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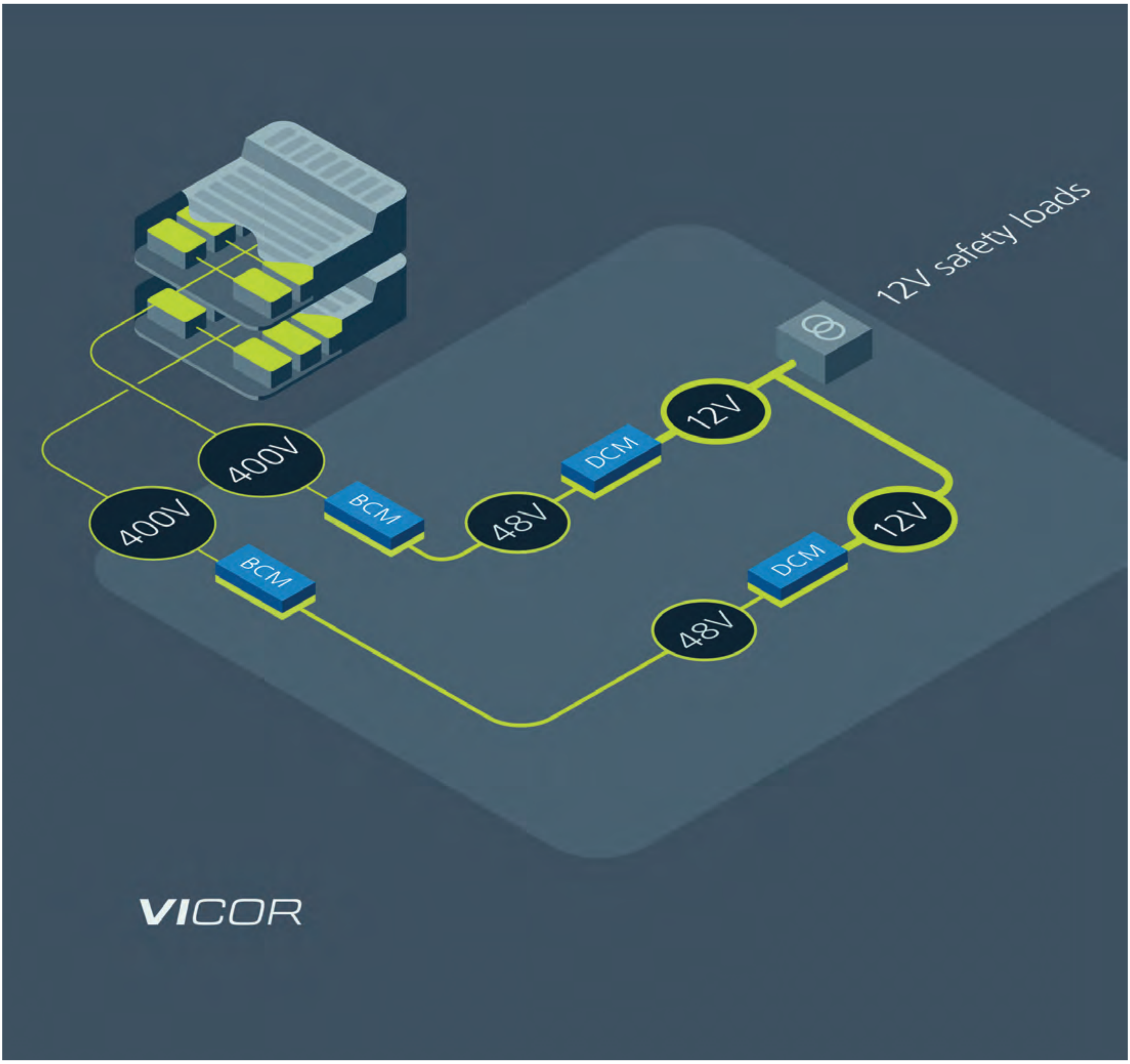
# POWER REDUNDANCY IS ESSENTIAL FOR BEV SAFETY, RELIABILITY

High-efficiency power modules convert dual 400V batteries down to loads




THE EUROPEAN JOURNAL FOR POWER ELECTRONICS AND TECHNOLOGY

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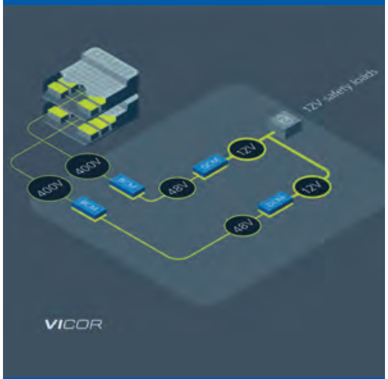
## FEATURE STORY




## BEV advancements are driving sales, but vehicle safety and reliability will ensure long-term viability

Innovative power architectures using power modules provide power redundancy and improve overall safety and system performance.

More details on page 10.

# PCIM Europe 2024's exhibition space grows with an extra hall


Increased demand from exhibiting companies means that PCIM Europe 2024 has expanded beyond halls 6, 7 and 9. An extra hall will be allocated for the exhibition and conference, which takes place between 11 to 13 June 2024 at the Nuremberg Exhibition Center, Nuremberg, Germany.

The additional hall reflects this increasing demand for opportunities for suppliers to present and exchange information and technology developments, says Messe Messago. PCIM Europe has been a platform for the power electronics community for 43 years and today reflects changes as the industry adapts to develop reliable energy supplies for new applications, such as electro mobility.

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. The organiser says that visitors to PCIM Europe can look forward to an even more extensive range of products and services as well as further networking opportunities.

The number of registered exhibiting companies is expected to be another record number, already surpassing 450 by the end of last year. "We are aiming to respond to the needs of the industry in a timely manner and thus significantly increase product diversity and networking opportunities," explains Lisette Hausser, Vice President PCIM Europe at organiser Mesago Messe Frankfurt GmbH.

A new focus for 2024 is smart power system integration. Miniaturisation and complexity in the electronics industry is leading to constantly increasing requirements in terms of power density, efficiency, signal frequencies and thermal properties, meaning that system integration occupies centre stage, with consequent demands on materials, components, circuit carriers, temperature resistance and, especially assembly and interconnection technologies.

At the Smart Power System Integration Zone and Stage in Hall 5, exhibiting companies will present innovative technologies, solutions, and application examples for current and future challenges in power electronics manufacturing, particularly for applications in areas such as automotive, railway and server technology.

For the first time, there will be an extensive programme of presentations on current products and trends on four stages. Each will have a different focus: the Smart Power System Integration Stage, Technology Stage, formerly known as the Industry Stage, Exhibitor Stage and E-Mobility & Energy Storage Stage.

There will be a special E-Mobility & Energy Storage Zone with its own stage which will host presentations on current topics and trends relating to the electromobility and energy storage value chain. In addition, live product demos will take place at the stands of suppliers from this area.

Electromobility and energy storage will also be addressed at the parallel conference in the form of presentations.

The 2024 conference received a record number of submissions, with presentations from the R&D departments of leading companies and universities from all areas of power electronics. The 2024 conference programme can be found at **www.pcim-europe.com**

# Arrow Electronics staffs High-Power Centre of Excellence with eInfochip

The centre at the company's Swindon facility in the UK will assist customers develop high-power solutions, a critical component in advancing electrification and sustainability initiatives.

High-power designs are essential for energy efficiency in net-zero projects such as electric vehicles, renewable energy, battery storage and grid infrastructure, for example. Challenges include a lack of power expertise, stringent functional safety and reliability requirements, intricate PCB layout and the necessity for costly testing equipment, explains the company.

The High-Power CoE is equipped with a high-power lab and an experienced engineering team from eInfochips. The goal is to empower innovators to navigate the complexities of high-power electronics design effectively, says the company.

"The Swindon facility is known for its configurable power supply capabilities, and the CoE builds on its legacy by investing in new equipment and engineering talent. We can now offer turnkey design services from the Swindon facility," says Murdoch Fitzgerald, vice president, global engineering and design services at Arrow Electronics.

The CoE will design products for all customers of Arrow and its subsidiaries, such as Richardson RFPD, supporting customers in planning and managing high-power product roadmap and lifecycles.

**https://www.einfochips.com/high-power-centre-of-excellence/.**

# Lab is dedicated to quantum electronics and power AI

A lab to develop and test microelectronic circuits for quantum computers and develop AI algorithms for the early detection of variances in power systems, has been opened by Infineon.

The lab in Oberhaching near Munich will use AI to simulate and better predict the ageing and failure characteristics of microelectronics in the power market. It will develop the necessary algorithms and introduce practical measurements to establish the data basis for training neural networks and verifying behaviour. This will help better estimate the service life of power converters and will aid in detection of anomalies. The insights will contribute to proactive maintenance to prevent equipment failure.

It will also focus on ensuring microcircuits are stable and small in size, reliable and can be produced on an industrial scale. Approximately 20 researchers will work at the lab.

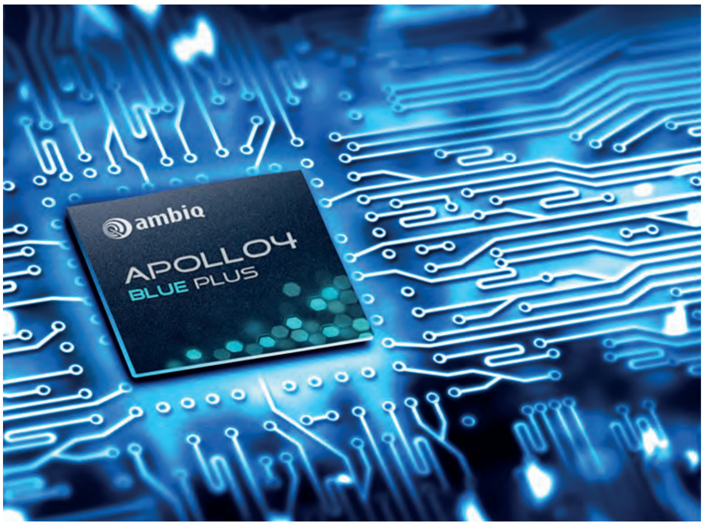
"Infineon plans to reinvent the core element of the quantum computer. One of the central tasks of the new quantum laboratory will be to develop and test electronic systems for ion trap quantum computing with the objective of integrating these systems in the Quantum Processing Unit," says Richard Kuncic, Senior Vice President and General Manager Power Systems at Infineon Technologies.

A cryostat has been installed, which can maintain cryogenic temperatures as low as 4°K (-269°C) for qubits, the smallest units for calculations with quantum computers. These are extremely sensitive and only adequately stable under extreme conditions, typically temperatures below -250°C, and at the lowest possible pressures. At the same time, electronic systems have to keep working in these extreme conditions, when many materials change their properties, including their electric behaviour.

Pictured from left to right: Chuck Spinner, Head of Central R&D Power Systems and Solutions (PSS); Hartmut Hiller, Head of R&D; Adam White, President Power Systems and Solutions; Richard Kuncic, Head of Power Systems).

**http://www.infineon.com**

# DigiKey signs global partnership with Ambiq




Low power IC supplier, Ambiq, has signed a global distribution deal with DigiKey which now stocks Apollo4 Blue Plus.

The distributor stocks Ambiq's low power ICs, including the latest SoC, the Apollo4 Blue Plus which combines Bluetooth Low Energy, graphics and audio for always-connected IoT endpoints. It is claimed to have one of the lowest dynamic powers for microcontrollers currently available making it suitable for wearables and battery-operated smart devices.

The Apollo4 Blue Plus is a 4th generation system processor solution built upon Ambiq's proprietary Subthreshold Power-Optimized Technology (SPOT) platform. The hardware and software solution enables current and future battery-powered endpoint devices to achieve a higher level of intelligence without sacrificing battery life, says the company.

It has sufficient compute and storage to handle complex AI algorithms and neural networks, always-on voice recognition, and display capability for smooth graphics.

"DigiKey is pleased to add Ambiq to our core supplier line card," said David Stein, vice president, semiconductors at DigiKey. He believes that Ambiq has raised the bar with this new MCU and SoC. "We're excited to support designers, engineers and builders globally as they work with these innovative solutions to accelerate progress," he says.

**https://www.digikey.com/en/product-highlight/a/ambiq/apollo4-blue-plus-soc/?utm_source=referral&utm_medium=pressrelease&utm_campaign=pressrelease**

# Nexperia and Mitsubishi Electric to develop joint SiC MOSFETs

A strategic partnership between Nexperia and Mitsubishi Electric to jointly develop SiC MOSFETs has been announced. It brings Mitsubishi Electric's power semiconductor portfolio and SiC modules, which are used in Japan's high speed Shinkansen trains, with Nxperia's wide bandgap device technology and discrete packaging experience to develop SiC wide bandgap semiconductors.

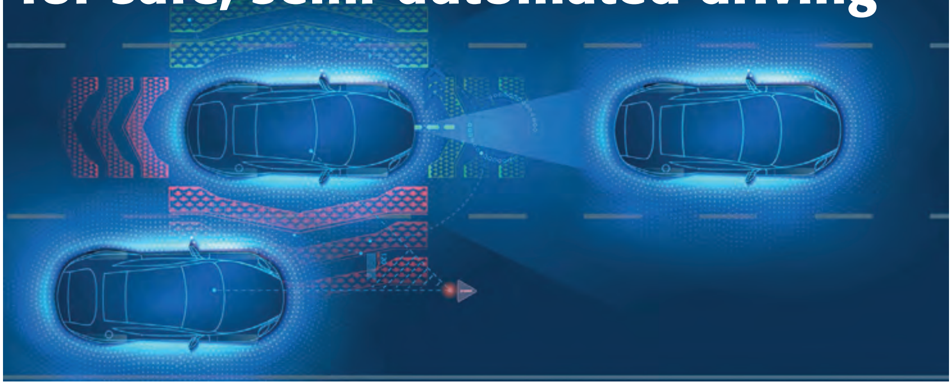
Nexperia's headquarters are in the Netherlands, with employees across Europe, Asia and the USA. It designs and builds components for "virtually every commercial electronic design in the world", from automotive and industrial to mobile and consumer applications. Mitsubishi Electric is based in Tokyo, Japan and manufactures electrical and electronic equipment used in information processing and communications, space development and satellite communications, consumer electronics, industrial technology, energy, transportation and building equipment.

