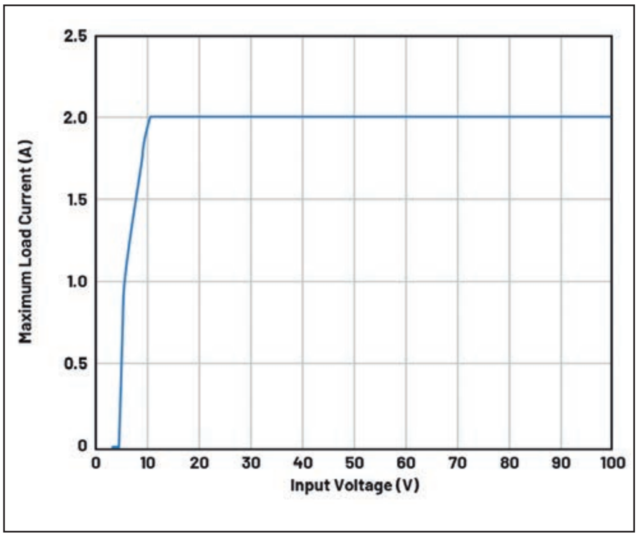


Figure 4: A CN0509 max charge current vs VIN.

performance graph shown in Figure 4.

Power sources

The primary power source selected was a 60W AC/DC 12V adapter. This served as one input to the LTC4416 demo board, and a relatively small solar panel was purchased to provide an alternative input source. It should be noted that this project was to be used at an indoor event without sufficient lighting available to provide a reasonable level of available power to run from solar energy, therefore this feature was included simply to demonstrate the capability and functionality of the power path prioritiser.

This design was developed to be a power bank and as such it would require a battery pack to act as the storage element. Shipping restrictions in relation to batteries are prohibitive. The demo was developed specifically so that a generic battery pack could be bought and inserted to run the demo on its arrival. Based on this limitation, a rechargeable two-series cell Li-Ion battery pack generating a nominal 7.4V with a 2600mAh capacity was selected to run the demo for the event. It is worth noting that a larger capacity battery could easily be installed here if required.

Build details

From a build perspective, the hardware was standard, so no electrical modifications were required beyond some adjustments of the LTC4416 thresholds to ensure the correct priority for the input power sources. In order to make it more visually appealing for the event, the boards were mounted on a simple black perspex sheet using some standard metal standoffs.

The charge current that was being provided for the evening was monitored by a simple USB meter. This device visually represented how much current was available to charge the attendee's phones (Figure 7).

The demo performed its core function effectively. It comfortably charged the battery pack from two alternate sources, the handover between sources was managed well by the power path prioritiser and the CN0509 provided charge to the connected USB devices.

This particular power bank has another useful feature that many power bank chargers do not have and that is the ability to simultaneously charge the battery pack and charge the connected USB device. Even a high end power bank may not charge a phone and the bank at the same time, which is a frustrating limitation.

The charge current to the USB port is limited by the capability of the LTC4162 with its internal FET design providing a max of 3.2A, the bulk of the current is sent to the battery during charging. The remaining current can be used through the USB charger ports.

Any time the input power source is removed, the power path FET on the LTC4162 demo board ensures that the battery power is redirected to the output port and hence maintains power to the CN0509 and USB ports. The available charge current in this mode drops as per the graph in Figure 4 since the input source to the CN0509 is now the battery voltage, which is a nominal 7.4V.

Prototyping

Once the application has been proven to work using some simple, readily available demo boards, the next reasonable step is to develop a product prototype that takes learnings from the initial prototype work and integrates this into the end solution. Part of this would be to modify the existing schematics from the boards used to remove the superfluous items (e.g., test points or connectors).

Next is PCB development. While the demo board generally looks to be quite large in size, this is simply to aid the testability and usability of the device. Closer inspection of the board layout reveals that the IC for which the board was developed and the enabling circuitry (e.g., resistors, capacitors, inductor) are all designed into as small a space as possible to allow developers to bring this into their own layout. This will then provide confidence with a tested design, which can be verified on the bench before building their own version.

For the end application, a larger capacity battery with a higher voltage would help to optimise the amount of charge current

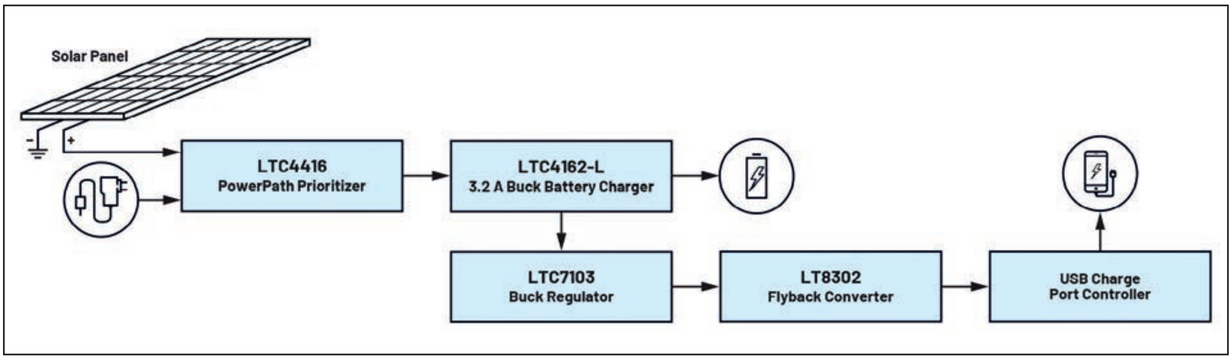


Figure 5: The power bank charger application tree.

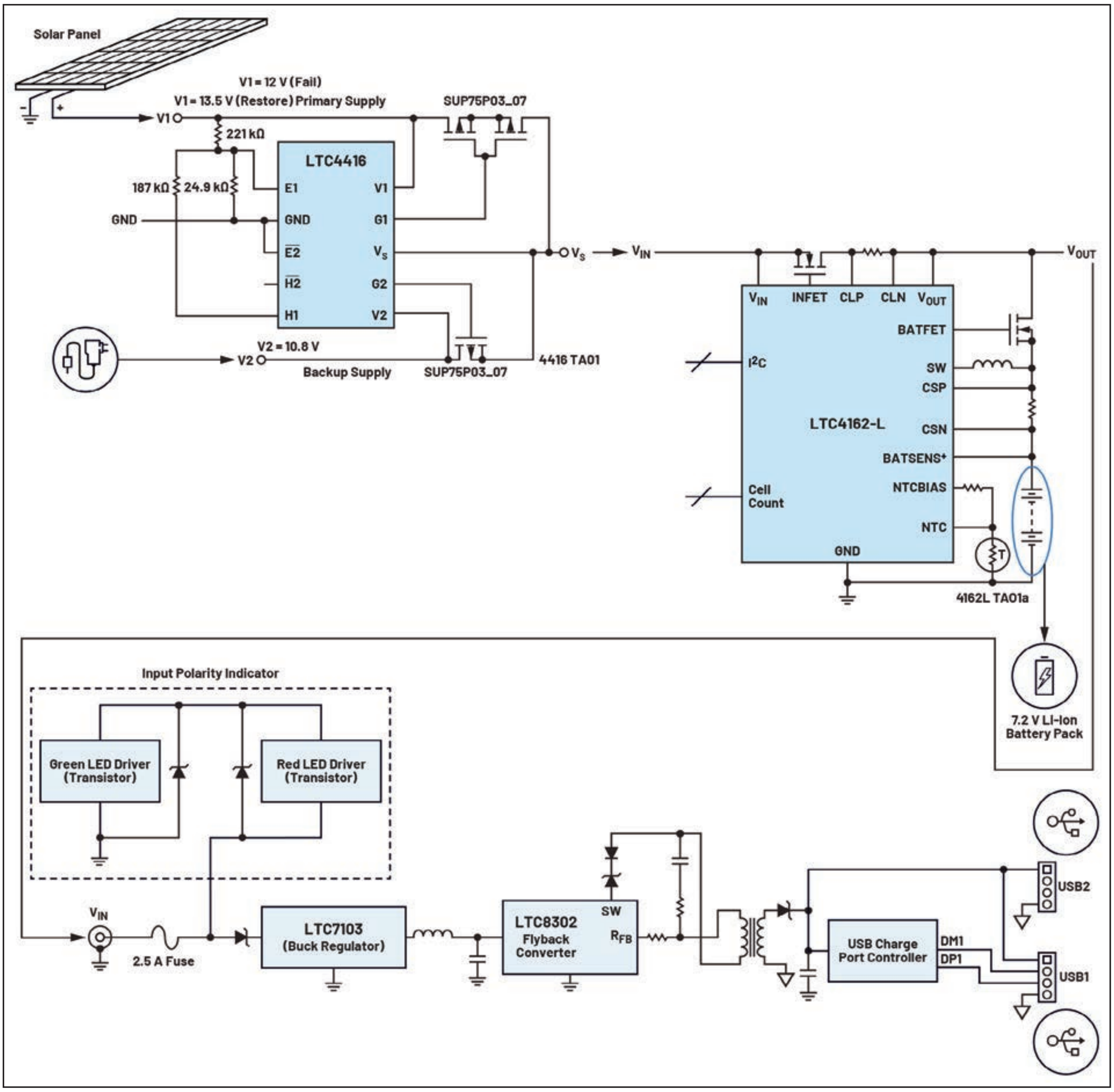


Figure 6: **A system diagram of the prototype.**

provided to the USB ports.

A more slimline version of the CN0509 could be used to reduce the overall battery bank cost. For example, the LTC7103 and input polarity protection circuitry would not be necessary for this design and the isolated flyback could be powered directly from the output of the LTC4162 (either 12V from the AC/DC wall wart or the battery voltage once mains power has been removed).