The Japan-Euro partnership was welcomed by Mark Roeloffzen, SVP and General Manager Business Group Bipolar Discretes at Nexperia. "This mutually beneficial strategic partnership . . . represents a significant stride in Nexperia's silicon carbide journey," he said. Combining Mitsubishi Electric's expertise in supplying technically proven SiC devices and modules with Nexperia's expertise in discrete products and packaging generate positive synergies between both companies - ultimately enabling our customers to deliver highly energy efficient products in the industrial, automotive or consumer markets they serve".

Dr. Masayoshi Takemi, Executive Officer, Group President, Semiconductor and Device of Mitsubishi Electric, added: "We are delighted to have reached an agreement on a partnership for joint development that leverages the semiconductor technologies of both companies."

**https://www.nexperia.com**

# onsemi and Renesas collaborate for safe, semi-automated driving



**Integrating onsemi's Hyperlux image sensor on Renesas' R-Car V4x for automotive vision systems to OEMs and Tier 1s.**

**In a strategic collaboration, the image sensor has been integrated to the R-Car V4x SoC family in an effort to develop the safety of semi-automated vehicles.**

**The 2.1µm pixel size image sensor has 150dB high dynamic range (HDR) and LED flicker mitigation (LFM) across the full automotive temperature range. Combined with the R-Car software platform, the partners say that OEMs and Tier 1s. can access automotive computing for applications including ADAS and up to Level 3 automated driving.**

**Takeshi Fuse, Head of Function Unit and**

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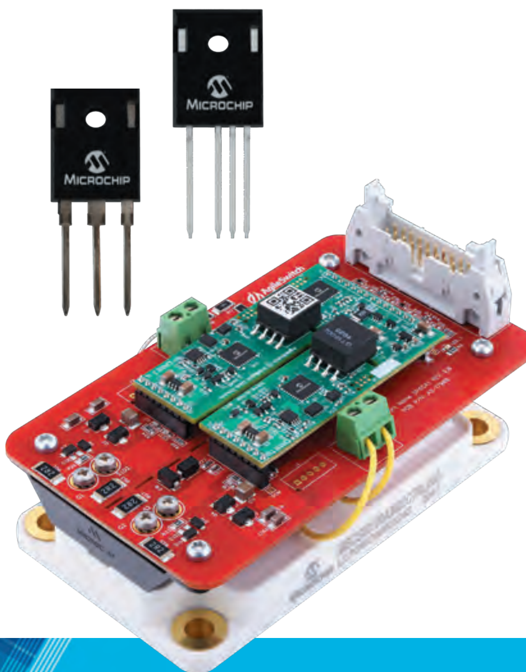


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**Business Development for the High Performance Computing, Analog and Power Solutions Group at Renesas, says: "Out-of-the-box compatibility of the onsemi Hyperlux image sensors on our R-Car V4x platform and continued collaboration on the next generation offerings are testament to the quality of our products and longstanding relationship."**

**The two companies' products have been deployed together in automotive applications for many years and product generations, says onsemi. Millions of vehicles on the road today are using a combination of R-Car Gen2 or Gen3 with onsemi image sensors in applications such as front camera, surround view and driver monitoring systems.**

**"The decision to integrate Hyperlux image sensors onto Renesas' latest platform demonstrates that our sensors are a key technology for safety-critical ADAS and autonomous driving solutions, delivering the uncompromised image quality that customers expect," comments Chris Adams, vice president, Automotive Sensing Division at onsemi.**

**https://www.onsemi.com/solutions/technology/hyperlux**

# Foundry adds CMOS integration to its galvanic isolation technology

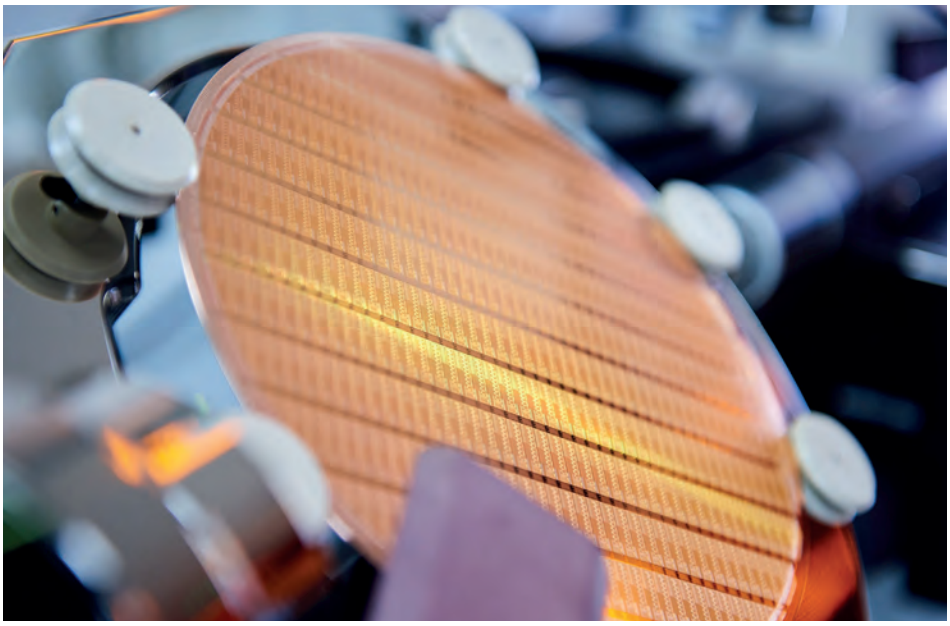
An integrated approach for X-Fab Silicon Foundries' XA035 process brings galvanic isolation elements directly together with active circuits

Building on the company's advanced process optimised for robust discrete capacitive or inductive couplers, existing galvanic isolation elements can be brought directly together with active circuits. This integrated approach allows more flexibility in the design of isolation products, says the company and addresses emerging opportunities in renewable energy, EV powertrains, factory automation and industrial power.

Based on a 350nm process node, XA035 is suitable for the fabrication of automotive sensors and high voltage industrial devices. The high voltage signal isolation capabilities it now supports mean long term operational performance is maintained, even in demanding environments, says X-Fab. It will enable the manufacture of robust components that are AEC-Q100 Grade 0-compliant and industrial-rated, such as digital isolators, isolated gate drivers and isolated amplifier ICs. X-Fab provides a comprehensive PDK (process development kit) that supports the new process technology for all major EDA vendors.

"We see a growing demand from our customers for robust foundry solutions to design galvanically isolated products. X-Fab has been in production for several years with its proven high-reliable isolation layer for discrete coupler implementations," says Tilman Metzger, Marketing Manager for High-Voltage Products at X-Fab. "By leveraging the very same process module, we are now able to offer even more flexibility in designing such products by enabling the direct integration with CMOS circuits on the same die. We are also excited to see the first integrated customer products nearing production."

**http://www.xfab.com.**



# Infineon completes acquisition of GaN Systems

Infineon Technologies has closed the acquisition of GaN Systems, acquiring its portfolio of GaN-based power conversion products.

On 2 March 2023, Infineon and GaN Systems announced that the companies had signed a definitive agreement under which Infineon would acquire GaN Systems for US$830 million. All required regulatory clearances have now been obtained and the all-cash acquisition was funded from existing liquidity.

"GaN technology is paving the way for more energy-efficient and CO 2-saving solutions that support decarbonisation," says Jochen Hanebeck (pictured), CEO of Infineon. He believes the acquisition "significantly accelerates our GaN roadmap".

With the acquisition of the Ottawa-based company, Infineon now has a total of 450 GaN experts and more than 350 GaN patent families. Both companies' complementary strengths in IP and application understanding as well as a well-filled customer project pipeline put Infineon in an excellent position to address various fast-growth applications, says the company.

Infineon Technologies' revenue in the fiscal year ending 30 September 2022 was € 14.2 billion.

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# BEV advancements are driving sales, but vehicle safety and reliability will ensure long-term viability

Innovative power architectures using power modules provide power redundancy and improve overall safety and system performance By **Patrick Kowalyk, Automotive FAE, Vicor**

**Sales of electric vehicles continue to** grow globally. March 2023 saw combined (BEV and PHEV) sales of over 322,000 plug-in electric vehicles registered across Europe, a 29% year-on-year increase. Furthermore, battery electric vehicles show a 44% year-on-year increase and account for a 16% share of all cars sold in Europe.[1]

These figures are good news for all vehicle manufacturers after the dismal car sales during the 2020-2021 COVID-19 period. The rebound in overall sales and the significant rise in EV sales bodes well for the future. Still there remains consumer reticence around charging infrastructure and battery range. In response, manufacturers already have second-generation EV models in production addressing consumer concerns.

### Trends shaping the second generation of electric vehicles

There are several trends worth noting.

1. Improving charging time and reducing vehicle weight. Weight directly influences an EV's range. Therefore, anything that reduces vehicle weight increases the payload and its maximum range.
2. Removing the traditional 12V DC primary battery offers significant weight advantages. Today reducing its size or removing it altogether are options.
3. Migrating to a 48V zonal networking architecture reduces the need for bulky, heavy and costly 4 gauge wire harnesses. Similarly, the move to a 48V architecture for secondary equipment (heated seats, seat movers, etc.) also benefits from reducing cable size and weight.
4. Upgrading from 400V to 800V battery voltage is being quickly adopted. This trend enables reduced cable weight and charging time but requires upgrading the charging post infrastructure to support both voltages.

Still, there are other important safety and reliability enhancements needed. There is no escaping the fact that since a BEV derives all its power from a single source— the high-voltage traction battery— any interruption to it is more than inconvenient, it can pose serious safety hazards. So while creature comforts may be captivating consumers and stimulating new sales today, long term viability of the EV platform is dependent on sound safety protocols being designed into the vehicle. In an all-electric automobile power redundancy is essential.

### Designing-in power redundancy is essential to safety and reliability

The addition of a redundant source of energy in an EV ensures safety and reliability for its driver, passengers and other road users. Redundant power is required for three load types:

- Steering, braking and safety sensor systems
- Always-on vehicle network (CAN bus, Ethernet, etc.) communication
- Non-essential loads that can be turned off during critical power situations

For example, EV power architects could achieve an 800V traction battery source by connecting two 400V battery packs in series, with each battery configuration having a separate DC-DC (400V to 800V) converter. This configuration (Figure 1) is called a Dual-400V series-stacked system.

Some manufacturers are presently using the Dual-400V series-stacked system for several reasons. The primary reason is that charging with a 400V charger is easier because many installed public chargers are not 800V compatible. Today, as new chargers are installed, they can support both 400V and 800V batteries. The second reason is that if a manufacturer has already designed and qualified a 400V battery pack, it is faster and easier to add two packs in series.

Another approach is the Dual 800V parallel battery configuration (Figure 2) that involves using two 800V batteries in parallel. Again, two separate DC-DC converters provide redundancy.

There are trade-offs with both configurations.

When using a Dual-400V series-stacked system these are the drawbacks to consider:

- The 400V DC-DC converters need more clearance to chassis ground as the topmost DC-DC converter is at 800V.
- The center tap between the two 400V

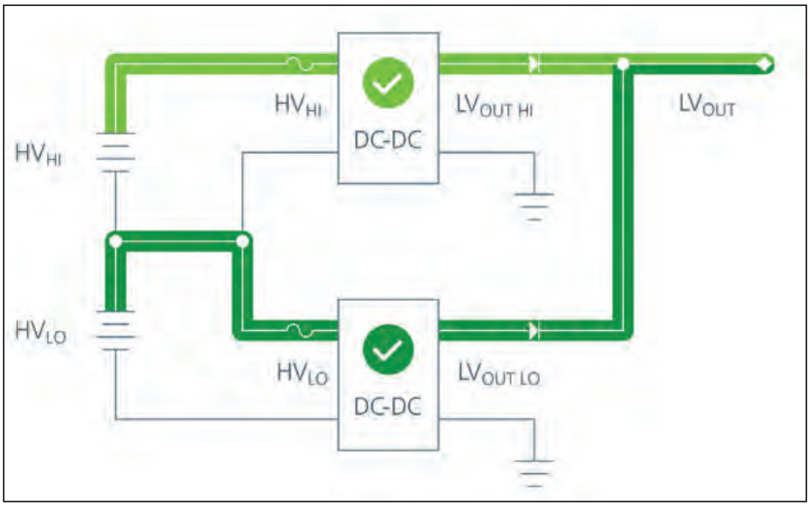



**Figure 1 – Dual-400V series-stacked system Connecting two 400V battery packs in series with separate DC-DC converters in a stacked architecture allows lower-voltage operation and splitting the load to two or more strings (Source: Vicor)**

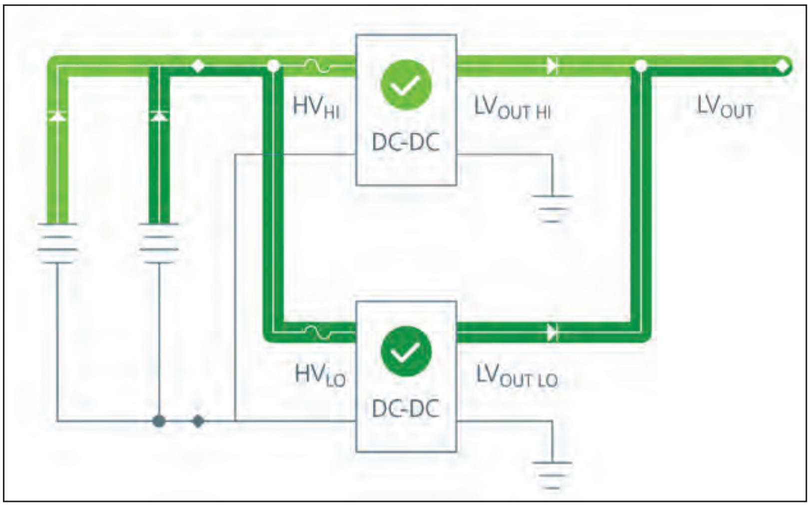



**Figure 2 – Dual-800V parallel battery configuration. This configuration, allows for lower-current operation and an easier method of implementing an N + 1 redundancy (Source: Vicor)**

battery packs needs to be accessible on the high voltage connector.

- An imbalance of two series connected 400V battery packs may cause the regulator to enter in an overvoltage protection mode condition, interrupting the power supply period.

The advantages of the system are:

- If one string fails, the other string will pick up the load.
- The components of the system have lower voltage ratings and are therefore less expensive.
- It is easier to create a 24V output by connecting the two outputs in series.

The Dual-800V parallel battery configuration also has some tradeoffs.

Advantages

- It operates with more stability than using 400V period.
- It is easier to charge, as the parallel combination will see the entire 800V source. In a parallel combination the packs are always at equal voltages. This makes it less complicated to charge.

Disadvantages:

- From a design perspective, the components do need more clearance to the chassis for high voltage safety.
- A short across the 800V will potentially shut down the entire system.

While relatively few vehicles currently utilize a dual 800V battery platform, the redundancy that it offers is important for safety. Without it, the most important car systems are one short away from a catastrophic event. EV power architectures are moving in this direction. Reliability and safety are the biggest reasons for the migration, but newer chargers are compatible with both 400V and 800V, which illustrates further market pull toward 800V.

Different factors may preclude choosing one approach over another, but in most cases the Dual-800V battery configuration is preferred for one simple reason. In this system, the power modules make it easy to build in redundancy by using the batteries in parallel. This enables a second power path to the load in the event of a short, protecting the system from total shut down.

There are weight and range considerations in addition to the demand on physical space to accommodate two battery packs. While some additional circuitry is required for the battery management system, the safety and reliability benefits outweigh that in the big picture.

## The many faces of power redundancy—which is best?

Implementing redundancy can be done in a number of ways (Figure 3). The load can be shared across two or more DC-DC converters, with the ability of a single converter to take up the entire load should one of the power sources or converters fail. Redundancy can take several forms. Look at the entire power chain from the source to the load and ask; If there would be a failure at this location or portion of the circuitry,

- What would be impacted?
- Will the vehicle still drive?
- What functions will not work?

The objective is to be able to continue the driving journey or be able to safely exit the highway off-ramp.

Redundancy in a DC-DC converter can take many forms (Figure 3). Some examples are N + 0, N +1, 2N + 1, etc. Each configuration has advantages and disadvantages in terms of size, cost and complexity. A careful study needs to be performed for each vehicle's architecture.

By using a bidirectional DC-DC converter and separating the loads of the vehicle, power can be passed from one zone to the other. Passing the power through a regulator provides a solid source to power the load or even charge a battery.

However, today's current converter technology is not capable of making DC-DC converters that are small and light enough to use multiple units in parallel in BEVs.

The Vicor BCM® and DCM™ power modules enable easy paralleling. Their

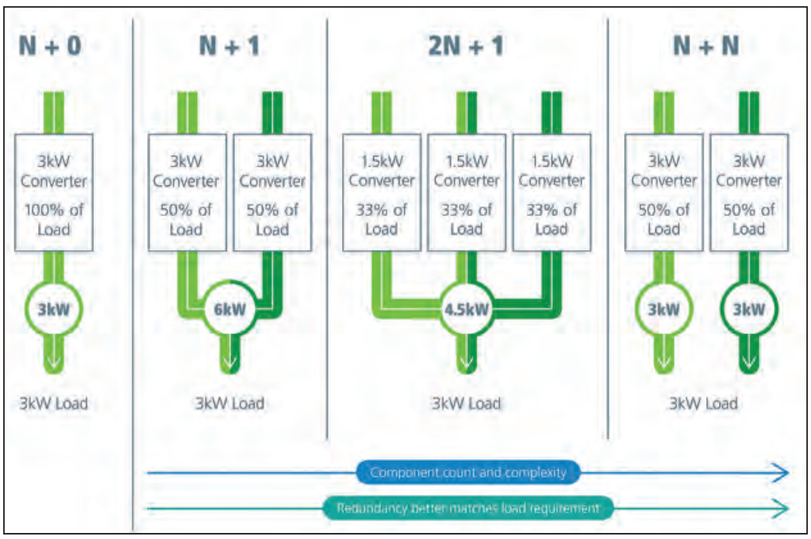



**Figure 3 – Several combinations of redundant architectures show power levels and power split in an EV powertrain. The N + 1 has more power capability and therefore can be a larger and more expensive solution. From left to right, the redundancy improves and the power supply more closely matches the load's requirement, but it also increases component count and system complexity. (Source: Vicor)**

**Figure 4: This 4kW DC-DC converter uses 2 Vicor BCM6135 and 2 DCM3735 (located on the underside of the board) to convert 800V power to 12V power in a package that weighs 0.08 kg and in a volume of only 0.8575 L. This can be configured into 2 redundant power supplies of 2 kW each, or paralleled with another unit to create a redundant 4 kW power supply.**

compact size reduces the overall DC-DC converter footprint and their efficiency and density bolster performance (Figure 4). This augments vehicle range and enables new architectures to enhance safety.

High-density power modules unlock creative opportunities and deliver performance and scalability in a way far superior to discrete solutions. Power modules provide up to 3x more power density, enable easy scalability and deliver higher transient speeds that can support down-sizing or removing the 12V/48V auxiliary battery altogether. The BCM (Figure 6) steps down the high-side voltage and multiples the current while providing isolation in a power-dense, highly efficient converter.

The BCM is a ratiometric device, where the output is a ratio of the input by a K factor. For example, if the source is 800V in a parallel configuration, the K factor would be 1/16, therefore the low-side voltage is the high-side voltage divided by 16, and the output current is the high-side current multiplied by 16. The Dual-400V series-stacked system uses a similar BCM, however the K factor is 1/8.

The DCM3735 regulator takes the voltage from the BCM and provides a tightly regulated output that can charge a capacitor or battery (Figure 5). The combination of BCMs and DCMs enables designers the flexibility to create space and weight efficient, redundant power networks in EVs. Vicor technology can provide 4kw of 800V to 12V power supply in less than 0.9 L. As seen in Figure 4 this system weighs less than 1 kg, and can enable further weight savings by enabling the downsizing of the 12V back-up battery.

Consumers want to purchase EVs, but many have reservations. At the top of the list are range and charging convenience. These are not easy problems to solve, but new innovations in power architectures and power density are helping tremendously. Compact power delivery network innovation save weight, which can improve range. Also, the introduction of power modules provides creative latitude and simpler ways to reduce size and weight, which also can deliver more range.

The power module is important to solving range, reliability and safety issues. Its scalability and small size adds immense flexibility to designing a power system.


**Figure 5: The DCM3735 is a non-isolated, regulated DC-DC converter with an input range of 35-58V. It offers constant current operation for battery charging, comes in a compact package (36.6 x 35.4 x 7.4mm) and can be used in array.**

When combined with innovative architectures power modules are a catalyst to rapidly advance the long-term adoption of today's battery electric vehicles.

**Sources:**

*1 Kane, Mark (May 10, 2023) "Europe: Plug-In Car Sales Accelerated In March 2023", INSIDEEVS*

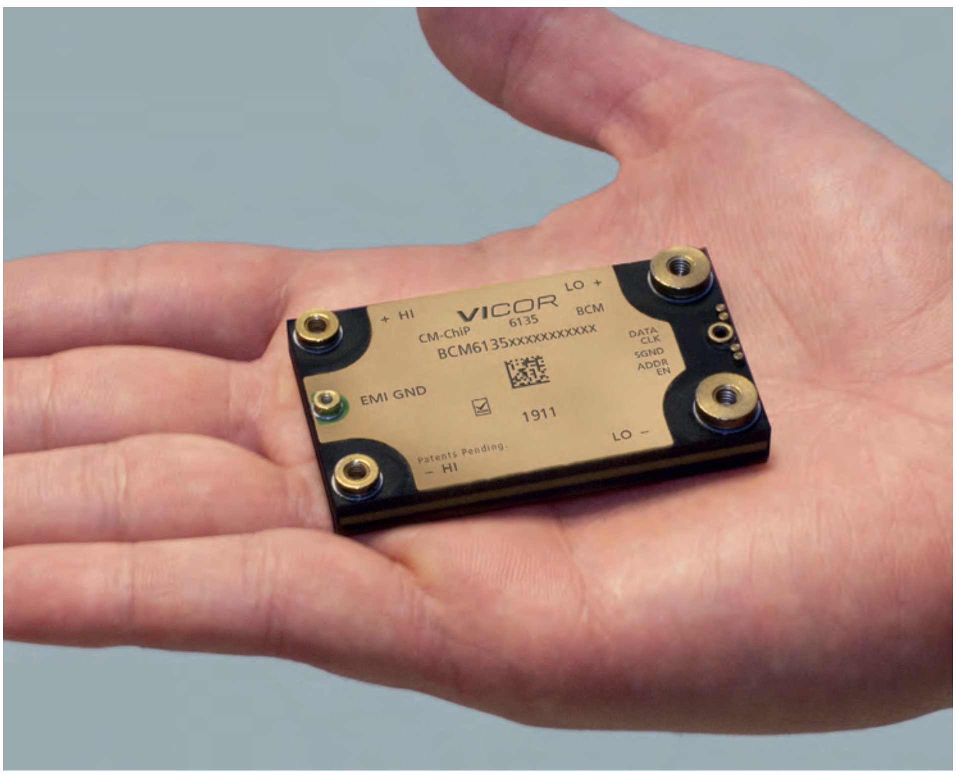



**Figure 6 BCM® bus converter. BCMs are high-density, high-efficiency, fixed-ratio (non-regulating) isolated DC-DC converter modules. The family extends from 800V or 400V to 48V inputs with various K factors to suit a wide range of applications period. The BCM provides the greatest power density for high-voltage battery conversion to low-voltage networks. The BCM product family leverages Vicor Sine Amplitude Converter™ technology that results in high-efficiency performance in miniaturized modules. Vicor develops BCMs to match the 400V or 800V battery. Vicor BCMs can be used in arrays to scale to the necessary power requirements.**

# The role of voltage supervisors for system power reliability

Voltage supervisors add reliability by monitoring the power supply failures and putting a microcontroller in reset mode to prevent system error and malfunction. By **Noel Tenorio, Product Applications Engineer, Analog Devices**

Power supply imperfections such as noise, voltage glitches, and transients can lead to false and nuisance resets that can affect system behaviour. Voltage supervisors address factors that can trigger false and nuisance resets to improve system performance and reliability.

Applications that compute and process data requiring FPGAs, microprocessors, DSPs and microcontrollers depend on safe and reliable operations. These devices tax power supply requirements as they are only allowed to operate at a certain range of power supply tolerance. Voltage supervisors can act immediately to put the system in reset mode when an unexpected failure from the power supply arises, such as under-voltage or over-voltage. Monitoring voltages in power supply rails always comes with some nuisances that can trigger unwanted false reset outputs. These are power supply noises, voltage transients, and glitches that can come from the power supply circuit itself.

## System glitches

Power supplies have inherent imperfections. There are always noise artefacts coupled on the DC that can come from the power supply circuit component itself, noise from other power supplies, and other noise generated from the system. These problems can be worse if the DC power supply is a switch mode power supply (SMPS). SMPS produces switching ripple that is coherently related to the switching frequency. They also produce high frequency switching transients that occur during switching transitions. These transitions are caused by the fast on and off switching of the power MOSFETs. Figure 1 shows an application circuit in which the MAX705 supervisor is used to monitor any failure in the output of the switching regulator, which is the voltage supply of the microcontroller.

Aside from the steady-state operation noise artefacts, there are also scenarios in the power supply where voltage transients are more pronounced. During startup, a voltage output over-shoot is usually observed related to the feedback-loop response of the power supply and is followed by voltage ringing for some time until it reaches stability. This ringing can be worse if the feedback loop compensation values are not optimised. Voltage over-shoot and under-shoot can also be observed during transient or dynamic loading. In the applications, there are times when the load needs more current to execute complex processes, which leads to a voltage under-shoot. On the other hand, reducing the load instantly or at a fast ramp rate will give a voltage over-shoot. There are also short-duration voltage glitches that can occur to the power supply due to external factors. Figure 2 shows an illustration of the different voltage transients and glitches that can be present on a

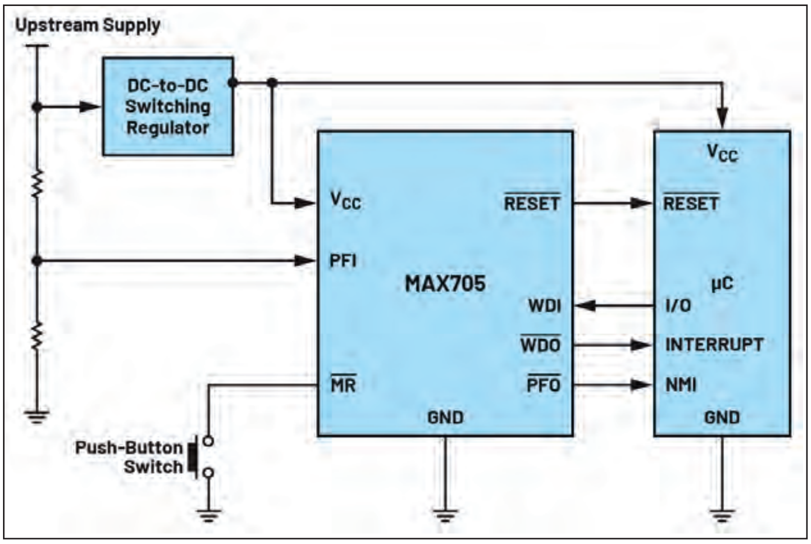



Figure 1: **The MAX705 supervisor is used to monitor a switching regulator output, which is the input voltage supply of a microcontroller.**

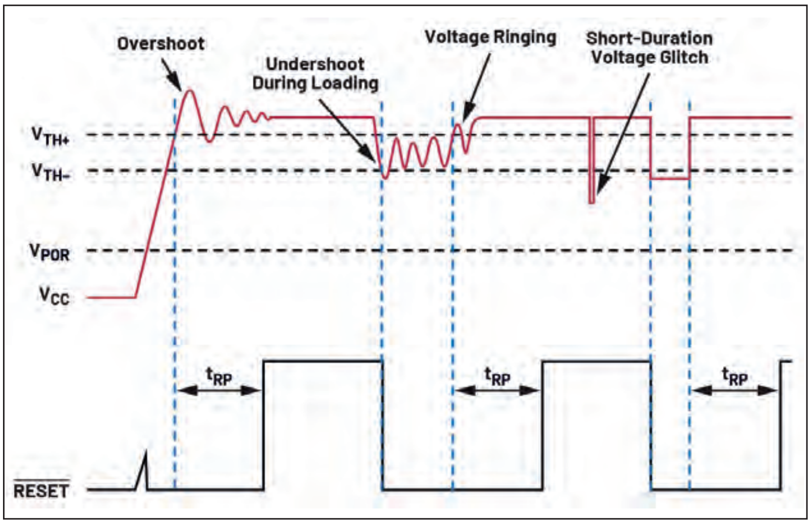



Figure 2: **Voltage transients and glitches that can be observed on a supply voltage in different scenarios.**

power supply voltage in different scenarios.