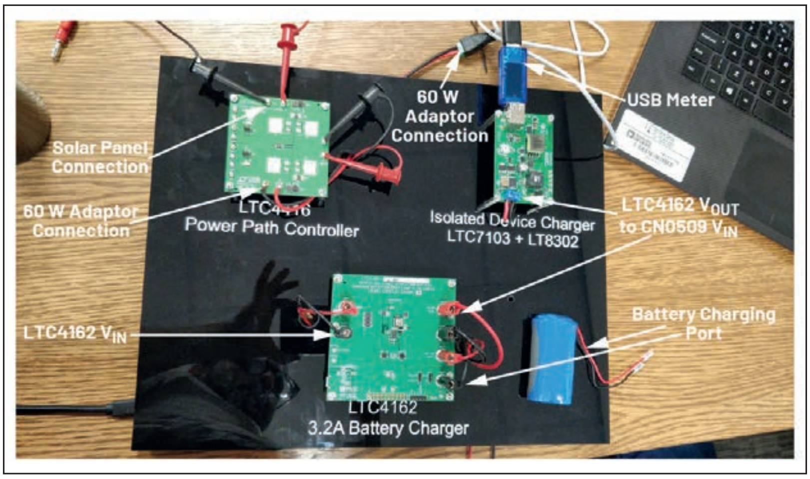


Figure 7: **A functional demo system.**

Conclusion

It is possible to prototype a power bank charger, or any other power supply design, using some readily available hardware and simple power sources. This highlights that using available demo board hardware can quickly provide a proof of concept for potential projects without spending much on development. Furthermore, this relatively small step will provide the user with confidence before committing to a more integrated design. Another point worth reiterating is that power supply design and, more specifically, the layout of a power design can be challenging so it is worth utilising the resources available to reduce the overall development time.

SiC soars to meet demand for small, lightweight power solutions

Using SiC can improve both efficiency and reliability of aerospace applications. As the industry strives for lightweight, compact, high density efficient power, SiC is being propelled into the spotlight.
By **Alain Calmels, Design Engineer, Microchip Technology**

As is the case in other strategic sectors of electronics, the aerospace industry is rapidly moving toward lightweight, small, high efficiency and high density power solutions. As a matter of fact, the new size, weight, power, and cost paradigm poses tough and stringent requirements to designers struggling to meet the market demand while at the same time providing high efficiency power solutions.

Traditional inverters and DC/DC and DC/AC converters are proving inadequate or inefficient for the most critical and challenging applications, such as latest generation satellites, unmanned aerial vehicles or electric aircraft. To overcome these challenges, the approach to high density power modules proves to be an effective solution to deliver high reliability and power density as well as flexibility.

An unprecedented boost to the aerospace power applications industry is coming from the third generation of wide bandgap (WBG) semiconductors. Silicon carbide (SiC) is moving the aerospace power supply to a new era, characterised by more efficient, smaller, lighter power solutions.

SiC properties

While SiC properties have been known since the end of the 19th century, it is relatively recently that this WBG material has been used as a semiconductor. Compared with traditional silicon-based power devices, SiC MOSFETs feature a high breakdown electrical field (3 to 5MV/cm, which is almost 10 times higher than that of silicon) and a bandgap about three time higher than that of silicon (3.26eV versus 1.11eV). Thermal management is also improved thanks to the thermal conductivity of SiC, which is nearly three times higher than silicon (4.9W/cmK versus 1.5W/cmK), and its specific resistance, which is much lower than silicon ($0.3m\Omega/cm^2$ versus $400m\Omega/cm^{-}$ for a 1200V breakdown voltage at room temperature). The on-resistance, or RDS(on), of commercially available SiC power devices can be up to 400 times lower than that of an equivalent silicon-based device at the same breakdown voltage.

Compared with silicon counterparts, SiC MOSFETs can operate at higher switching frequencies with less conduction and power losses, allowing for smaller passive components in power systems and more compact and lighter power solutions. This, in turn, has enabled the replacement of current IGBT devices with SiC MOSFETs in high-power, volume-constrained applications such as aeronautics.

Aerospace applications

The gate driver circuit for SiC MOSFETs requires a high positive gate drive voltage (about 20V) and, depending on the specific application, a negative "off" gate voltage in the -2-V to -6-V range (for dV/dt immunity and for achieving the fastest turn-off speed). Combined with low output capacitance and low RDS(on), that makes SiC devices attractive for switching designs such as power supplies, three-phase inverters, amplifiers and voltage converters (AC/DC and DC/DC). The use of SiC devices also allows significant cost savings and a reduction in the size of the magnetic parts (transformers and inductors) used in many aerospace power applications.

In the aerospace industry, the concept of more electric aircraft (MEA) has become very popular. MEA aims to electrify auxiliary aircraft on-board systems, previously powered through mechanical, hydraulic and pneumatic means for efficiency improvement, cost reduction and increased reliability.

New power devices are being designed to meet MEA requirements, including AC and DC power systems, which need power electronic converters for operation.

Several power conversion functions required by an MEA power system are performed by DC/AC converters, such as engine starting, control of pumps and generators and flight control actuators.

To meet these challenging requirements, DC/AC converters with high power density and that can operate at high switching frequencies are needed. Efficiency is also a key factor, as it allows you to reduce both the size and weight of the converter, simplifying thermal management. Due to their reduced conduction and switching losses, SiC power devices are proposing themselves as a viable candidate to replace silicon-based IGBTs and MOSFETs in avionic power converters.

Clean and sustainable aviation

The aerospace industry is moving towards zero-emissions goals, developing new technologies able to reduce net greenhouse gas while promoting the usage of sustainable drop-in fuels.

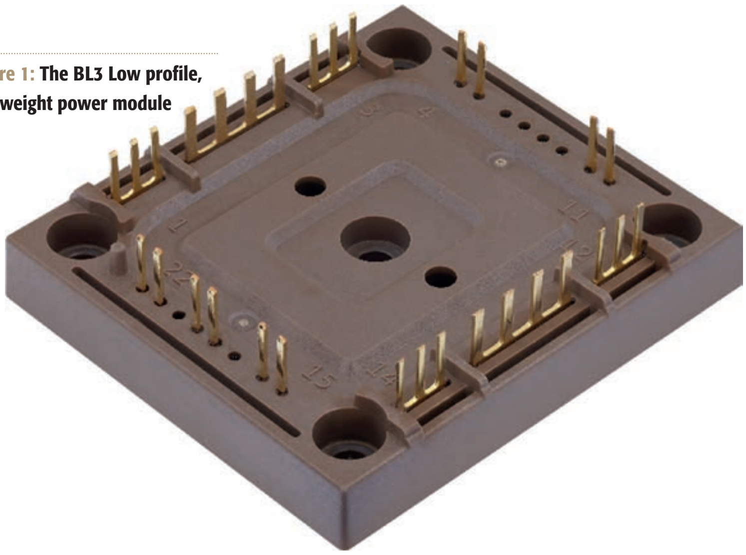
In Europe, the Clean Sky Consortium, a partnership between the European Commission and the European aeronautics industry, aims to develop cleaner air transport technologies capable of reducing CO^2, NOx, and noise emissions. A similar initiative has been taken by the International Air Transport Association, which last October approved a resolution for the global air transport industry to achieve net zero carbon emissions by 2050.

To fulfill these challenging requirements, pneumatic and hydraulic control systems need to be progressively replaced with high efficiency electrical and electronic control systems. Higher efficiency is a key factor for reducing fuel consumption, weight, and size.

Microchip Technology has introduced a series of AC/DC and DC/DC low profile, low weight power modules that provide higher power conversion efficiency through the utilisation of SiC. Capable of delivering from 100W to up to 20kW of power, they have been developed in collaboration with the European Clean Sky Consortium to meet new, demanding, clean requirements for the aviation industry. That includes compliance with RTCA DO-160G testing procedure (Environmental Conditions and Test Procedures for Airborne Equipment, version G). A DO-160G–compliant device can deliver reliable and accurate operation in any flight condition.

The modules (Figure 1) have a modified substrate, which results in a 40% reduction in weight and 10% in costs compared with standard solutions that incorporate metal baseplates and require a heatsink. In

Figure 1: The BL3 Low profile, low weight power module



addition, the low-inductance and low-profile package can be soldered directly on the PCB, accelerating the development and increasing the reliability.

Believed to be the first aerospace-qualified low profile, low weight power module technology to serve aerospace applications, the family includes three sizes of power modules (BL1, BL2, and BL3). The standard configuration integrates 1.2kV full-SiC topologies, with or without freewheeling diodes. The modules are available as 75A and 145A SiC MOSFETs, 50A IGBTs and 90A rectifier diode outputs. IGBT-based and custom solutions containing devices with voltage ratings from 700V to 1,700V are also available. Depending on the specific version, different topologies are supported, such as full bridge, asymmetrical bridge, phase leg, dual common source, buck, and boost.

Figure 2 shows the phase leg topology supported by the BL1 power module (1200V, 79A, RDS(on) typical 25mΩ). The SiC power MOSFET features low RDS(on) and high switching frequency, while the SiC Schottky diode provides zero reverse- and forward-recovery and temperature-independent switching behaviour.

The full bridge topology, shown in Figure 3, is supported by both the BL2 and BL3 power modules. These modules feature a drain-source voltage of 1.2kV, continuous drain current up to 150A at ambient temperature (up to 300A of pulsed drain current), and drain-source on-resistance as low as 16mΩ. The SiC MOSFET features a Kelvin source for easy drive, and the SiC Schottky diodes also feature zero reverse- and forward-recoveries. Maximum power is 560W, while maximum gate-source voltage is -10V (off state) and 24V (on state).

Qualification tests

All of the BL1, BL2, and BL3 power modules have undergone qualification tests to demonstrate the ability to serve aerospace applications. The Acceptance Test Procedure, based on the conditions specified in RTCA DO-160G and in compliance with civil aircraft environmental conditions, included parametric test over the full voltage, current, and temperature range (–55°C, 25°C and 125°C), partial discharge test (10pC max at 1200V AC), hipot (3kV AC) and isolation resistance test (>100 MR at 500V DC).