There are voltage transients that can occur in a system that are not associated with the power supply voltage but rather on a user interface such as a mechanical switch or a conductive card for some applications. Turning a switch on and off produces voltage transients and noise on the input pin, typically a manual reset pin. Power supply noise, voltage transients, and glitches, if excessive, can unintentionally hit the under-voltage or over-voltage threshold of a supervisor and trigger false resets if not accounted for in the design. This can lead to oscillatory behaviour and instability, which is undesirable with regards to system reliability.

### Noise and transients

There are parameters that help mask these transients that are associated with the power supply or monitored voltage. These are the reset timeout period, reset threshold hysteresis, and the reset threshold overdrive versus duration. The transients that are associated with the mechanical contact in the circuit such as a pushbutton switch in the manual reset pin, the manual reset setup period and the debounce time mask the transients. These parameters make the voltage supervisors robust and unaffected by transients and glitches, thus keeping the system from undesirable responses.

### Reset timeout period (tRP)

During startup or when the supply voltage is rising up from an under-voltage event and exceeds the threshold, there is an additional time on the reset signal before it de-asserts, which is called the reset timeout period (tRP). For example, Figure 3 shows that after the monitored voltage, which in this case is the supply voltage labeled as VCC, reaches the threshold from an under-voltage or startup, an added delay is present for an active LOW reset before it de-asserts 'high'. This additional time gives room for the monitored voltage to stabilise first, masking the over-shoot and ringing before enabling the system or taking it out of reset mode. The reset time-out period suppresses false system resets to prevent oscillation and potential malfunction, thus helping improve the reliability of the system.

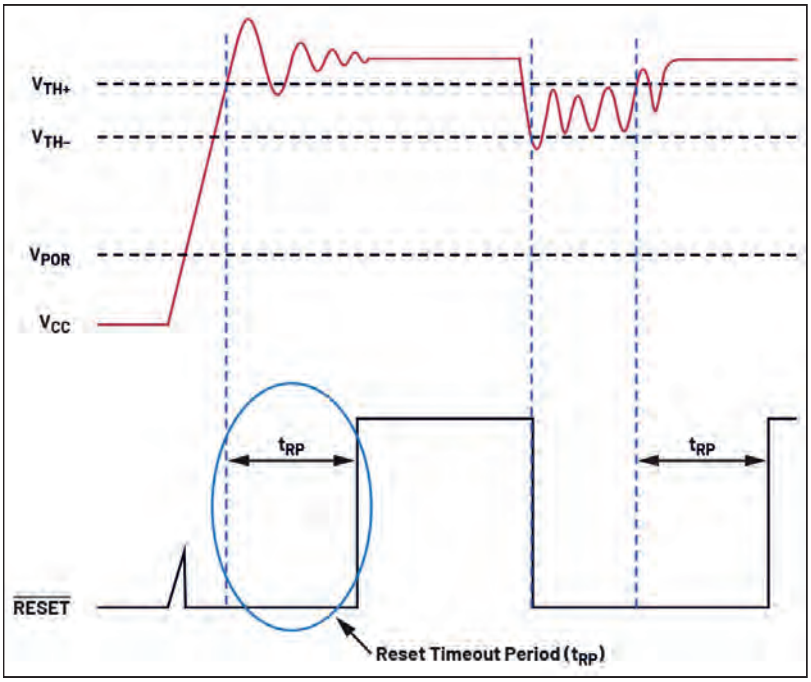



**Figure 3: The reset timeout period (tRP) helps keep the system in reset mode while the supply voltage stabilises.**

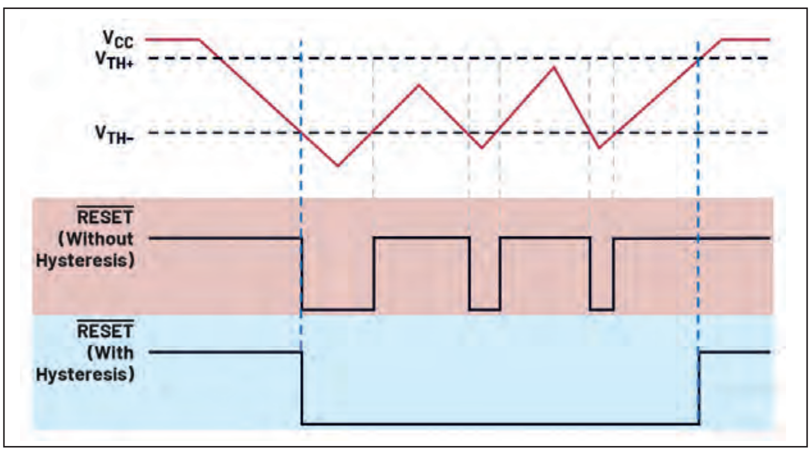



**Figure 4: Reset output response without and with threshold hysteresis (reset timeout period not shown to focus on the effect of hysteresis).**

### Threshold hysteresis (VTH+)

There are two main benefits of having threshold hysteresis. First, it provides certainty that the monitored voltage has overcome the threshold level with enough margin before de-asserting a reset. Second, it gives room for the power supply to stabilise first before de-asserting a reset. There is a tendency for the reset output to produce multiple transitions when processing signals with superimposed noise, as the power supply bounces and recrosses the threshold region. This is shown in Figure 4. In applications such as industrial environments, noisy signals and voltage fluctuations can occur anytime. Without hysteresis, the reset output will continuously toggle assert and de-assert until the power supply stabilises. It will also put the system into oscillation. Threshold hysteresis cures the oscillation by putting the system hold on reset to prevent the system from unwanted behaviour shown in the blue-shaded area in Figure 4. This helps the supervisor in protecting the system from false resets.

Voltage glitches from external factors can occur in any system for either short or long periods. They can also have different magnitudes of voltage dip. Reset threshold overdrive versus transient duration has something to do with the magnitude and duration of the voltage glitch or overdrive. A short-duration glitch with a greater magnitude will not trigger a reset signal to assert, while a less-magnitude overdrive with a longer duration will trigger a reset as shown in Figure 5.

Voltage transients in the monitored supply are ignored depending on the duration. Disregarding these transients will protect a system from nuisance resets such as those caused by short-duration glitches. These glitches can falsely trigger system resets, to undesirable behaviour of the system. In the product data sheet, the reset threshold overdrive vs. duration is often illustrated in one of the typical performance characteristics plots such as in Figure 6. Any values above the curve will trigger a reset output while values within the curve will be ignored to prevent the system from false resets.

### Rest and debounce

The reset timeout period, threshold overdrive versus duration, and the threshold hysteresis address voltage glitches and transients associated with the monitored voltage, which is usually the power supply of the system microcontroller. For the glitches brought by the mechanical contacts such as switches, the manual reset setup period and the debounce time alleviate the possible effects of the voltage transients and glitches.

The manual reset setup period (tMR) is the time required for the manual reset to hold and complete before it triggers a reset output. Some supervisors are made to have a long manual reset setup period to add protection to the system. These are common on consumer products on which the button needs to be held for several seconds to reset the system. This method avoids accidental and unintended reset, thus adding protection and reliability. With the manual reset setup period, all the short-duration transients and glitches when pushing on the switch are ignored, as shown in Figure 7a, thus helping the system to be glitch immune.

The same concept applies to the debounce time. Like the setup period, debounce time (tDB) ignores the high frequency periodic voltage transients when pushing on or off a switch. These high frequency transients are considered invalid and do not trigger a reset as shown in Figure 7b. When the signal exceeds the debounce time, that is the time it will be considered a valid input signal from a switch or a push button.

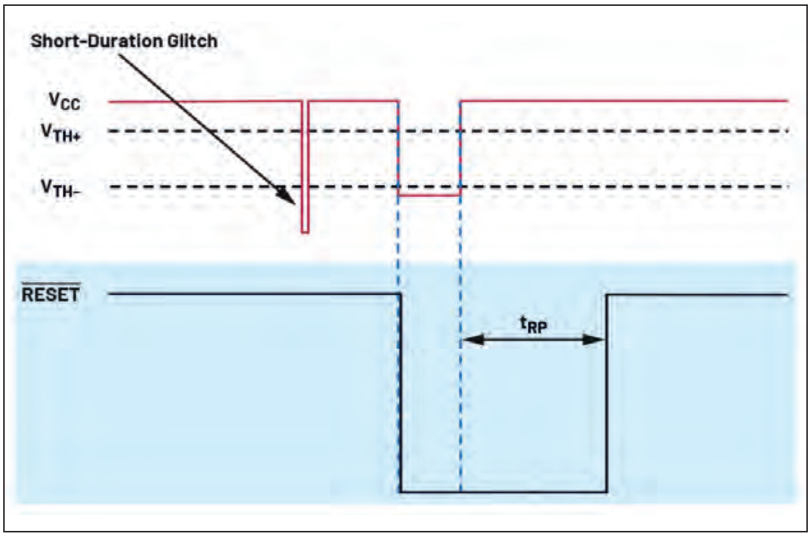



**Figure 5:** **A glitch with a less magnitude but occurs in a longer duration will trigger a reset signal as opposed to a short-duration glitch with greater magnitude.**

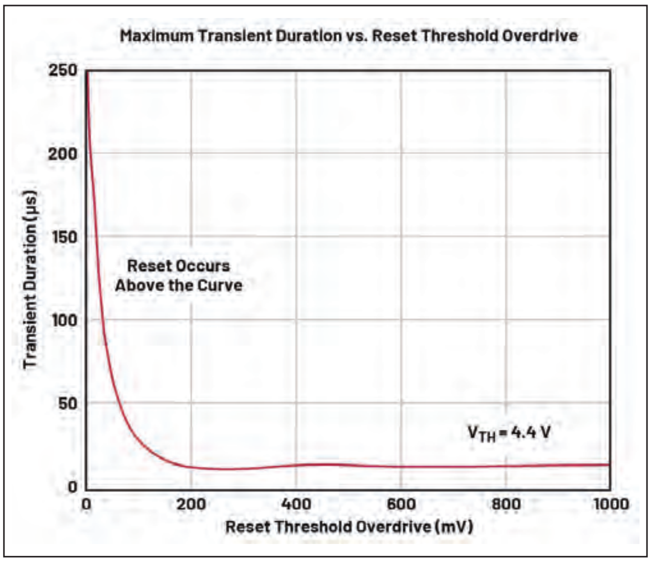



**Figure 6:** **Asserting of the reset signal will depend on the magnitude of the overdrive and its duration.**

### Conclusion

Without voltage supervisors, systems are at risk of brownout conditions and malfunction during voltage transients and glitches. Voltage supervisors solve this by putting processors into reset mode during such scenarios, All the parameters discussed here, including reset timeout period, threshold hysteresis, threshold overdrive, manual reset setup period and debounce time, improve the reliability of voltage supervisors in monitoring power supply voltages by making them immune to glitches and transients. This gives stability and reliability to overall system performance.

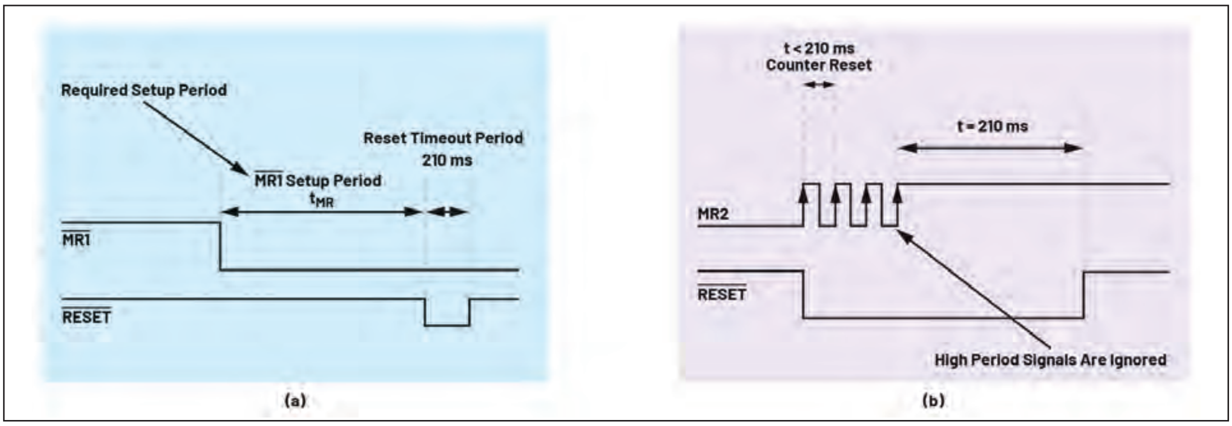



**Figure 7:** **The manual reset setup period and debounce time diagram of a supervisor with a long manual reset setup period (MAX6444). The manual reset setup period (tMR) needs to be completed first before a reset signal asserts (a) and debounce time (tDB) is required (b) to be considered as a valid input signal.**

# Power choices to minimise maintenance

The choice of power source can reduce telecomms maintenance cost.

**By Andy Brown, Director, Technical Marketing DC/DC, Advanced Energy Industries**

The telecomms RAN (radio access network) is essential to almost every aspect of our daily lives and operators are being challenged to deliver ever greater capacities and coverage with high uptime and low costs. Unsurprisingly, energy is one of the largest operating costs for cells and towers that support the RAN infrastructure. Meanwhile, the power consumption of macro cell radios has increased steadily as access technologies have evolved. Typical power consumption for radio units was in the range of 100 to 300W in 2001 and is estimated to reach up to 1,800W by 20301. As a result, careful selection of the power supply, converter and power management technologies is a fundamental aspect to enabling modern RAN design.

However, there is another significant cost associated with running a RAN that can also be impacted by the choice of power technologies, namely maintenance. Unplanned downtime and maintenance costs can mount very quickly, reaching many hundreds if not thousands of times the cost of any specific part or system that has failed.

## The cost of failure

Consider a large network such that has 100,000 cell sites in a network. Each will have a variety of power supplies and modules, including AC/DC and DC/DC converters (Figure 1).

There are two key areas for power supply technologies in a RAN infrastructure. One is the DC/DC converters that support the power amplifiers in the integrated radio antennas and the second are the high-power systems deployed in base station controllers. In terms of a DC/DC converter in a remote radio head (RRH), even the highest quality, well-engineered module may have a failure rate of about 10ppm (parts per million), so it would be expected to exhibit failure at some point. Once time is factored in to diagnose the fault, and an engineer is dispatched to ascend the antenna and fix the problem, costs can run to many thousands of dollars.

Actual costs will vary depending on the individual scenario. However, an approximate cost of $20,000 to $30,000 to repair a fault of a failed DC/DC converter located in the RRH equipment is many times the value of the DC/DC converter itself. Figure 2 shows the key factors contributing to such a cost might break down. As the cost of the converter is likely to be in the range of $50, the cost of repair makes the cost of the original part negligible in comparison. If a batch of DC/DC converters has a latent fault, the ppm failure rate could be higher. Furthermore, if this were to reach 500ppm, then the same network could experience 50 failures at a significant cost.

While clearly these figures are just for illustration purposes and could be debated, it is clear that component / module fallibility has the potential to drive

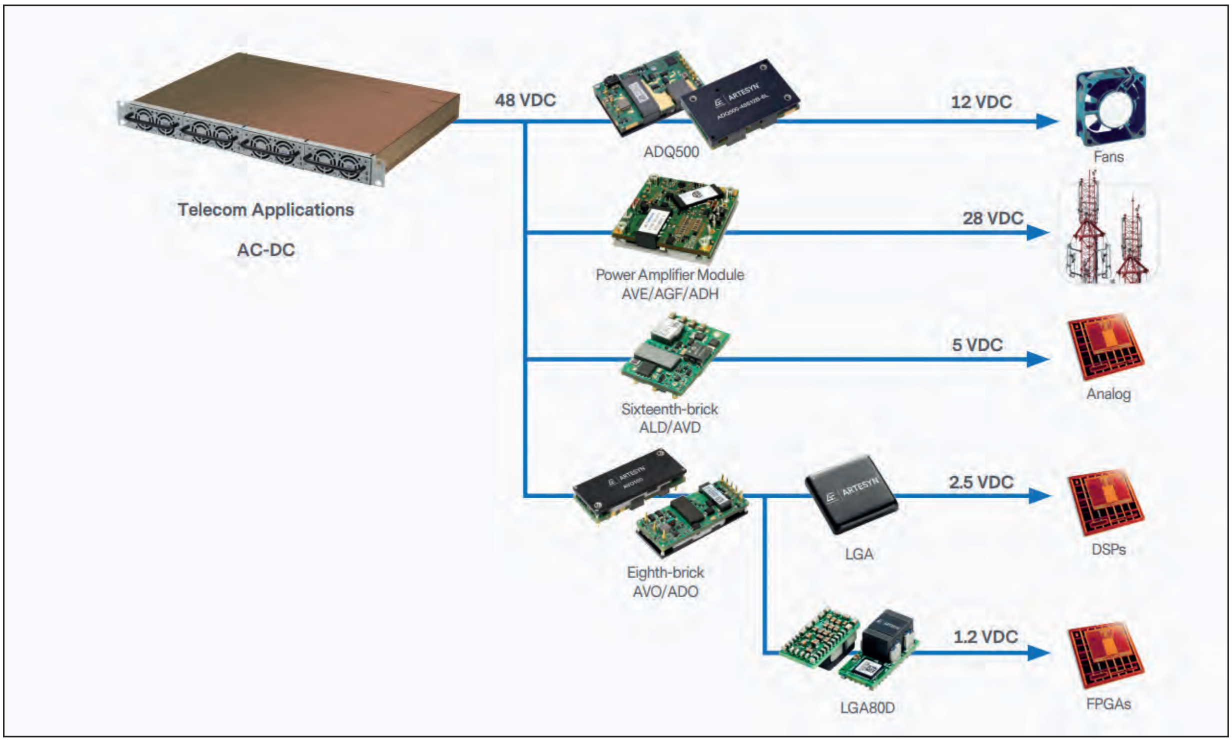



**Figure 1: Power modules for RAN applications.**

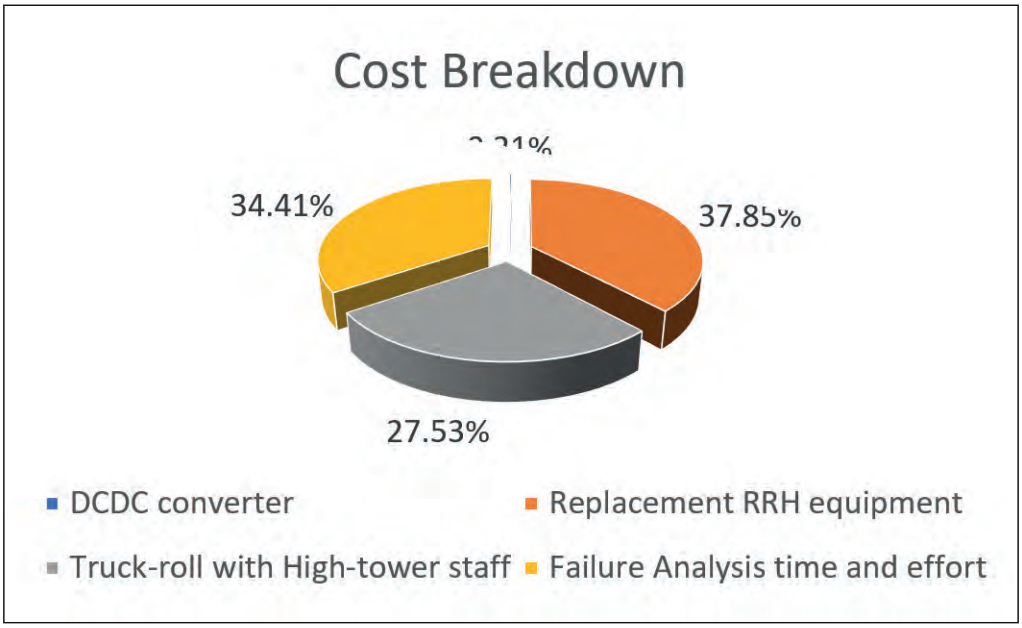



**Figure 2: Example breakdown of costs to rectify a DC/DC converter failure in a RRH**

very significant costs for a network operator.

The piece-part cost of a DC/DC module becomes almost irrelevant once the true cost of long-term unplanned maintenance is understood. Therefore, engineers need to design power architectures that meet performance requirements as well as the current, voltage and power specifications of an individual design and create them with optimum reliability in mind. As a failure in the field can cost hundreds, or even thousands, of dollars, the cost of the individual component is very sobering and precludes any cutting of corners in the design and qualification process.

## Component selection

Operating efficiency is a critically important factor when selecting a power component. Efficiency has become more important in product design. This is driven by commercial demands i.e., more efficient components reduce the total cost of ownership by driving down energy costs and also legislative pressures relating to sustainability. Efficiency plays a fundamental role in reliability because of the consequent excess heat in causing component failures. The rule of thumb is that every 10°C increase in temperature reduces the life of electronics by 50% although this is a broad approximation. It is clear that elevated temperatures reduce the operating life of both the power components themselves and other components around them.

For this reason, power supply manufacturers are developing high performance power products that deliver percentage levels of efficiency well into the high nineties. Advanced Energy's AVE450B 450W single output, half brick DC/DC converter, for example, is a product suitable for supplying power to a power amplifier in telecomms and datacomms applications. It operates at 95% efficiency with demonstrated long term field failure rates under 15ppm. The Artesyn ADH700 700W half brick converter also operates at efficiencies at or above 95% and its thermal management allows it to operate at full power in enclosed spaces with a baseplate temperature up to 100°C.

Designers that understand how a design can impact maintenance costs take a more conservative approach to tolerances and design margins – especially in terms of thermal and electrical stress. This ensures components operate at levels that reduce the likelihood of failure. Focusing the component selection process on reliability, rather than cost, can lead to a dramatic reduction in field failures. While calculated MTTF (mean time to failure) data is a good first step, choosing power products that have been tested to an IPC9592-based qualification process often has more relevance and benefit.

Working with an experienced telecomms supplier brings greater likelihood of design success as there is a pathway to leverage the many years of experience designing power modules for Tier 1 OEMs that operate in the telecomms space.

As well as direct cost savings that can be attributed to maintaining and repairing the infrastructure there are also several indirect cost benefits that result from a more robust approach to designing in reliability from the start. Engineers, for example, can spend less time on failure analysis and field repairs and more time developing those products and systems that will generate future revenues. Even more intangible, but still important, is the fact that minimising callouts at unsociable hours reduces the impact on the morale of employees, improving the quality of their work and minimising possible retention, hiring and training costs.

## TCO is key

The true impact of reliability in a telecomms network cannot be under-estimated, whether in terms of direct and indirect maintenance costs, lost revenue through downtime or more intangible factors including customer loyalty and a de-motivated workforce. Power amplifiers and the circuits that support them represent critical elements of a RAN infrastructure, and ensuring reliable, long term operation in harsh environments is fundamental to successful implementation.

Taking a total cost of ownership (TCO) approach that goes beyond just the piece-price and operational expense related to conversion efficiency is key to success when choosing and designing products - including the power conversion technologies at the heart of the RAN hardware.

Market innovators must widen the definition of TCO to include the very real and considerable costs associated with any potential field failures or compromised network performance. This thinking leads to an emphasis on product reliability beyond just using the usual calculated mean time between failures (MTBF) figure as a benchmark data point between supplier solutions.

As a result, wireless access system designers are now focusing their efforts to reduce the overall cost of ownership by designing systems in a way that significantly reduces the number of unscheduled maintenance incidents and the consequences caused by product failures.

# Why EVs don't need 12V lead acid batteries

The continuous advancement of lithium-ion battery technology has given EVs longer driving range, faster acceleration and more horsepower than ever before. So why are most EVs still carrying a 12V lead acid battery for standby power? By **Power Integrations**

**Inexpensive and dependable, lead acid** batteries have been around for more than 100 years, including being used in the early versions of electric vehicles back in the 1890s. It offers the high current (500A in cold conditions for up to five seconds) needed to start an internal combustion engine, and the entire electric subsystem of an ICE (internal combustion engine) vehicle has been designed to be powered by the 12V battery when the engine is turned off.

As the auto industry began electrification in the late 1990s with hybrid or plug-in hybrid electric vehicles, a lead-acid battery is still needed because there is still a gasoline engine to be started.

### Cars without engines

Even without the need for the 500A peak output current to start a gas engine, most fully electric vehicles retain the use of this heavy battery for supplying 12V power to all electric subsystems when the motor is not running. The idea of eliminating the 12V battery in a fully electric car might sound simple, but a few more issues need to be addressed before it can happen.

The first is cost. Lead-acid batteries are cheap. In most instances, it costs more to employ a DC/DC conversion system to turn 400V (from the battery pack) to 12V for all the lights, pumps, windows, power steering and the infotainment/navigation systems.

Second is complexity. Redesigning anything in a car is complicated, as automotive qualification alone can take years to complete. Lead-acid batteries offer proven durability and a relatively long lifespan. Designing an electric car to run low-voltage systems with a 12V battery simplifies engineering.

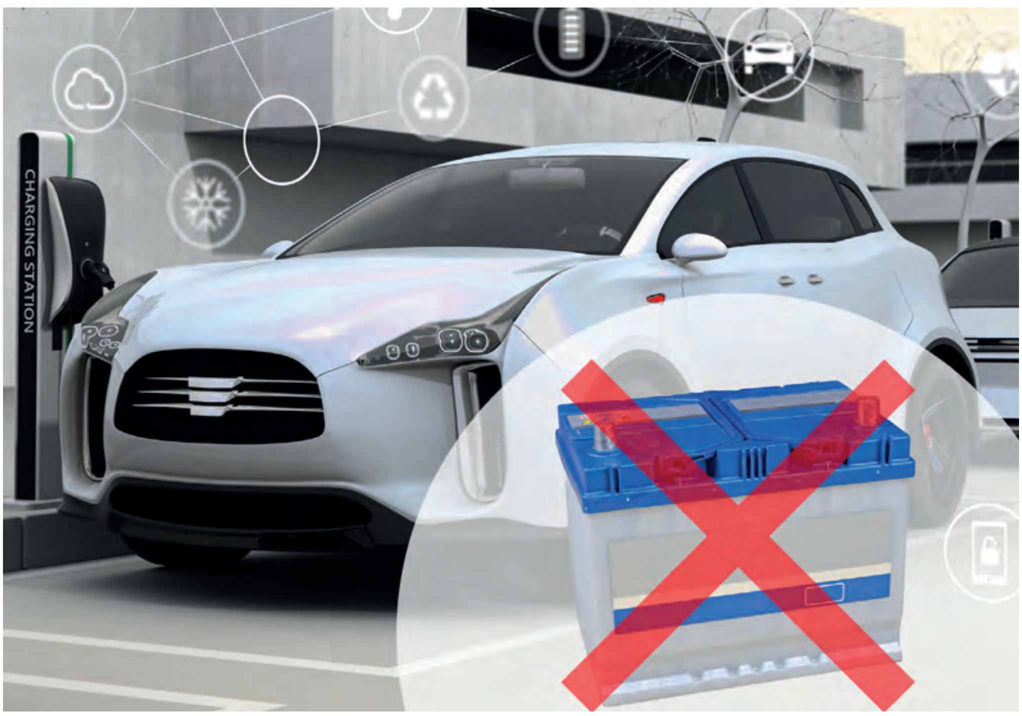
The third consideration is safety. Most of the low-voltage systems are in very close proximity to the passengers. The idea of drawing power directly from a 400V or 800V battery can be scary. Lead-acid batteries allow the higher voltage to be isolated by disconnecting the main battery back from critical systems. High voltage inside the passenger compartment would require many layers of safety protection. Instead of eliminating the 12V battery altogether, some recent EV designs replace the lead-acid battery with a much smaller and lighter lithium-based battery with lower available output current.

### Rugged power supply

To completely eliminate the 12V battery requires a rugged power supply that can safely draw from the high-voltage battery packs. It needs to have a wide input voltage range, ideally 30V DC to 1000V DC, to cover both 400V and 800V nominal battery voltages, as well as 30V operation for functional safety critical applications.

It needs to be highly efficient to reduce operating temperature and minimise discharge of the traction battery. It also needs to have a low component count, which saves space and increases reliability.