The following tests have been performed:

- High temperature gate bias. The purpose of this test, performed at both VGS = 20V and VGS = -8V, is to verify that the device performance is not affected by high temperature gate bias. At a junction temperature of 175°C, the Vth measurements before and after 1,000 hours of high temperature gate bias stress show negligible variations.
- Temperature cycling. This test aims to assess the resistance of the device to extreme high and low temperatures. The X-rays and scanning electron microscopy analysis, performed after 1,000 cycles

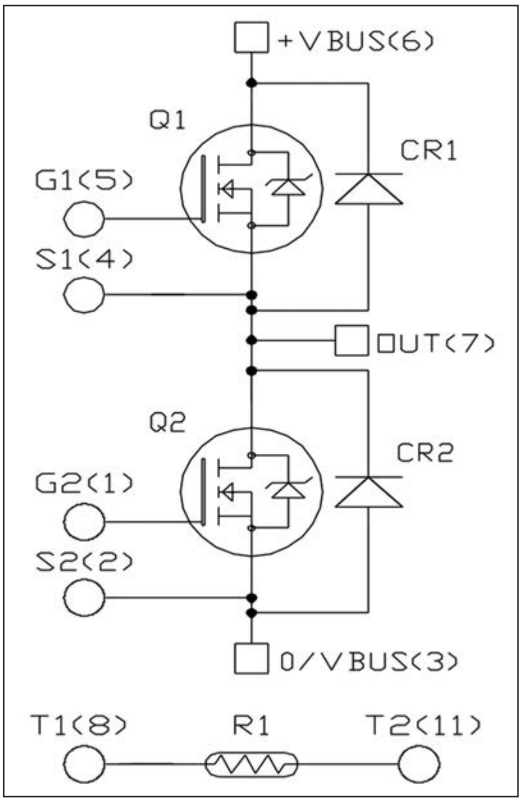


Figure 2: Phase leg topology supported by the BL1 power module

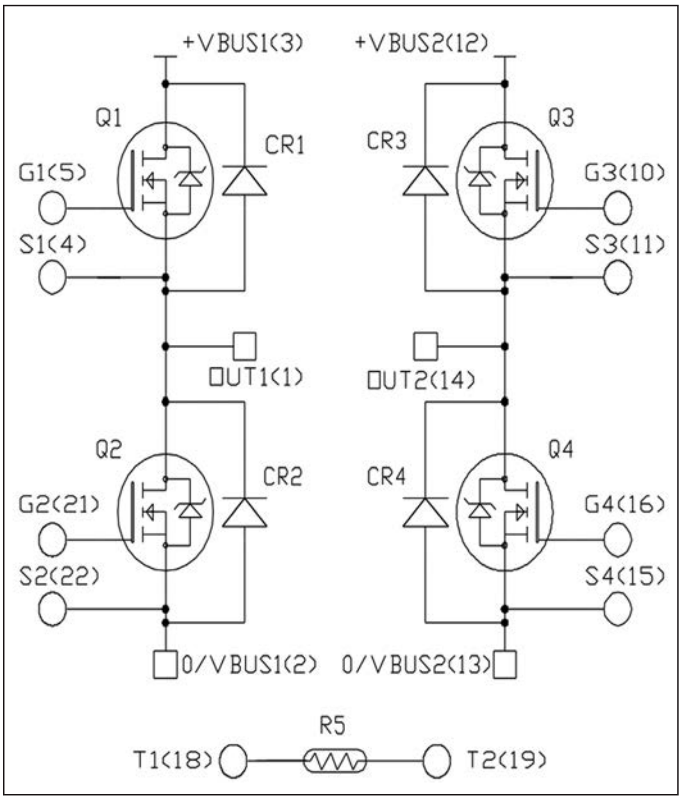


Figure 3: Full bridge topology (dual phase leg) available in the BL2 and BL3 modules

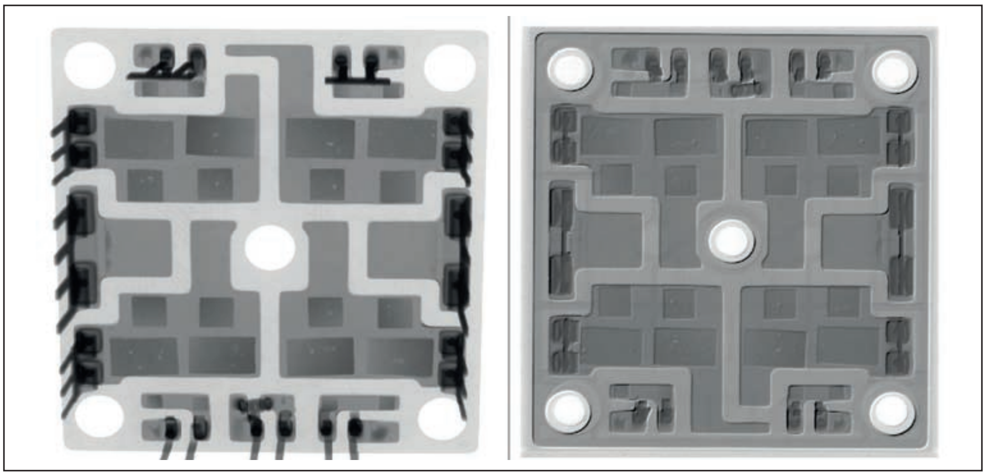


Figure 4: **X-ray analysis before and after 1,000 temperature cycles**

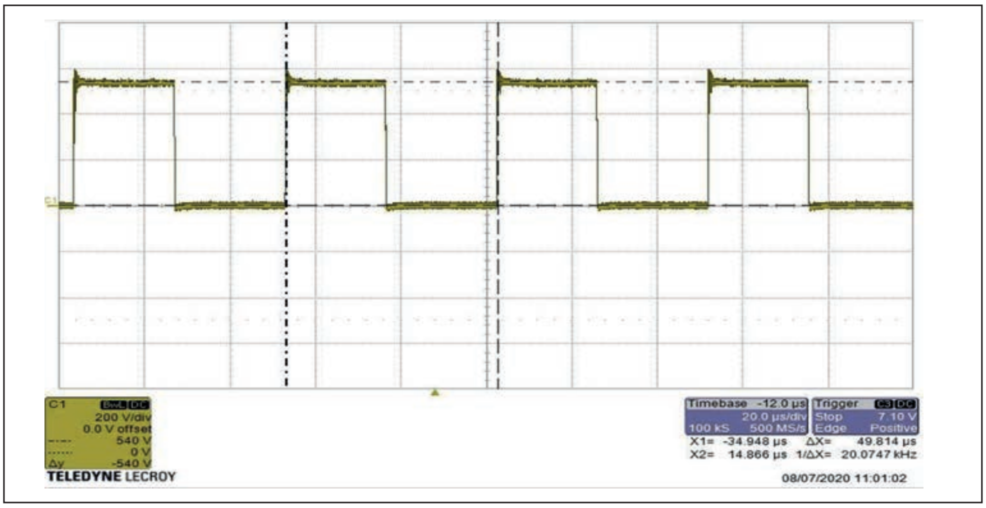


Figure 5: **CMB test plot**

(see Figure 4), do not show degradation at solder joint or substrate level capable of reducing the device performances.

- Vibration and shocks. After securing the power modules to a plate mounted on a vibration shaker, they were tested in three axes for vibration and shocks.
- Chopper mode bias (CMB). The purpose of this test is to verify the robustness of the device when it is operating in chopper mode at high temperature. Test conditions were the following: VGS = -5V, switching frequency = 20kHz, duty cycle = 0.5, T = 150˚C, test duration = 1,000 hours. Figure 5 shows the CMB test plot after 1,000 hours (200V/div).
- Partial discharge. This test aims to verify the insulation health of the DUT and is important for SiC power modules, which operate at high voltages and high dV/dt rates.
- Thermal simulations and measurements. Thermal simulation determines the DUT thermal resistance and thermal impedance values, while thermal measurement confirms the thermal resistance junction-to-heatsink calculated during the simulation. The switch under test, previously prepared with a modified package (Figure 6) was turned on, and a constant-current generator produced a junction temperature increase to calculate the thermal resistance. The results of the measurement confirmed the thermal simulations.

All tests were performed by Microchip. The company says passing these tests demonstrate reliability and prove this technology is qualified and suitable to serve ever more challenging aircraft applications.

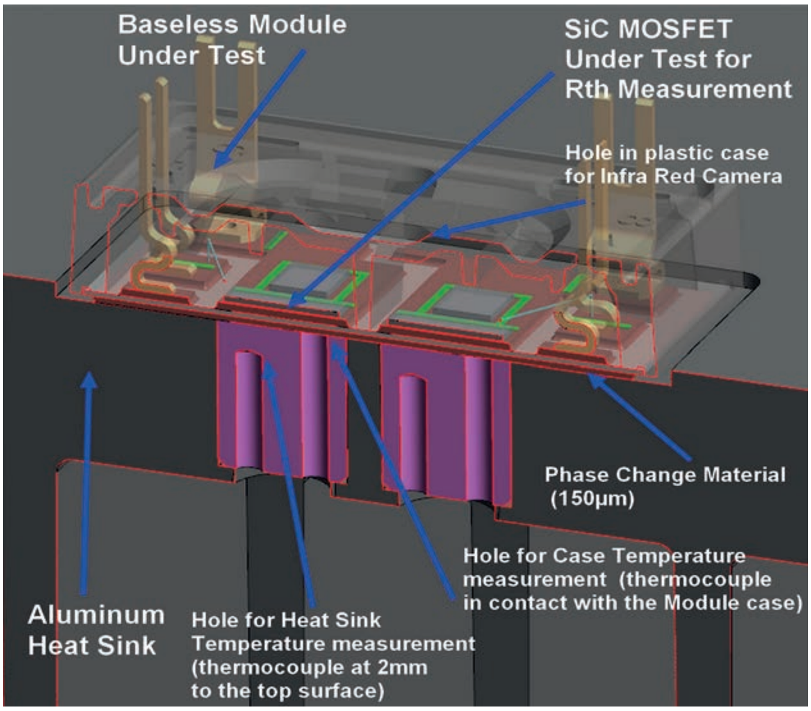


Figure 6: **Thermal measurement setup**

Eco-friendly choices shine through for clean energy

As the world moves towards making more eco-friendly responsible choices, the demand for sustainable and renewable energy has driven consistent high growth in the solar inverter market. By Panasonic Industry.