Power Integrations' AEC-Q 100-qualified InnoSwitch3-AQ flyback switcher ICs with a 900V PowiGaN switch are suitable for such a power supply. The devices use a FluxLink feedback link, providing reinforced isolation up to 5,000V RMS for secondary-side control. The circuit will start from 30V without external circuitry, and the ICs achieve greater than 90% efficiency while




**An EV's 12V battery can be eliminated with a rugged power supply that can safely draw from the HV battery packs.**

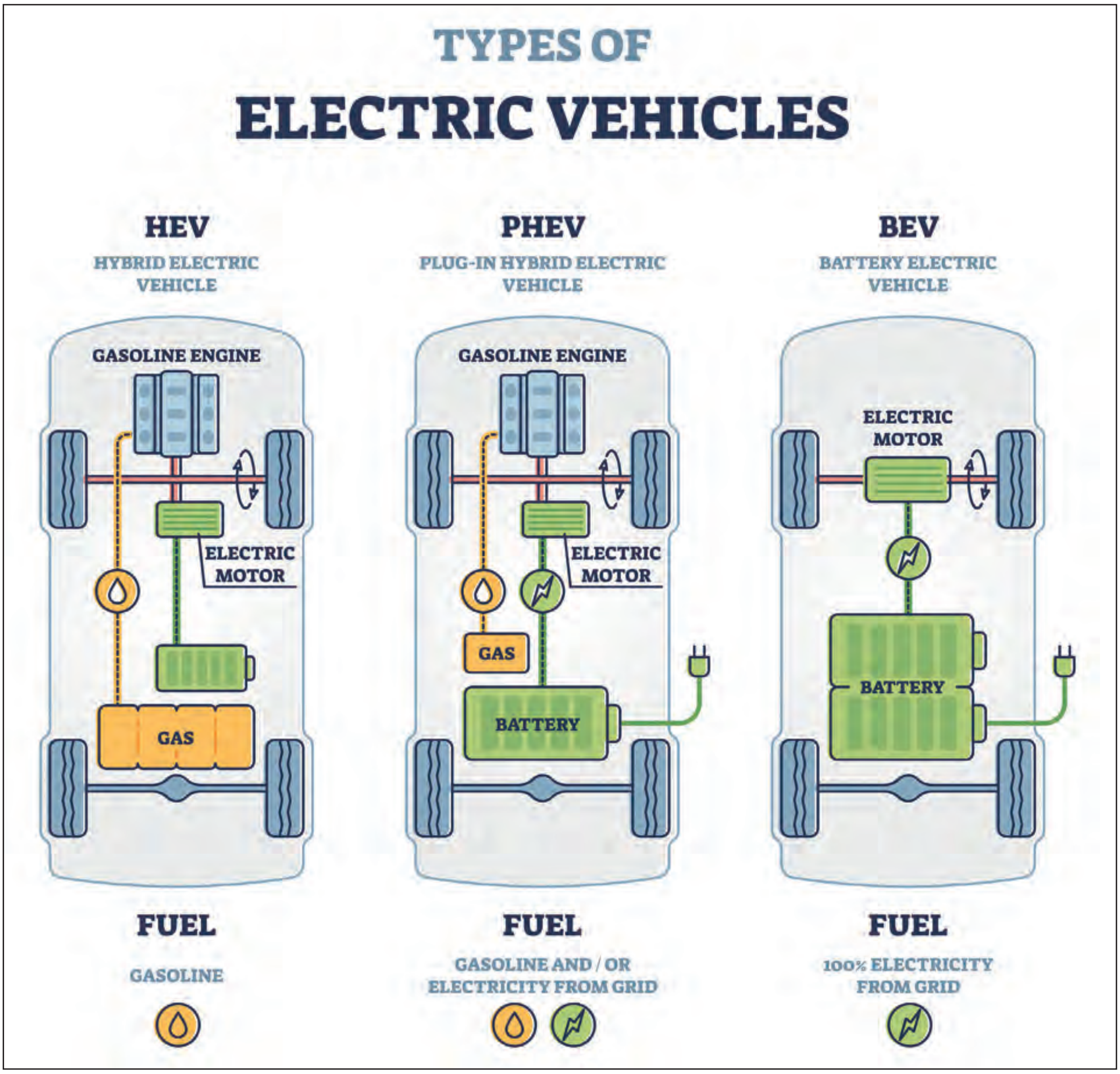



Figure 1: **Definitions of EV types.**

consuming less than 15mW at no-load, which is ideal for reducing self-discharge in battery management systems.

A new design example, DER-953Q, is now available for download on the company's website. This compact 100W power supply uses InnoSwitch3-AQ and eliminates the need for a 12V battery in EVs.

### Innoswitch

The InnoSwitch family of ICs combines primary, secondary and feedback circuits in a single, surface mount off-line flyback switcher IC. The IC incorporates a high voltage, primary side switch, the primary side controller, a secondary side controller for synchronous rectification and FluxLink technology that eliminates the need for an optocoupler.

FluxLink communication technology enables feedback information to be delivered across an isolation barrier without the use of any magnetic materials. FluxLink delivers a high communication bandwidth which enables a much faster load transient response. This proprietary technology meets all global noise immunity standards. For safety, it complies not only with UL and TUV global isolation standards but also the more stringent CQC 5,000 metre Chinese safety standard.

InnoSwitch3-EP flyback off-line CV/CC QR flyback switcher ICs are available with a number of switch options: 725V and 750V

silicon, 900V and the recently released 1,250V PowiGaN gallium nitride (GaN) devices, and a 1,700V silicon carbide (SiC) device.

PowiGaN is Power Integrations' internally developed GaN technology. PowiGaN switches replace the traditional silicon transistors on the primary side, reducing switching losses and enabling power supplies that are more efficient, smaller and lighter than silicon alternatives, says the company. PowiGaN-based ICs achieve up to 95% efficiency across the full load range and up to 100W in enclosed adapter implementations without requiring a heatsink.

InnoSwitch3 designs' ability to offer exceptional light load efficiency makes them ideal for providing auxiliary power in electric vehicles during low power sleep modes. The AEC-Q100-qualified InnoSwitch3-AQ family is particularly suitable for EVs based on 400V bus systems where the 900V PowiGaN switch provides more power and increased design margin - required for 12V battery replacement systems - with enhanced efficiency over silicon-based converters.

The 900V InnoSwitch3-AQ off-line CV/CC flyback switcher ICs employ synchronous rectification, a valley switching discontinuous conduction mode (DCM) and continuous conduction mode (CCM) flyback controller. PowiGaN technology enables automotive InnoSwitch3-AQ devices to deliver 100W from a 400V bus and provide performance and protection features similar to those of the popular 1,700V SiC InnoSwitch3-AQ ICs currently used in 800V EV systems. There are multiple protection features including line over- and under-voltage protection, output over-voltage and over-current limiting, and over-temperature shutdown.

**Figure 2:** **Conventional EV design has to accommodate battery packs and the driver train.**

# The art of noise: how to design to minimise interference

In a perfect world, signal margins and power supply voltages are maintained for a safe, stable environment, says **Graeme Clark, Principal Engineer, Renesas Electronics**

**In an ideal world, signal voltage margins** and signal timing margins are always positive, power supply voltages are always within the operating voltage range, and our environment is completely benign. Unfortunately, we live in the real world.

The real world is dirty and noisy with power distribution systems that are not perfect. The supply voltage can drop below the operating voltage, resulting in system malfunction or failure. Switching transients create noise and reduce signal margins, and impedance discontinuities can distort signals, reducing signal operating margins.

There is also radiated or conducted noise from internal and external sources and electrostatic discharge and lightning surges which can disrupt or even destroy systems. In addition, thermal stress, mechanical stress and component ageing can cause systems to fail.

This article will look at some of these issues and the measures that can be applied to designs to remove or at least minimise some of them. In particular, some features implemented in microcontroller design can mitigate some of these issues.

In the past, around 25 years ago, microcontrollers were designed and implemented on 1.0µm or 0.8µm CMOS technology. Today's devices use significantly more advanced process technology, with line widths orders of magnitude smaller. For example, the latest Renesas RA family microcontrollers are implemented on the latest 40nm and 22nm process geometries.

As the transistor size in the latest devices becomes smaller and the transistor switching frequency becomes faster, noise becomes an increasing concern.

Figure 1 shows a simplified comparison between a 1.0µm device operating at 8MHz and a modern device operating at 100MHz on a 40nm process. It is clear that the switching time of the 40nm device is much faster and the signals can be faster than the typical noise signal. Noise becomes a larger concern as design moves towards smaller process geometries. Design practices include integrating features to help operate in such an environment, with carefully designed power supply circuits, optimised I/O buffers and specialist protection circuitry. It is still important to minimise any effects in designs as much as possible; once noise enters the device, it is much harder to remove.

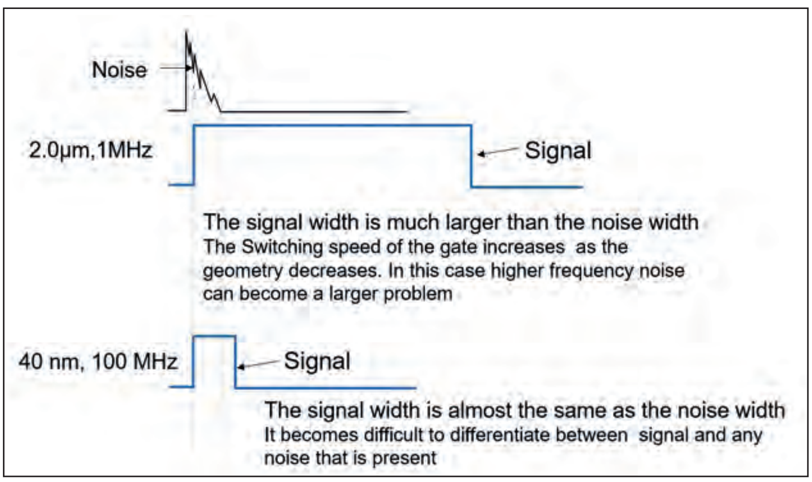



**Figure 1: Simplified comparison between a 1.0µm device and one implemented in a 40nm process.**

## Noise sources

External noise sources are often one of the biggest threats to reliable operation. These can include switching noise from a power supply, noise caused by sparks from industrial machinery or motors, for example. Other sources include induction noise from relays, transformers, buzzers or fluorescent lamps, as well as static discharges, typically, but not exclusively, from the body of users, and of course lightning.

Internal noise can come from a wide variety of sources. Current loops on a PCB can be a significant source of radiated noise. If current flows in a closed loop formed by the microcontroller and its I/O signals, as shown in Figure 2, this current loop can act like an antenna and significant noise can be radiated, especially if the current is large.

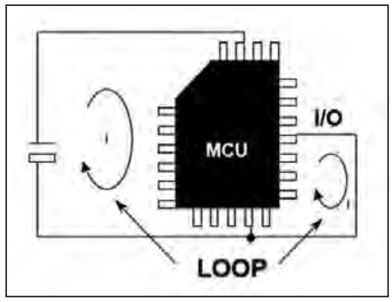



**Figure 2: An example of PCB current loops.**

With a badly designed ground plane, where there is a voltage difference between the ground at different points on the PCB, current can flow between these points, which can act like an antenna. Badly designed oscillator circuits can also radiate noise. This is why it is advisable to follow the recommended circuit parameters and ground plan. This is especially important as a badly designed oscillator can inject noise into many parts of the circuit. A badly designed oscillator circuit can also fail.

Another key area is the I/O system, especially with multiple high-speed devices on an external bus. A badly designed I/O system, where over- or under-shoot occurs, can cause devices to exceed the electrical specification. This can damage devices over time, causing failure, as well as increased power consumption and noise radiation.

## Noise on pins

Noise can affect any pin on a microcontroller. However, microcontrollers'

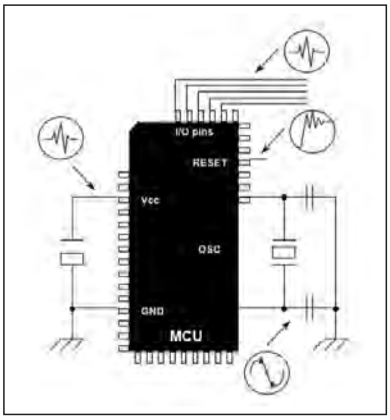



**Figure 3: Microcontroller system pins.**

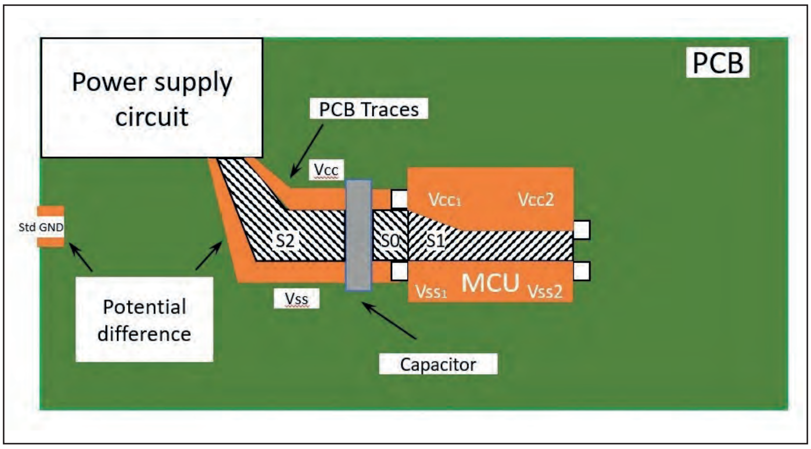



**Figure 4: The relationship between microcontroller and PCB.**

system pins are particularly sensitive to noise, as they typically control the fundamental operation of the device, and a failure induced by noise here could cause the device to malfunction. Special care should be taken to make sure the possibility of noise interfering with the normal operation of the system pins is minimised.

System pins on a typical microcontroller can include the reset pin, the power supply pins, the oscillator pins, and the mode or special function pins. To minimise the chance of noise disturbing these pins, special care should be taken to make sure the power supply pins have solid voltage levels with the required filtering and that the ground plan does not have any current loops. Designers should also make sure the oscillator is placed as close to the chip as possible, that the PCB layout follows the recommendations of the supplier and that the reset pin is protected from fast transient signals.

### Rules to minimise noise effects:

- Guard memory/clock traces from other signals;
- Consider filtering and/or buffering external connections;
- Always use high-frequency Vcc/Vss bypass capacitors close to every device;
- Always run Vcc/Vss in parallel and as close together as possible to minimise current loops;
- Use parallel signal/return traces on PCB, especially for fast signals or traces carrying substantial current;
- Consider the use of a multi-layer layer board with dedicated, unbroken Vss/Vcc planes;
- Do not use a higher frequency than required – the correct frequency minimises noise and power consumption as well.

### Power traces on the PCB

The area between the power supply lines should be kept as small as possible to minimise the potential antenna. Designers should also minimise the current flow to this antenna to keep radiated noise to a minimum.