A solar inverter (also called a photovoltaic or PV inverter) converts direct current (DC) into alternating current (AC), and is widely used in solar photovoltaic power generation systems.

Solar inverters available today are generally divided into three types: central inverters, string inverters and micro inverters.

Central inverters are mainly used in large-scale ground power stations, suitable for high voltage grid connection. The power range is normally between 100kW and 2500kW.

String inverters, also known as distributed inverters, are mainly used in industrial, commercial and residential areas. Power stations that use string inverters are not generally very large, and they are integrated into the national supply through full or surplus power grid connection. Power range is normally up to 200kW. String inverters are most commonly used and encountered in our daily lives.

Micro inverters are mainly used for direct integration on battery boards, that are suitable for small household power stations.

Standard film capacitors

Film capacitors can optimise the design of string inverters. Regardless of the type of solar inverter, the key requirements are high efficiency, high reliability and input voltage with a wide range of capacitance values. Metallised PP(polyproylene) film capacitors can play an essential role in a solar inverter's circuit design because they feature a large current handling ability, high reliability and proven safety performance. They can be used for I/O filtering, EMI suppression, snubber and DC link circuits.

On the input side of the primary DC filter circuit as well as for the DC-link circuit, DC-rated film capacitors provide DC filtering. For example, parts with voltage ratings of up to 1300V DC and a wide capacitance range of up to 110µF are available as one single component in Panasonic's EZPV series; both two-pin and four-pin terminal devices are available.

On the input side of the DC/DC converter circuit, as well as in snubber circuits, capacitors such as Panasonic's DC-rated ECWFD series (coating type), ECWFE and ECWFG (box type) film capacitors, are suitable for smoothing. Various rated voltage values are available from 450V DC up to 1100V DC with a capacitance range from 0.01µF to 12µF. The built-in fuse provides safety performance which, together with high frequency characteristics and high ripple current capacity help film capacitor devices to optimise the high voltage circuit of a solar inverter. Film capacitors with a higher rated voltage of 250 to 600V AC, for example Panasonic's AC-rated EZPQ industrial-grade AC capacitors, can be used as an output filter.

Reliability - especially in humid conditions - is critical for solar inverters which are used outdoors. To achieve high humidity resistance, for example, Panasonic has developed enclosure sealing technology and 100% aluminium vapour deposition processes (Figure 2).

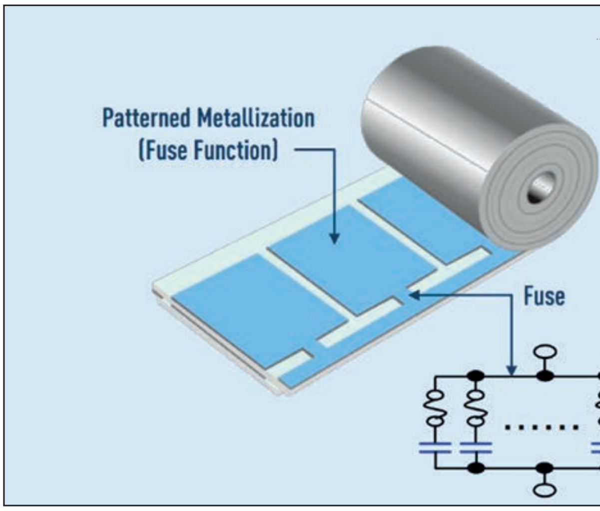


Figure 1: Structure of patterned metallisation (fuse function).

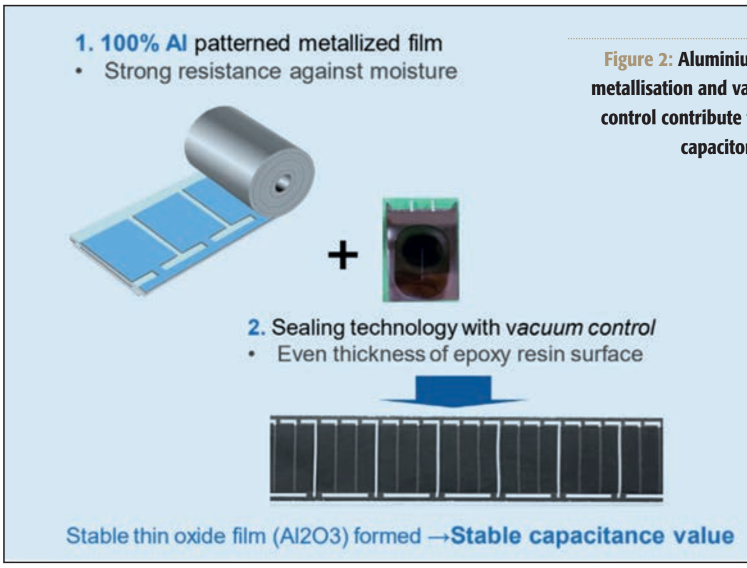


Figure 2: Aluminium for metallisation and vacuum control contribute to the capacitor seal.

Polymer aluminium capacitors

Conductive polymer solid aluminium capacitors play a major role in the optimisation of solar inverters. To efficiently generate energy from the sun, the solar panel must absorb energy from the sun

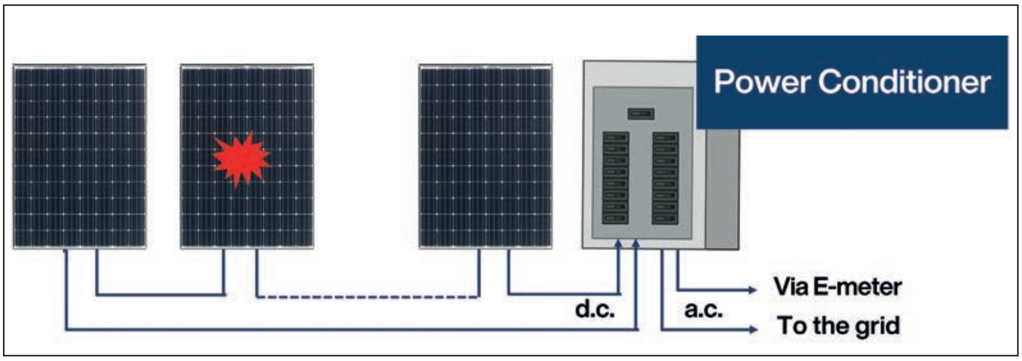


Figure 3: The role of a centralised power conditioner.

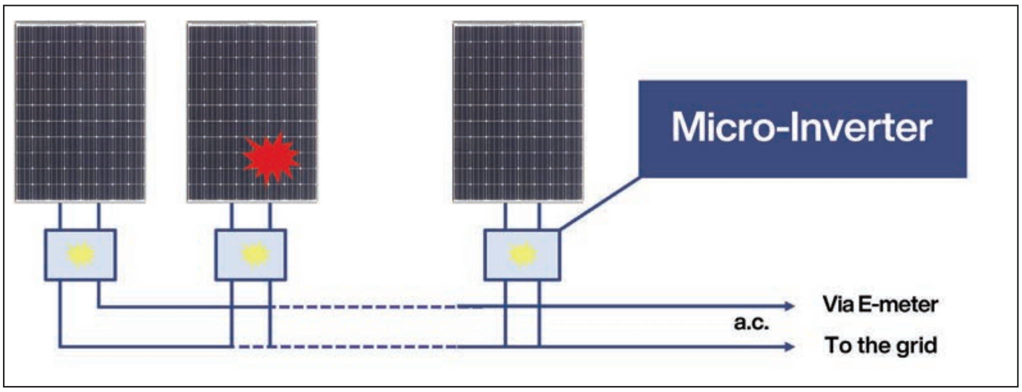


Figure 4: The position of a micro inverter.

continuously as the earth rotates. Detecting and tracking the live position of the sun and adjusting the angles of the panel to ensure that it always faces the sun, maximises the solar energy harvested.

Conventional solar inverters have a centralised power conditioner that controls the entire module but, ironically can cause the modules to become shaded, resulting in a decrease in energy output (Figure 3).

An example of conductive polymer solid aluminium capacitors is Panasonic's OS-CON series. Conductive polymer solid aluminum capacitors play a major role in the optimisation of solar inverters.

To resolve this, micro inverters are installed on each module to keep the panel facing the sun, while only one centralised power conditioner is necessary for several modules (Figure 4).

These micro inverters demand a long lifetime of five to 10 years and must save space as well as reduce costs. For example, a single OS-CON can replace seven MLCCs (multi-layer ceramic capacitors) in a micro inverter design, reducing PCB space by 31% without reducing capacitance, whereas using MLCCs reduces capacitance due to DC bias.

The 10 year life span is more than three times that of an electrolytic device, enabling OS-CON capacitors to replace aluminium electrolytic versions to increase the life of the micro inverter. Two OS-CON capacitors can replace three electrolytic ones to save space.

Resistors for solar inverters

Many resistors are used in a solar inverter circuit (Figure 6). Current requirements focus on high voltage, high efficiency for energy saving, and long life. For the resistor this means high reliability with long life, high voltage-withstand capability and high accuracy.

For the regulator and voltage-sense functions, resistors with a small case size (e.g., Panasonic's ERJP series) can be used. (Pansonic claims the resistive element trimming shape ensures anti-surge and anti-pulse-withstand performance.)

Gate driver resistors are normally required to have a high power capacity and to be able to survive the high temperatures caused by heat generated within the IGBT and inverter. Panasonic's ERJH series resistors use newly developed materials to achieve high heat resistance, says the

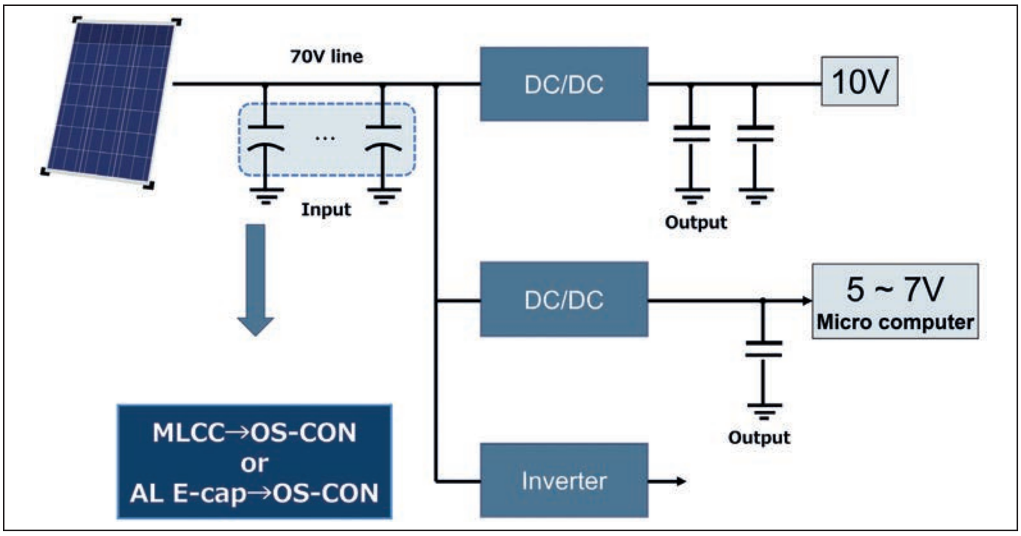


Figure 5: An example of a solar inverter circuit.

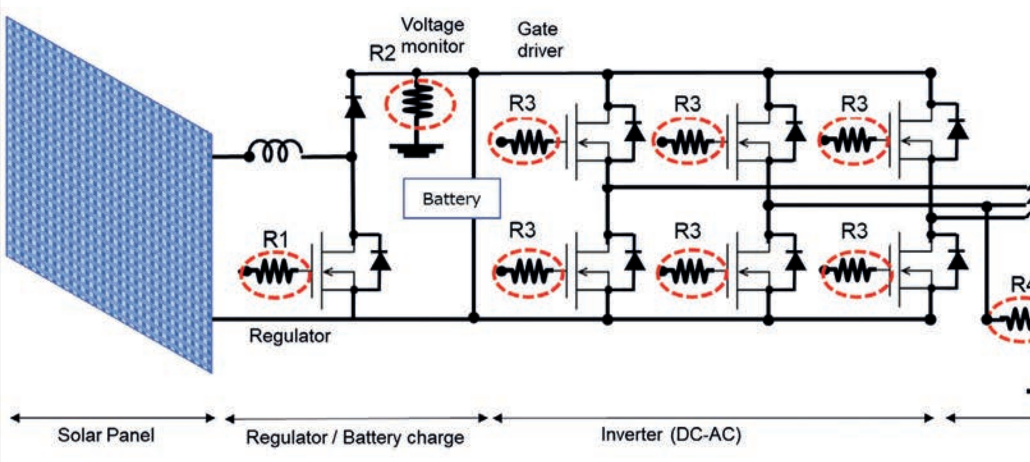


Figure 6: The use of resistors in solar inverters.

company. Maximum operating temperatures is now 175ºC) with rated operating range of 70ºC to 105ºC. The company also claims that solder crack resistance has been improved at high temperature.

In the motor drive control unit, resistors are required in the amplifier and feedback circuits. Key requirements are high reliability, long life and stable resistance. Resistors with an additonal resin layer on the underside can reduce solder joint cracking, while improvements to material and construction design can improve precision and extend life expectancy. Devices which meet anti-sulphuration specifications enable them to survive the harsh operating conditions that micro inverter applications routinely encounter.

Inductor design

Solar inverters need inductors that are capable of handling high voltages and large currents in the main circuit. These components are typically a custom design to meet both current handling and inductance requirements of the system. In addition to the inductor's role in the primary circuit, power inductors are also used in the auxiliary circuit for the controller and gate drivers, where digital logic provides critical controlling and monitoring functions for solar energy harvesting systems. The high switching speeds and harsh operating conditions can require high performance, metal composite power inductors to be specified.

One of the most important requirements of a power inductor for a DC/DC converter is high power efficiency. Inverter suppliers are facing tough demands for reduced inverter system size and higher efficiency, so the challenge for the inductor supplier is to provide an inductor at small size with high current capability and minimal heat dissipation.

A general trend in the electronic industry is the standardisation and modularisation of systems but this means that passive components suppliers need to provide products which scale over a broad range of requirements in regards to electrical power capability. A high current capability of an inductor series can support the standardisation of solar inverter systems, supporting a wider range of current flow, depending of the requirement of the individual system.

Exhibiting stability

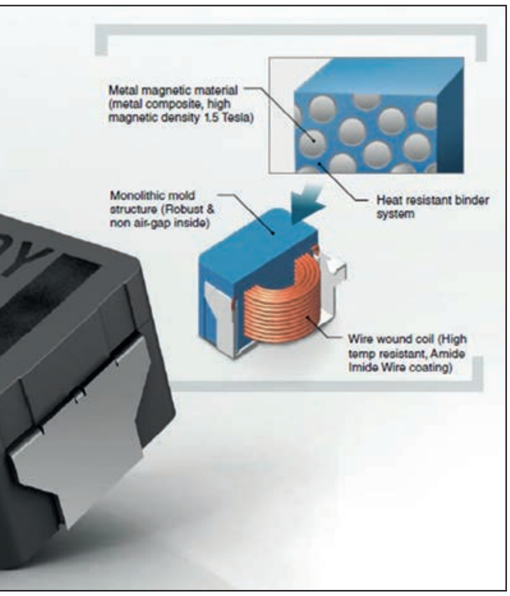
Metal composite power choke coils exhibit stable inductance over current, but are also stable with temperature, in comparison to ferrite inductors, where the inductance value is influenced by the temperature of the inductor. This means design engineers need to qualify the component for different temperature ranges when used in solar inverters. With stable temperature behaviour, much less time is required for qualification, which reduces development cost and time.

Another area within a solar power inverter that requires a power inductor is the gate driver of the FET that transforms the DC current of the battery to the three-phase sine wave, which is fed in the power grid. While the inductance of a ferrite inductor will vary with age, the metal composite material is free from any effects of ageing, helping the inverter manufacturer to guarantee a system that functions over its entire specified lifetime.

As is the case with the DC/DC converter, the power inductor of the gate driver circuit benefits from a stable temperature behaviour of the inductance value. This attribute also helps to reduce development and qualification time of the gate driver circuit, as engineers do not need to consider a fluctuation of the inductance value of the inductor, which is not only influenced by the power loss of the inductor itself, but also by the heat dissipated by surrounding components.

Additionally, designers of inverter systems are under constant pressure to make systems smaller and more efficient. Compared to ferrite inductors, metal composite inductors have a much higher energy density, which leads to a size reduction of 30% to 50% for comparable current specifications. PCB space can be saved, or higher currents used, simply by replacing ferrite inductors with metal composite ones.

Figure 7: Exploded view of Panasonic's metal composite power inductors.



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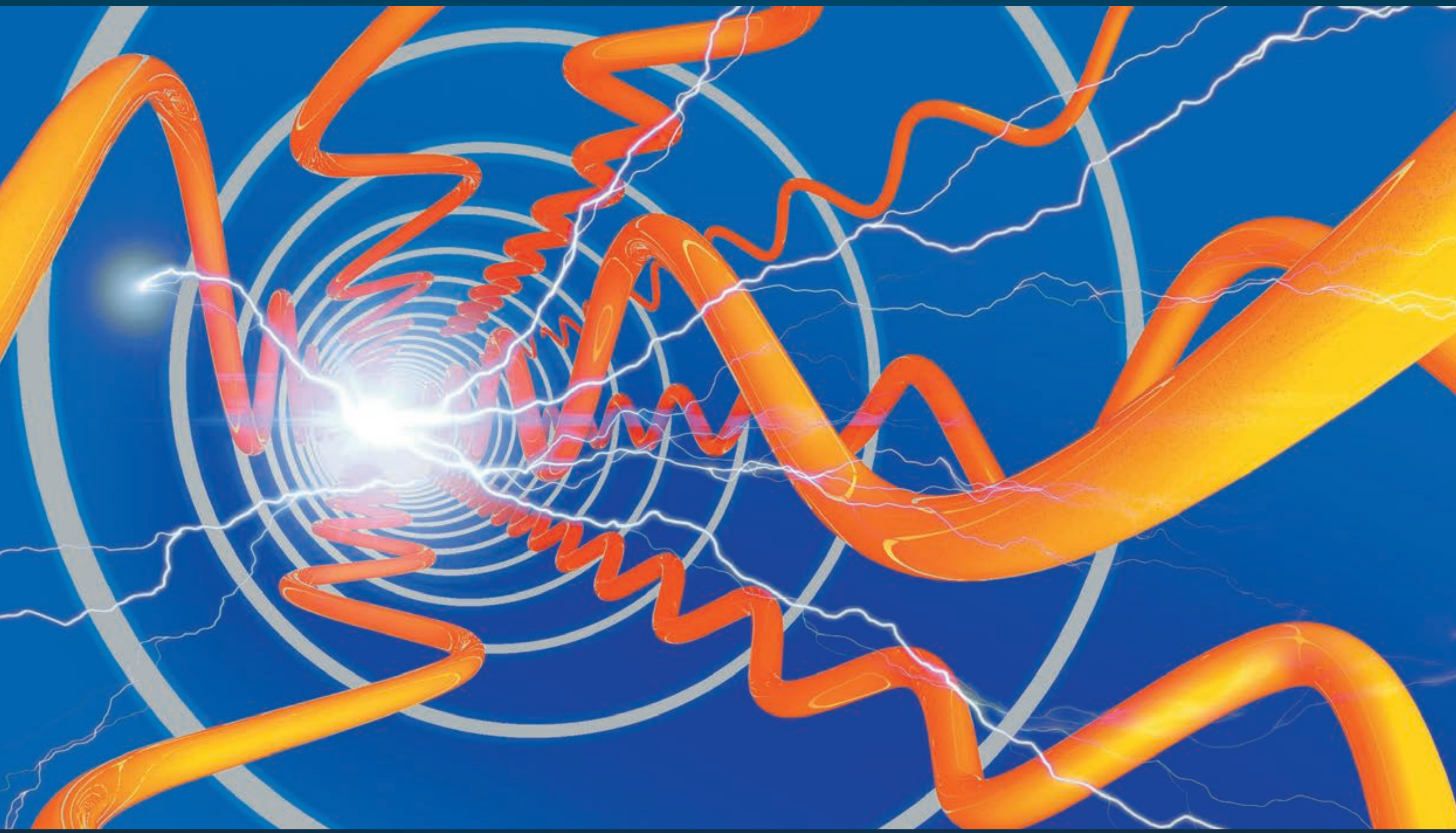

- Automotive
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IoT calls for a new approach to backup circuitry design

Two backup options are compared and new backup circuitry is proposed to meet a 15ms holdup time for a 12V/60W flyback converter with a 9V to 60V wide input range.