The system power supply is often one of the largest sources of internal noise. An effective power distribution system can be designed using bypass capacitors and EMI filters. Keeping the antenna pattern area between the power traces on the PCB as small as possible means that the surrounding current loop area (S0, S1, S2) is reduced. The most effective way to do this is to use parallel tracks for Vcc and Vss lines.

A bypass capacitor connected across the power supply lines to every IC will significantly reduce noise. These should be as close as possible to each device. Typically, the most effective capacitor values are 0.01µF to around 0.1µF. In a particularly noisy system, it may be worth combining different values of a capacitor to try to improve the noise performance.

Due to differences in the high-frequency characteristics of various types of bypass capacitors, designers should choose the most suitable, lowest impedance capacitor according to the noise frequency range. For most microcontrollers, ceramic and tantalum type capacitors are usually suitable. An electrolytic capacitor can be used for filtering at the PCB power supply input.

The number of tracks between devices should also be minimised and the length of each should be as short as possible. Tracks between the microcontroller and other devices act like an antenna which causes noise. For example, the serial bus, such as I2C or SPI, could be used to talk to external devices rather than a full parallel bus. This minimises noise as well as power consumption and PCB space. These are typically high-frequency connections, so users should be sure to keep the traces short.

Traces that carry high current in a design need special care. This is why large current traces should not be placed near the oscillator or other system pins, such as the mode or reset pin. These could easily be interfered with by noise.

Special care needs to be taken with any external oscillator circuits, especially if the design uses the low power 32kHz crystal for low power operation. It is advised to follow the oscillator circuit layout in the hardware manual and follow the circuit recommendations of the oscillator supplier as well as to take advantage of an oscillator specification service if offered (especially for a 32kHz oscillator design). Other signal lines should not cross the oscillator traces to avoid crosstalk.

It is important to keep signal and power supply tracks as far as possible from the oscillator and to not feed the ground between the pins of the microcontroller. A stable oscillator circuit with a large operating margin is much less likely to cause problems. Using an internal oscillator instead also solves a lot of these issues.

### Layout advice

Other good layout practices for microcontroller systems include:

- The use of wide and short traces for Vcc/Vss wherever possible;
- Reducing the impedance of the power supply circuit to reduce inductive noise problems;
- Use Vss/Vcc planes where possible. (At higher frequencies, typically >4MHz, the return current follows as closely to the signal path as possible. Therefore, users should plan signal returns paths carefully, especially for signals with high currents.)
- The ground plane should not be broken, as this increases signal path impedance;
- Use current limiting resistors on I/O pins.

A typical technique to minimise the issues caused by external noise include separating the CPU bus (with memory) from the peripheral bus to can minimise disturbance of the CPU operation. Other techniques are the use of a distributed clock system and a module stop function on every peripheral. The RA family, for example, also includes on-chip noise filtering on some of the more sensitive inputs, such as reset or oscillator inputs as well as optimising the I/O buffers and the power supply design.

The use of an advanced process technology enables the integration of various components that otherwise would have to be located externally. This helps to improve reliability, removing the need for external circuitry such as oscillators and power management devices. The integration of on-chip oscillators, POR/LVD (brownout systems) and watchdog timers on-chip can greatly help in reducing the impact of noise.

## Addressing the CPU

Designers should also consider how fast they need to run the CPU. The maximum speed may be dictated by the baud rate needed for the UART or by the time in which a Fast Fourier Transform (FFT) filter function must be completed. However much of the time, and for many designs, the device does not have to run at its full speed but only as fast as needed to achieve everything required. The higher the clock speed, the faster the signals and the more problems may arise. The slower it runs, the less current is used and switching in the power supply, and the less noise is generated.

For example, RA microcontrollers have the capability to throttle their speed. Users can change the clock dividers dynamically if required to speed up and speed down. This can add complexity to an application as users must manage the peripheral clocks, but it is worth considering if the clock speed can be reduced.

It is also advisable to check the power supply's dimensions are correct for the design. Rather than reusing the same power supply circuit, ensure it is capable of supplying the maximum amount of current required. If the supply drops occasionally, this can cause noise issues as well as generate other system problems.

Many peripheral input pins also have programmable noise filters. These are commonly found on communication peripherals such as UART, SPI, and I2C interfaces as well as many timer inputs. The correct choice of filter clock selection is important to get the best performance from these filters. Often, this is only achieved through trial and error.

## Watchdog timers

Communication interfaces are connected to the outside world and often bring high-speed signals into the system. The use of external protection circuitry is often advisable depending on the nature of the external environment.

Watchdog timers are an excellent method of recovering an application when noise causes a system's crash. However, it's important to consider how to use these correctly.

For example, there are two watchdog timers in the RA microcontroller design. The first is a standard watchdog timer which can be clocked from several of the standard clock sources on the microcontroller. This watchdog is typically used to check the application's code execution and to detect any malfunction or unexpected operation. It is typically switched off during low-power applications. This watchdog can generate a reset or an interrupt.

The second watchdog timer is the Intelligent Watchdog Timer (iWDT). This uses a dedicated low speed, on-chip oscillator as its clock source, allowing a long timeout and independent operation from the normal CPU clocks. Even if the CPU clock fails, the iWDT will still cause a reset or an interrupt after it times out. Each of the watchdogs can operate with a window function, where a tickle that occurs too early, as well as the watchdog timing out, can cause a reset. Each watchdog can be selected to auto-start after a reset by setting the relevant bits in the option function select register, a flash-based register that holds initialisation data for the device.

A common mistake is to place the watchdog tickle inside an interrupt service routine, because only one instance is normally required. This can be dangerous, however, as while the main application may crash, the interrupt system may continue to operate, negating the watchdog.

Upon completion of the application, designers should analyse all the possible execution paths. This can be difficult for complex applications using an OS, but modern code analysis tools integrated into modern development tools can help.

Multiple instances of the watchdog tickle can be placed at relevant locations throughout the application. This will make the application much more reliable and have the added advantage that it will detect if the application takes an unexpected execution path. This is normally an indication of a serious issue such as a system crash or a pointer overflow.

In any system, the best way to avoid noise problems is to consider noise reduction from the beginning of the design. It is important to understand the environment that the system will operate in, what noise sources will be present, and what steps can be taken to mitigate these.

It's always worth spending some time to consider these issues at the start of the design, as it is much easier to design noise mitigations from the start than to add them at the end of the design - or even worse, modify a design when noise problems are discovered in the field.

# Making sense of the world around us with sensor ICs

How accurate sensing enables better system performance and increased efficiency.

By **Giovanni Campanella, Sector General Manager, Industrial Systems at Texas Instruments**

Sensor ICs are everywhere and can measure almost any type of physical stimuli. From measuring the ambient temperature and humidity of a room to detecting cars and other obstacles on the road, sensor ICs help systems more quickly and reliably react to the world around them.

They can measure almost any type of physical stimuli. For example, measuring the ambient temperature and humidity of a room to detecting cars and other obstacles on the road.

## Sensing types

Sensor ICs are typically designed for a specific modality or type of sensing; current, voltage, humidity, proximity or radar, for example. Recent sensor IC technology innovations have focused on integrating more capabilities into the IC while also increasing overall accuracy and reliability for its given modality. These innovations have led to better system performance, increased energy efficiency and – in some cases –new applications.

One example is the continuous monitoring of a car's interior and exterior with low-power radar sensing. In the past, radar sensing consumed too much power to be used continuously when the car engine was off. With innovations in millimeter-wave (mmWave) radar sensors, 360° continuous monitoring of a car for unauthorised access or unattended children is now possible.

## EVs and charging stations

Sensing ICs play an important role in the shift from internal combustion engines to electric drivetrains, particularly in terms of current and voltage sensing for battery management systems, on-board chargers and DC fast charging stations, as shown in Figure 1.

DC fast charging stations are an example of how impactful current sensors are in electric vehicles (EVs) - specifically the power-module control loop of the charging station. Current sensors monitor the signal bandwidth, gain and offset errors that can affect the power module's ability to reliably regulate AC/DC power conversion, which enables fast charging of the car's battery. In systems where power consumption is a design priority, a shunt-based current design can be implemented with isolated amplifiers or delta-sigma modulators such as TI's AMC1306M05 precision current sensing reinforced isolated modulator or its AMC3302 precision current sensing reinforced

**Figure 1: An EV at a fast-charging station.**

**Figure 2: Server racks in a data centre.**

isolated amplifier with integrated DC/DC converter.

Sensor ICs are also involved in automotive systems beyond battery management and charging systems. While not a recent development, the electrification of systems across the entire automobile – from windshield wipers to seat adjustment motors – continues to provide opportunities for more efficient system design through sensing.

Linear, 3D, angle, switch and latch Hall-effect sensors enable precise responses for real-time feedback of the actuator or motors, helping automotive systems contribute to a more responsive and comfortable environment for drivers.

In addition to using sensors to improve driver and passenger comfort in modern vehicles, automotive engineers are seeking to implement systems that can improve the overall safety of the vehicle by detecting failures before they occur. This requires sensor ICs with diagnostic features that support device- and system-level functions to detect, monitor and report failures during operation. Position sensors, such as TI's TMAG5170-Q1, TMAG5170D-Q1 or the TMAG5173-Q1, are designed to monitor automotive system operation and detect faults quickly in order to help engineers meet regulatory requirements such as those in the ISO 26262 standard up to ASIL D level.

## Data centres

Servers in data centres store and analyse an ever-increasing flow of data, which increases server power consumption. Achieving higher power densities and thus improved efficiency in server power-supply units (PSUs) is one way to optimise data centre operations.

Meeting the strictest efficiency standards for PSUs, 80 Plus Titanium has become a minimum requirement for current and next-generation data centres. Current sensing plays a major role in helping achieve this level of efficiency and can be implemented with isolated amplifiers and Hall-effect current sensors. Sensors like the AMC3302 and TMCS1100 precision isolated current sensing ICs can help server PSUs meet the >96% system efficiency threshold required by the 80 Plus Titanium standard.

The AMC3302 isolated amplifier provides input voltages of ±50mV, enabling the use of a shunt resistor with smaller resistance to help reduce the amplifier's power dissipation and improve system efficiency. While the TMCS1100 Hall-effect sensor converts signals through the magnetic field inside the IC itself, eliminating the need for an isolated power rail. These sensors also reduce power losses through their input conductor resistance, which can be >1mΩ for high-current sensing.

## Energy management

The transition from fossil fuels to renewable energy sources requires more than changes in energy generation. It also depends on the efficient distribution and management of power from electric grids to buildings and homes. A simultaneously sampling ADC with a wide dynamic range and internal calibrations, e.g., the ADS131M04, can be used to achieve reliably accurate energy consumption data in an electricity meter, an integral application for efficient energy management.

The ADS131M04 can connect directly to a resistor divider, current transformer or shunt for designs that require a multiphase meter with shunt measurements. These sensors can reach high measurement accuracies (0.1 accuracy class), while a high sample rate can provide a basis for harmonics measurement to provide load management and other advanced features.

## Robotics and automation

Increased demand for automation across all industries is boosting the use of robots in both factories and our daily lives. For autonomous robotic systems to be successful, they must be able to interact in their contextual environments as they collaborate, co-work and co-exist with humans and other robots. Collaboration and safety are made possible through vision, radar and lidar sensing in robots since these modalities allow the robot to perceive the proximity and nature of objects around it.

Similar to humans, robots rely on their sense of sight, hearing and touch in order to react to the world around them. These senses allow them to stop or reduce their speed when humans or another robot are approaching, or when there is an obstacle in their path. Similarly, in ADAS (advanced driver assistance systems), sensors are deployed around the vehicle to provide a

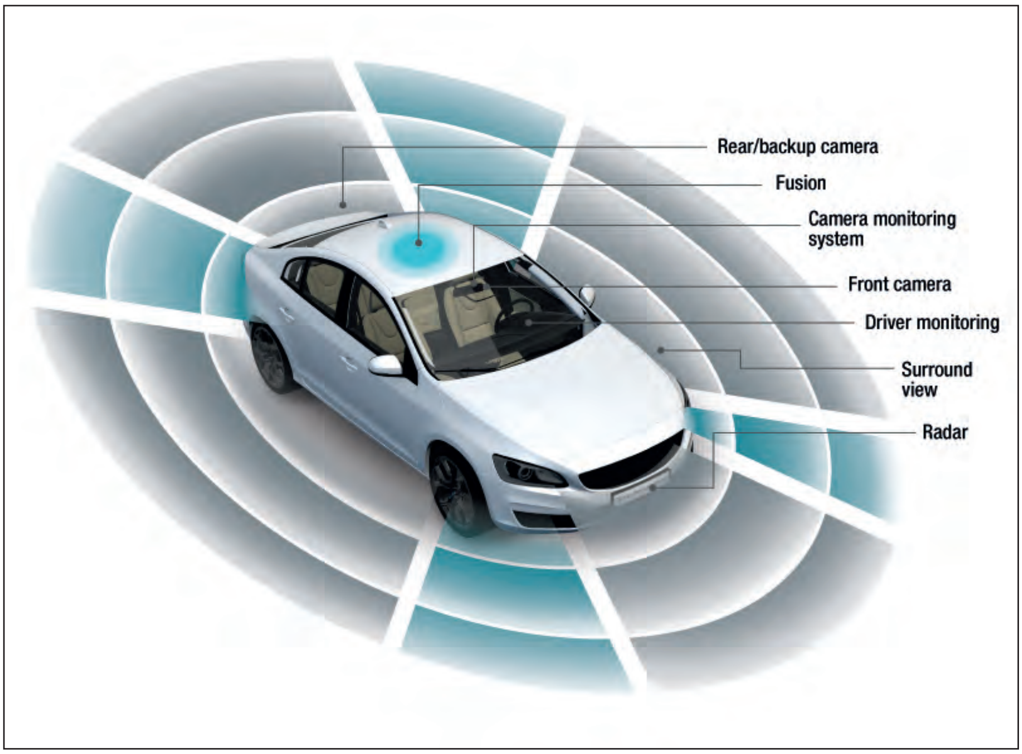



**Figure 3: Radar sensing for ADAS showing the range of view for multiple cameras and sensors.**

comprehensive, real-time 360° view of the surrounding environments, as shown in Figure 3. These "senses" provide actionable information for the driver, helping them assess the hazards around them and react accordingly.

TI mmWave radar sensors, for example, the IWRL6432, can provide highly accurate measurements for both robotics and automotive applications. These sensors measure not only the distance of objects in their field of view, but also the relative velocities of any obstacles in challenging environmental conditions like darkness.