By Tiger Zhou, Applications Engineer Battery Charging Products, Texas Instruments

In telecommunication applications, network devices often need input status data so that they can send out dying last-gasp messages to users in the event of a power interruption. These network devices rely on temporary energy storage such as capacitor banks, which enables graceful shutdowns and the generation of these messages. The backup (holdup) circuity is designed to last from 10 to 20ms in order to perform these tasks. This extended period is called the holdup time.

Power supply designers are likely to have two questions about the holdup circuitry, especially for a wide input DC/DC converter. The first is should the holdup capacitor be placed on the input side or output side.

Traditionally, the power supply has a bulky output capacitor bank. The output capacitor holds up the output voltage and slowly decays, thus extending operation time before total system shutdown. The holdup energy, Ecap is quadratically proportional to the capacitor voltage, V as shown in the equation:

$$Ecap = {}^{1}CcapV^{2}$$

where, Ccap is the capacitance.

Since the output voltage is slowly decaying, it requires a downstream system with a wide input voltage tolerance. If the input range is limited, the energy utilisation is poor. In the following equation, the energy utilisation rate (EU%), is defined as a percentage of energy used over the energy stored:

$$EU\% = \frac{E_{MAX} - E_{MIN}}{E_{MAX}} = \frac{V^2_{O(MAX)} - V^2_{O(MIN)}}{V^2_{O(MAX)}}$$

The second question is: for a wide input range is a two-stage or single-stage approach preferrable?

Where to place the holdup capacitor

Consider a 60V input, 12V/60W flyback converter as an example, with a design holdup time of 30ms.

In a typical 12V system operating with a minimum 8V input, the utilisation on the capacitor bank would be 55%. For sensitive equipment with a tight voltage tolerance, such as 10%, the utilisation rate would be just 19%.

It is also possible to use high voltage capacitors on the input side. If the input voltage is allowed to discharge from 60V to 9V, the energy utilisation rate improves to 97.8%.

A high voltage capacitor has higher energy density than a low voltage capacitor. For example, a 1,200µF, 80V aluminium capacitor is the same size as a 6,800µF, 16V aluminium capacitor, but its energy density is 4.4 times higher than the low voltage capacitor.

There are two designs to consider. The first design uses a simple and straightforward approach, with holdup capacitors on the output side. This requires seven 6,800µF, 16V, 16 x 40mm output capacitors, which occupy more than half the available board space. The holdup time is an estimated 32ms with a full 60W load.

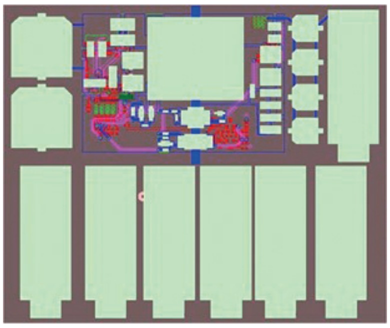


Figure 1: The holdup solution with the capacitor located on the output side.

The second design uses one high voltage, 1,200µF, 80V, 16 x 40mm input capacitor as the energy source. This single input capacitor provides a 32ms holdup time at a full load, assuming 90% system efficiency. The system efficiency reduces the available holdup time, since the flyback converter processes the input-side energy.

The first design (shown in Figure 1) measures 116.84 x 93.98mm (4.6 x 3.7 inches) which is twice as big as the second design, shown in Figure 2. The holdup time is 32ms for both designs. This comparison shows that placing the high voltage capacitor on the input side results in the use of fewer capacitors and that the input-side holdup design halves holdup capacitor bank size - and cost.

Comparing approaches

If the converter has a wide input range, such as 9V to 60V, the stored energy and energy utilisation rate will drop significantly as the input voltage level drops. At the minimum 9V input, the high voltage input capacitor offers virtually zero holdup capability.

One quick remedy is to add a boost converter in the front end (Figure 3). The boost converter steps up the wide input to 60V or higher. There are drawbacks to this two-stage approach, however. It lowers system efficiency and adds extra cost.

An alternative is to use an auxiliary

Figure 2: The input-side holdup design option measures 116.84 x 47mm.

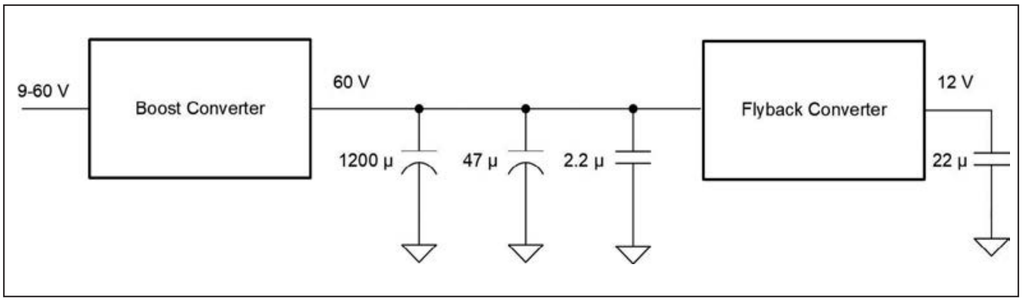


Figure 3: The traditional two-stage holdup solution.

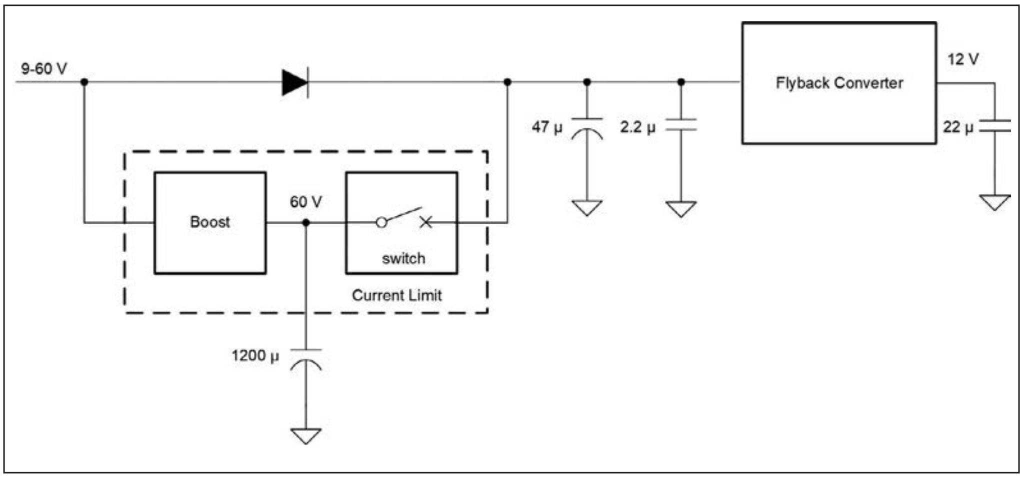


Figure 4: A proposed single-stage holdup solution maintains high efficiency.

boost converter to charge the high voltage capacitor to 60V and switch in the capacitor when the holdup circuitry detects a power interruption. Figure 4 shows this proposed high voltage holdup solution. The boost converter is not in the main power path, and therefore does not affect system efficiency.

The converter size is small given the low power level, which is just enough to charge the high voltage capacitor. The diode in Figure 4 could be a hot swap device or an ORing device, which is commonly available for telecommunication applications.

The energy transfer switch also needs special attention. It has to be fast acting; otherwise, the design needs a large amount of fixed input capacitance. It also has to limit power. During energy transfer, the flyback converter may drop to minimal operation levels while the holdup capacitor is fully charged, creating a large differential voltage across the switch. At the same time, a large amount of current is injected into the flyback input, generating tremendous electrical stress on the switch. Figure 5 illustrates a scalable current source with on/off control.

This energy transfer switch has a fast acting delay of less than 2.5µs. It also has an adjustable current limit set by the current-sense resistor. Connecting multiple current sources in parallel extends the power level. When the control FET (field effect transistor) gate is high, it pulls the main FET gate down, turning off the main transfer switch.

Figure 6 illustrates the verification of this concept in an IoT application. The flyback converter has a wide input range from 9V to 60V and the output is 12V/5A. There is only one holdup capacitor. The boost converter is small and three current sources are connected in parallel, placed on the back of the board, to relieve the device stress.

The worst-case test condition is when the input voltage is 9V. The small boost converter charges the holdup capacitor up to 60V. The power interruption detection circuitry sets the threshold at 8V. When the input voltage drops below 8V after a power interruption, the energy transfer switch turns on, thus transferring the energy from the holdup capacitor to the main flyback input capacitor. The result is that the

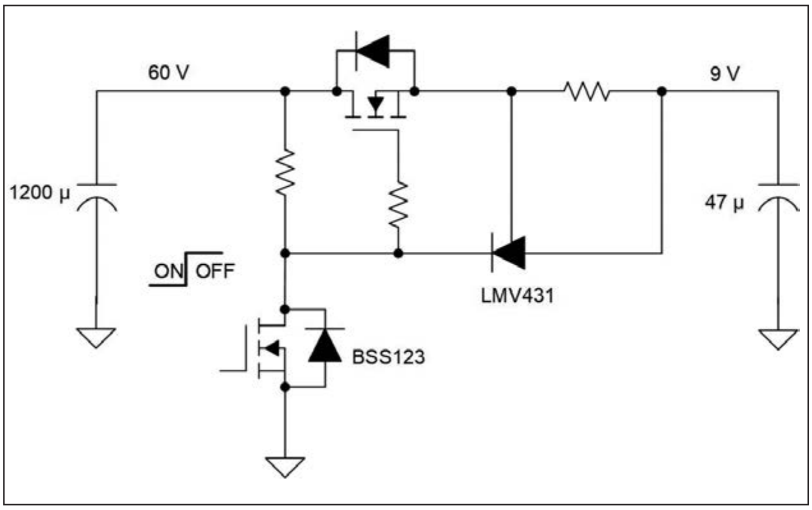


Figure 5. A scalable current source with on/off control.

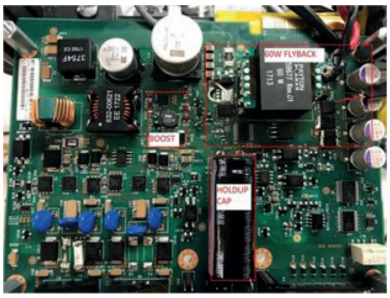


Figure 6. An IoT system example using a 60W flyback converter, holdup capacitor and a small boost converter.

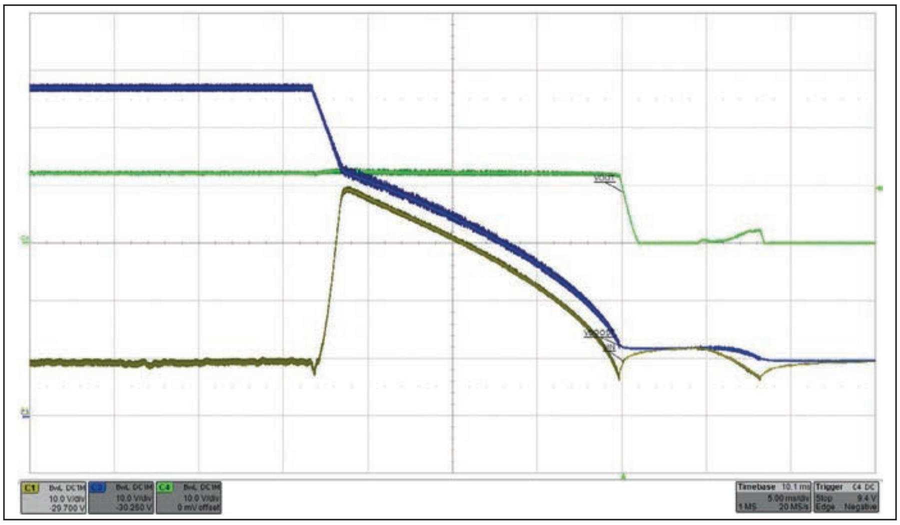


Figure 7. Test data shows the energy transfer: holdup capacitor voltage (blue), flyback input voltage (olive green) and flyback output voltage (light green).

holdup time is extended by 17ms.

The test data in Figure 7 shows that the flyback voltage rose from 9V to 40V during the energy transfer and the holdup capacitor voltage dropped from 58V to 43V. Both voltages depleted to supply the flyback converter for 17ms.

Conclusion

To meet the increasing holdup time requirement using a capacitor bank, two major considerations are energy density and the energy utilisation. An input-side holdup solution saves 50% board space compared to an easy-to-implement output-side holdup design, by taking advantage of the energy density and utilisation rate of a high voltage capacitor.

A backup circuitry designed to minimise insertion losses uses a small auxiliary boost converter to pump up the high voltage capacitor and a fast acting, current limiting switch to relieve stress during power dump. This proposed "pump-and-dump" solution maintains system efficiency, while the conventional two-stage solution takes a 5% efficiency hit because of the additional boost converter stage. The implementation of this backup circuitry in a 60W IoT application achieves a 17ms holdup time with a single 1,200μF holdup capacitor. This option is suitable for a wide input DC/DC converter where efficiency, space and cost are top design priorities. It also reduces the costly and bulky capacitor banks and significantly extends the holdup time of the energy storage capacitor.

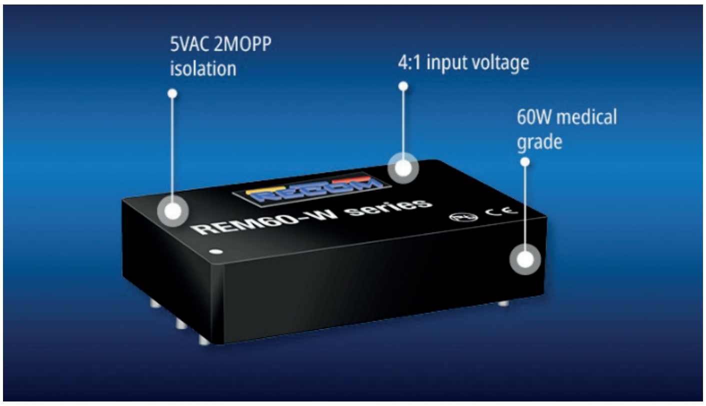
High density capacitors exhibit high ripple current capability

The Epcos B43657 aluminium electrolytic capacitor series have high ripple current capability of up to 8.54A (120Hz, 60°C). The capacitors achieve a service life of at least 2000 hours at a maximum operating temperature of 105°C, claims TDK. They also cover a rated voltage range from 450 to 475V DC with capacitance values from 120 to 1250?F.

The compact capacitors are offered in case sizes as low as 22 x 25mm up to 35 x 60mm. They are designed with snap-in terminals for ease of installation. The RoHS-compatible capacitors are intended for use in high-end switched-mode power supplies and power supplies for industrial and telecommunications applications. In addition, they are well-suited for UPS (uninterruptible power supplies), photovoltaic inverters and frequency converters.

Designers can perform a lifetime calculation under application-specific conditions using the online AlCap Tool.

High density DC/DC converter is medical grade



The REM60-W is available with two input ranges : 9.0 to 36V DC, and 18 to 75V DC and with a selection of tightly regulated single and dual outputs (5V, 5.1V, 12V, 15V, 24V /-12V, and /-15V). The DC/DC converter has a case size of 57.9 x 36.8 x 12.7mm. According to Recom, this delivers industry-leading power density for a 60W part. Efficiency peaks at over 90%. Operating temperature range is 105°C ambient with derating. The REM60-4824SW model, for example operates at 83°C at full 60W output power with 2m/s airflow.

The REM60-W series has reinforced / 2MOPP isolation and is rated 5kV AC per minute for 250V AC working voltage. Creepage and clearance distance from input to output is more than 8mm. The devices also have patient leakage current of 4.5μA maximum to suit medical B, BF, and CF applications.

Design features include an industry standard pinout, on/off control, remote sense, and output voltage trimming with full protection against over-temperature, output overloads, short circuits and input under-voltage. Operation to zero load is possible. Light load efficiency is high and quiescent and standby current is low, adds the company.

The REM60-W series operates at up to 5000m altitude and for a pollution degree 2 (PD2) environment. It is reliable, at over 1Mhrs MTBF according to MIL-HDBK-217F, 25°C, ground benign conditions.

It is certified to IEC/EN 60601-1 3rd edition, ANSI/AAMI ES60601-1 and CAN/CSA-C22.2 No. 60601-1:14 for the North American markets and complies with EN 60601-1-2 for EMI immunity for medical equipment. It is also certified to IEC/UL/EN 62368-1 certifications for IT/multimedia markets. EMC standards EN 55032 Class A and B can be met with a simple external filter.

The DC/DC converters are covered by a three-year warranty. Samples are available from all authorised distributors, or directly from Re

Infineon introduces OptiMOS power MOSFETs to PQFN 2x2 mm² portfolio

The new OptiMOS 6 power MOSFET 40V (ISK057N04LM6) with 5.7mΩ RDS(on) and OptiMOS 5 power MOSFETs 25 V (ISK024NE2LM5) and 30V (ISK036N03LM5) with 2.4mΩ and 3.6mΩ RDS(on), respectively, are available in the improved PQFN 2x2 mm? package and can be ordered now.

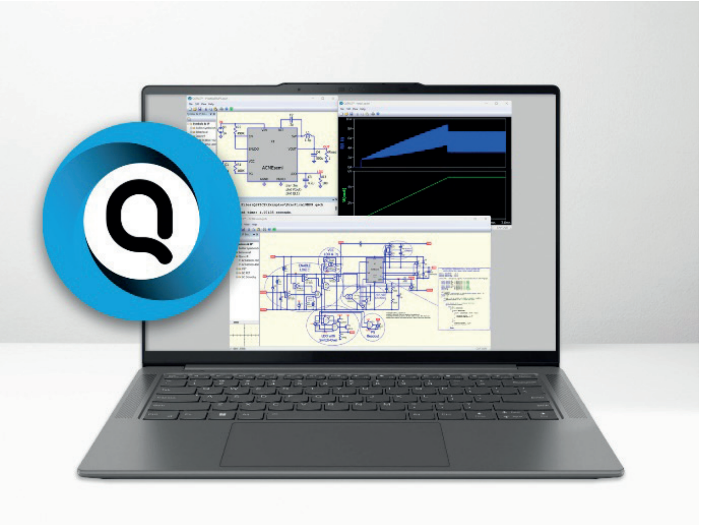
The two new power MOSFETs are claimed to be best in class OptiMOS power MOSFETs to achieve a small footprint and with higher power density for layout routing flexibility and overall system size reduction.

The OptiMOS 6 40V and OptiMOS 5 25V and 30V power MOSFETs are intended for applications such as synchronous rectification in switched mode power supplies (SMPS) for servers, telecomms and portable and wireless chargers, as well as electric speed controllers for small brushless motors in drones.

Infineon says the new OptiMOS 6 40 V and OptiMOS 5 25V and 30V power MOSFETs offer leading-edge silicon technology, package reliability and superior thermal resistance (R thJC, max = 3.2 K/W) in the small PQFN 2x2mm? package. They combine low on-resistance RDS(on) with what Infineon says are industry-leading figures of merit (FOMs, Q G and Q OSS) for "outstanding dynamic switching performance". The low switching and reduced conduction losses ensure optimal energy efficiency and power density, and also simplify thermal management, adds the company.

The compact PQFN package outline allows smaller, more flexible geometric outlines for end-user applications, continues Infineon. The MOSFETs also require less need for paralleling in a design which "significantly" reduces space and system cost.

Circuit simulation software accelerates power design, says Qorvo



The circuit simulation software can also advance analogue simulation technology and allows designers to simulate complex digital circuits and algorithms. It is distinguished, says Qorvo, by its combination of modern schematic capture and fast mixed-mode simulation for complex hardware and software challenges.

According to Jeff Strang, General Manager for Qorvo's Power Management business, the software "enables an entirely new generation of mixed-mode circuit simulation. In the past, power designers relied on analogue circuits and silicon power switches. Today, digital control and compound semiconductors are common elements of advanced power designs," he said. The software can be used by an engineer developing AI algorithms for EV battery charging, optimising a Qorvo pulsed radar power supply or evaluating the newest SiC FETs, he said.

QSPICE is available free of charge. Enhancements over legacy analogue modeling tools include support for advanced analogue and digital system simulations, such as those used in AI and machine learning applications.

There is also an upgraded simulation engine that uses numerical methods and is optimised for modern computing hardware, including a GPU-rendered user interface and SSD-aware memory management, to increase speed and accuracy, says the company.

It also features reduced overall runtimes and a 100% completion rate, based on Qorvo benchmark tests with a suite of test circuits. This compares to a failure rate of up to 15% with these same test circuits using other popular SPICE simulators, reports Qorvo.

A regularly updated QSPICE model library featuring Qorvo's SiC and advanced power management devices is also available.

Three 600V super junction MOSFETs are optimised for driving small motors

Other features are lower power loss and fewer external parts required for noise suppression in devices which have small motors.

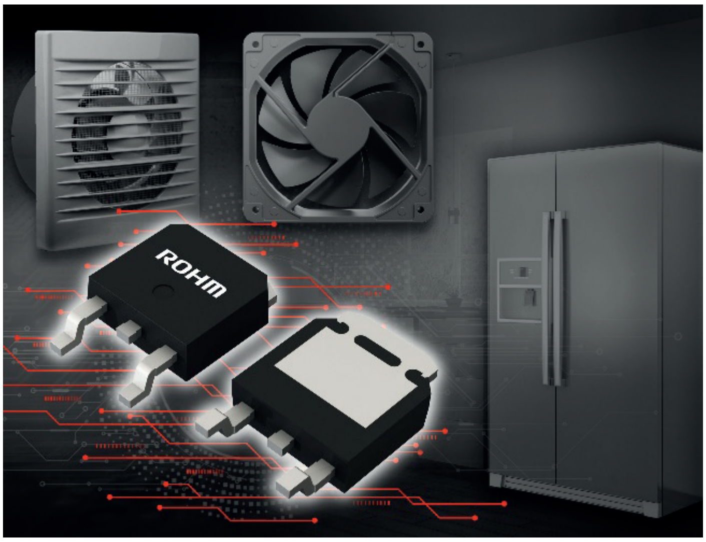
There are three new models in the R60xxRNx series which have been added the Rohm's PrestoMOS portfolio of 600V super junction MOSFETs. They are optimised for driving small motors in refrigerators, ventilation fans, and other applications where noise suppression is a consideration.

Greater energy efficiency in equipment is required due to energy concerns and motor drives account for up to 50% of the world's total power demand. High efficiency MOSFETs are therefore increasingly being used in inverter circuits that convert power to drive motors. MOSFET operation can generate noise, however, which can be address by adding components and/or changing circuit patterns.

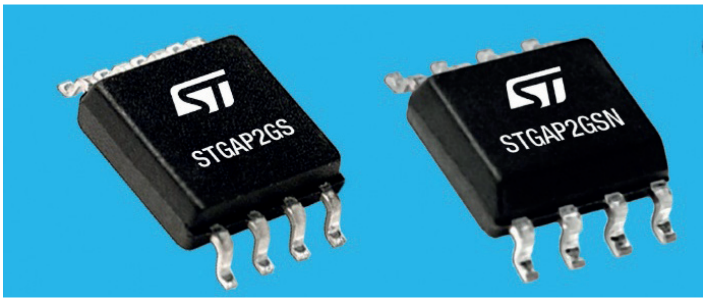
The PrestoMOS Super Junction MOSFETs feature the industry's fastest reverse recovery time(trr) characteristics, claims Rohm, to receive high marks for achieving lower power consumption. The three new models are claimed to provide best-in-class noise characteristics while maintaining the fast trr through an optimised structure.

The R60xxRNx series maintains the high-speed trr characteristics of PrestoMOS while minimising noise. A reverse recovery time of 40ns is achieved by improving conventional lifetime control technology, reducing switching losses by approximately 30% over general products to lower application power loss. The super junction structure reduces noise characteristics (which are inversely related to faster trr) by about 15dB compared to standard products says Rohm (under measurement conditions at 40MHz).

Typical applications are refrigerators, ventilation fans and fan motors and any devices equipped with small motors, says the company.



STGAP2GS GaN driver integrates galvanic isolation



STMicroelectronics' first galvanically isolated gate driver for GaN transistors, the STGAP2GS, has been developed for applications that demand superior wide bandgap efficiency with robust safety and electrical protection.

The single-channel driver can be connected to a high voltage rail up to 1200V. There is also a narrow body version, the STGAP2GSN, which operates up to 1700V. Both versions provide gate driving voltage up to 15V. It can sink and source up to 3A gate current to the connected GaN transistor to control switching transitions up to high operating frequencies.

Characterised by minimal propagation delay across the isolation barrier of 45ns, the STGAP2GS delivers a fast dynamic response and also has dV/dt transient immunity of ±100V/ns over the full temperature range to guard against unwanted transistor gate change. The STGAP2GS is available with separate sink and source pins for tuning the gate driving operation and performance.

It also has a built-in system protection including thermal shutdown and under-voltage lockout (UVLO) optimised for GaN technology, to ensure reliability and ruggedness.

There is no need for discrete components to provide optical isolation, says the company. The company believes the driver can introduce GaN technology in a range of consumer and industrial applications such as power supplies in computer servers, factory-automation equipment, motor drivers, solar and wind power systems, home appliances, domestic fans, and wireless chargers.

Two demonstration boards, the EVSTGAP2GS and EVSTGAP2GSN, combine the standard STGAP2GS and narrow STGAP2GSN with ST's SGT120R65AL 75mΩ, 650V enhancement-Mode GaN transistors to help users evaluate the drivers' capabilities.

The STGAP2GS in SO-8 widebody package, and the STGAP2GSN SO-8 narrow version, are available now.

Models with adjustable current limit expand i7A series of DC/DC converters

They have a 400W maximum rating, offering 0.8 to 8.0V adjustable outputs from a 12V nominal input. There is now the option to adjust the over-current limit on all input voltage and output current models. This feature helps reduce stress on the converter when exposed to excessive overload conditions and also helps to fine tune the over-current limit based on actual system needs, says the company.

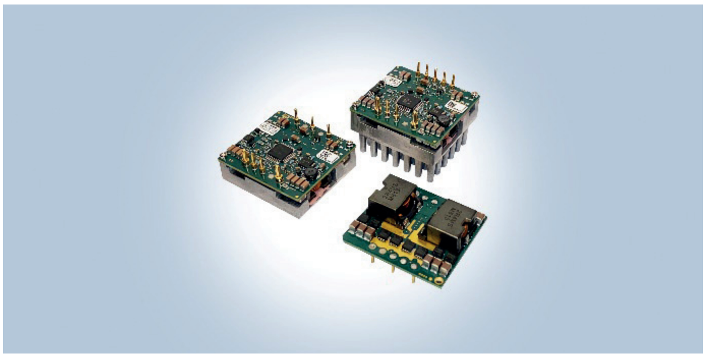
The 60A i7A models can be used to derive additional high-power outputs from a 9.0 to 18V DC power supply at a lower cost and higher efficiency than isolated DC/DC converters. The compact modules are suitable for mobile robotics, drones, medical, industrial, test, measurement, communications, computing and portable battery-powered equipment.

Efficiencies are up to 97% and the DC/DC converter operates in ambient temperatures of -40°C to 125°C, even with low airflow conditions, says TDK-Lambda. In addition to low output ripple and response to dynamic loads, the modules have a lower bill of materials compared to discrete solutions, with minimal external components required, according to the company. This saves both cost and PCB space requirements.

The i7A 60A standard features include output voltage adjustment, remote sense, negative logic remote on-off, input under-voltage, over-current and over-temperature protection. Evaluation boards are available for simplified qualification.

The 60A version joins the existing 33A and 45A models. All measure 34mm wide and 36.8mm long with a choice of profiles. The open frame model at 11.5mm high is suitable for applications requiring a low profile. The baseplate version can be conduction cooled to a cold plate and is 12.7mm high. Models with an integral heatsink for convection or forced air cooling are 24.9mm high.

All models have safety certification to the IEC/UL/CSA/EN 62368-1 standards, with CE and UKCA marking to the Low Voltage and RoHS Directives.



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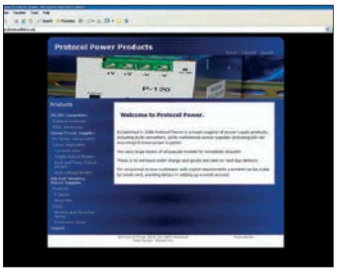

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