These sensors use radio waves and their echoes to determine the direction and distance of a moving object by measuring velocity, angle and range, helping robots and vehicles take more predictive actions based on how quickly objects are approaching the sensor. TI mmWave sensors are also Safety Integrity Level 2-certified and include built-in security to support evolving safety standards at a system level.

Accurate odometry information is essential for navigation in autonomous mobile robots. Information is derived from measuring the rotation of wheels on the robot's platform. 3D Hall-effect position sensors, e.g., the TMAG5170, provide high precision at speeds up to 20ks/s while using less power. The TMAG5170 also has an integral angle calculator engine, which frees up the microcontroller for other functions.

Sensing technologies can drive forward the potential of sensing in modern systems to allow electronics to act and react faster and more accurately to the world around us.

**Figure 4: An autonomous mobile robot in a warehouse.**

# Characteristics that boost a supercapacitor's power

There are many uses for supercapacitors beyond emergency power supplies, explains **Dr René Kalbitz, Product Manager Capacitors & Resistors Division at Würth Elektronik eiSos GmbH**

Supercapacitors feature very high charge storage capacity, long service life, short charging times, and fast power delivery. One application is emergency power supply units, but they can also be used for hot-swap and hybrid applications, for example, to support batteries during power peaks. Figure 1 illustrates the typical circuit for such applications.

Supercapacitors are energy storage devices, comparable to batteries in many respects. They can be charged from any current limiting energy source and drive electrical applications. Supercapacitors, like any other energy storage system, require a certain technical structure to store and supply energy, including a circuit for charging the supercapacitor under real conditions and an electronic application to be operated.

## Characteristics

When it comes to charging and discharging, two characteristics of supercapacitors need to be considered. Firstly, unlike batteries, the voltage depends on the charged state. The voltage at the component rises or falls as soon as the supercapacitor is charged or discharged. This property is unfavourable for the discharging process, because electronic applications need a constant working voltage. Secondly, supercapacitors can be charged with relatively high currents, which might lead to a semi short-circuit condition for the power supply at the moment of switching on. Although the design-in process for supercapacitors may differ from case to case, the basic procedure is always as follows:

The required energy capacity is first calculated on the basis of the expected energy requirement. Determination of the required capacitance (C) depends on the specification of the load, as well as the efficiency of the DC/DC converter, its lowest operating voltage and the charging voltage. The maximum power output is limited by the equivalent series resistance (RESR) and any other resistance (Rp) caused by contacts or intentionally introduced for protection. The charging regime is then determined, and the corresponding charging times are calculated. In the case of constant voltage charging, a protective resistor is selected depending on the specification of the charger. Charging with constant current is more common, however, and has the advantage of shorter charging times.

The following example shows how supercapacitors - in this case electric double layer capacitors (EDLC) - can be used as a backup power source. In this scenario, both the actual current source and the application operate at higher voltages than the supercapacitor rated voltage. A step-down converter is used to charge the supercapacitors and a step-up converter to supply the test application. A wireless power transfer (WPT) is used for the application with a simple LED panel as the load.

For the following measurements of the voltage and current characteristics during the charging and discharging process, the step-down converter (buck) and the step-up converter (boost) were separated from the supercapacitor. The aim is to operate the application with a power consumption of about P = 0.8W (including conversion losses) for about t = 5 min. A total energy of around E = P • t = 0.8W • 300s = 240J = 0.067Wh is therefore needed. As the converter used has a set charge-cutoff voltage of 2.7V, the capacitance must be at least:

$$C = 2 \cdot \frac{E}{V_1^2 - V_2^2} = 2 \cdot \frac{240\ J}{(2{,}7\ V)^2 - (1\ V)^2}$$

Where V1 = fully charged voltage, V2 = lowest useful voltage

In the typical circuit, two capacitors are charged in parallel, each with a capacitance of 50F. The total capacitance of the

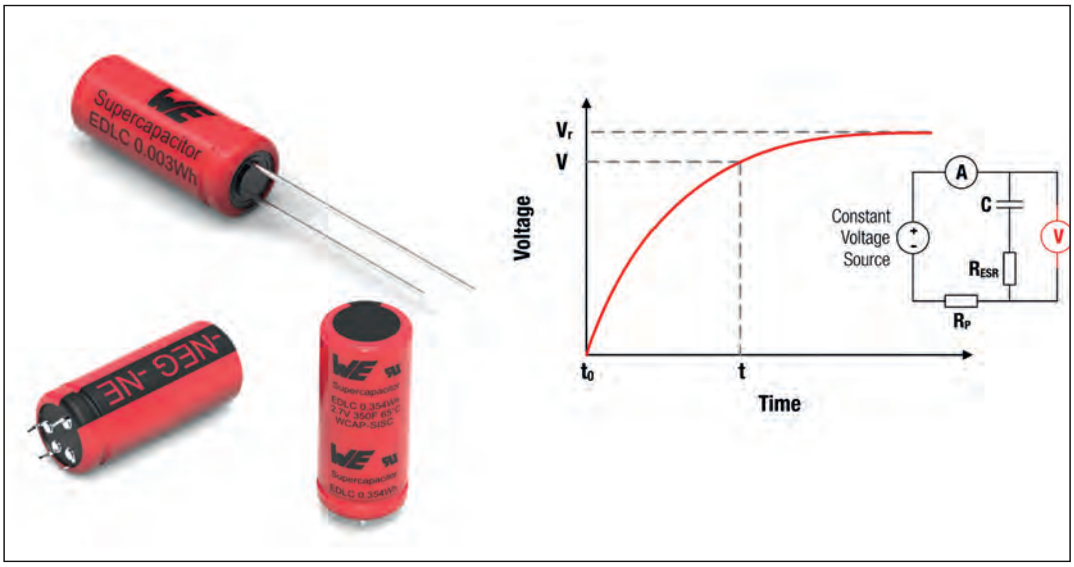



**Figure 1:** EDLC supercapacitors can be used as a backup power source.

supercapacitor is therefore 100F at a rated voltage of 2.7V. As the minimum required capacitance is 76F, the unit will provide sufficient energy capacity. A step-down converter was selected as the current source for charging, which converts a DC input voltage of 12V to a DC output voltage of 2.7V.

The step-up converter used requires an input voltage of at least 1V. For this reason, the calculation must also be based on 1V for the lower supercapacitor voltage (Figure 3).

Figure 3 (top) shows the measured and calculated voltage charging characteristic for the supercapacitor as it is charged with a constant current of 3A from 0.95 to 2.7V. During the charging process, the load was switched off. The following parameters were selected for calculating the theoretical curves: RESR + Rp = 0.08Ω, C = 100F and V1 = 2.7V. The voltage increases linearly from the residual voltage of 0.95V to almost 2.7V. During this period, which lasts around 32 to 86 seconds, the current is constantly regulated to 3A. The loading time for this process given by

$$\frac{100\ \mathrm{F}}{3\ \mathrm{A}}(2.7\ \mathrm{V} - 0.95\ \mathrm{V}) \approx 53\ \mathrm{s}.$$

This constant current charging process is followed by a phase of constant voltage charging, as can be seen from the exponential fall in charging current in Figure 3 (bottom).

### The discharging process

The measured data for the discharging process is also compared with the theoretical model. The step-up converter discharges the supercapacitor from = 2.7V to its cut-off voltage of 1V. It supplies a WPT system with a small array of LEDs at a voltage of 5V and a power consumption of approx. 0.75W. The efficiency of the systems is generally not constant, but changes with the input voltage, the ambient temperature, and various design factors. In this example, the efficiency changes from 90% at 2.7V to around 70% as soon as the converter approaches its cut-off voltage of 1V.

For simplicity, an average output power of Pc = 0.75W is used, calculated as:

$$\overline{P_c} = \frac{1}{\Delta t}\int P(t)dt.$$

The function P(t) was determined experimentally on the basis of the total current and voltage curves of the converter and the LED array. As the calculation was carried out on the basis of an average output power, only the current curve in Figure 4 deviates increasingly from the theoretical curve. The time required for this discharge process is given by:

$$\frac{100\ \mathrm{F}}{2 \cdot 0.75\ \mathrm{W}}((2.7\ \mathrm{V})^2 - (1\ \mathrm{V})^2) \approx 420\ \mathrm{s}.$$

This corresponds to the time after which the measured voltage has dropped from 2.7V to the cut-off voltage of 1V. The voltage curve is shown in Figure 4. A

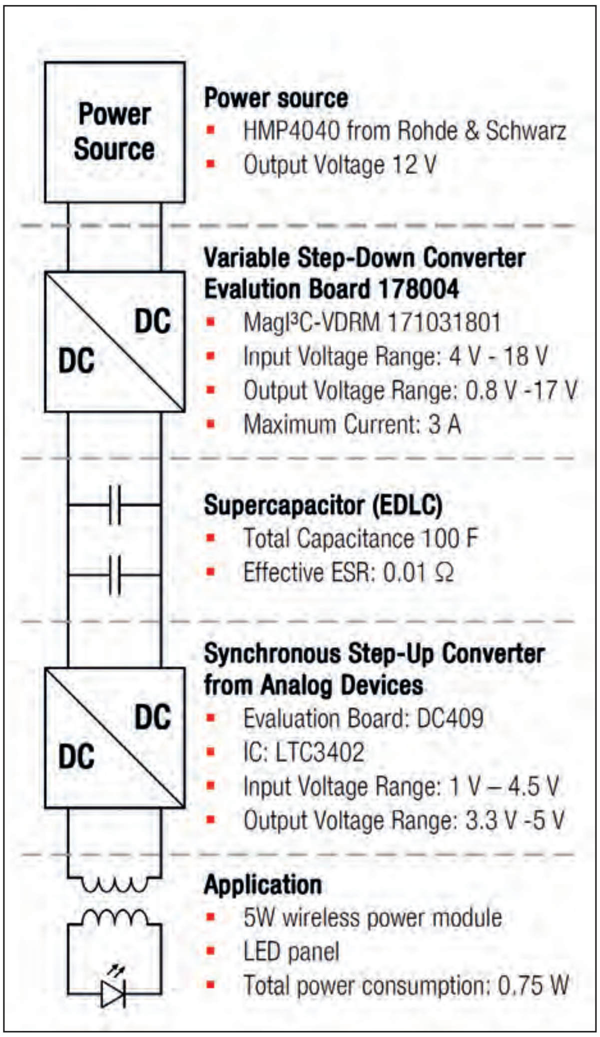



Figure 2: **Example application using a supercapacitor in a wireless power module.**

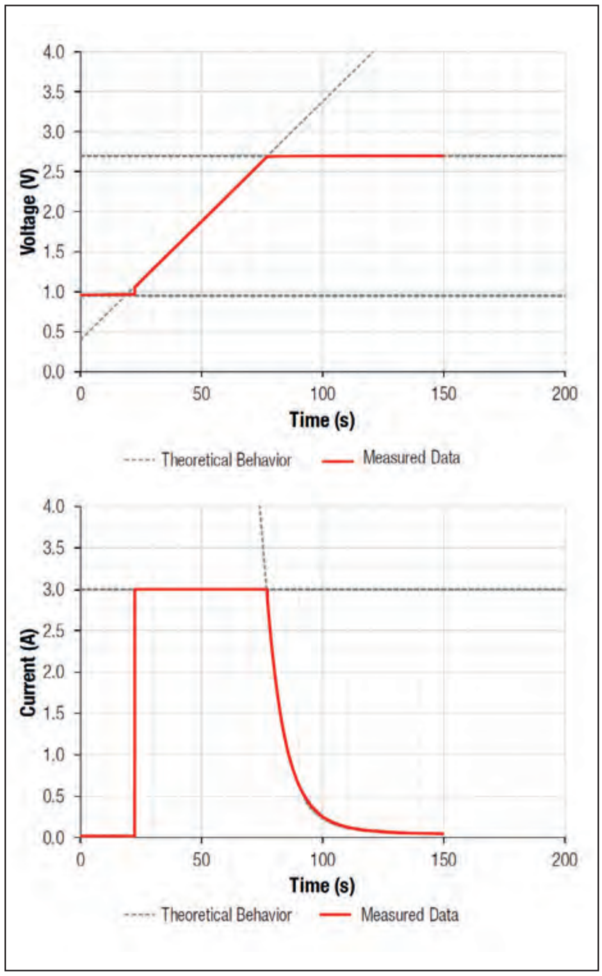



Figure 3: **Voltage (top) and current (bottom) characteristics for charging the supercapacitor with constant current.**

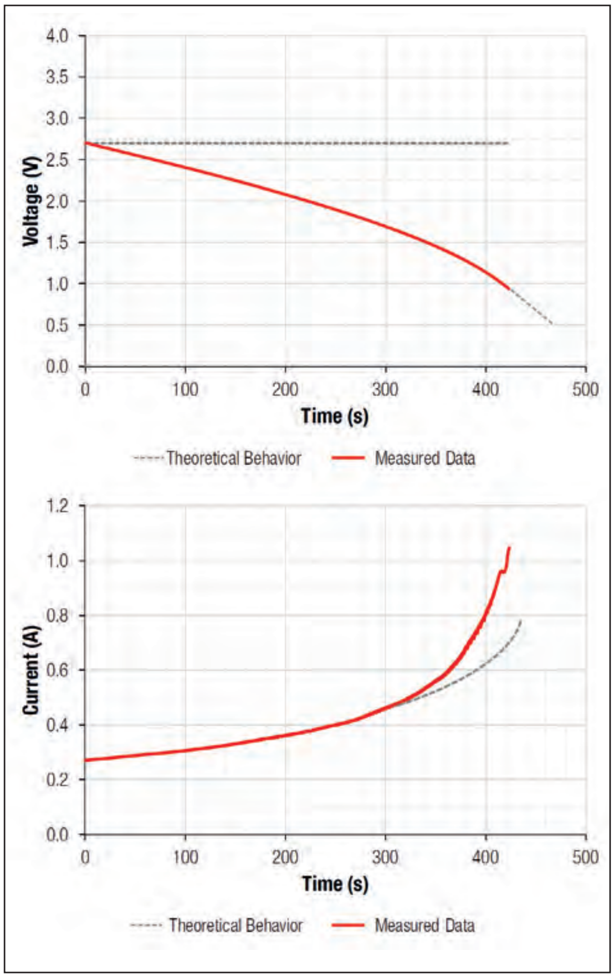
dashed line shows the theoretical discharging behaviour and a solid red line shows the actual measured data.

### Supercapacitor blueprint

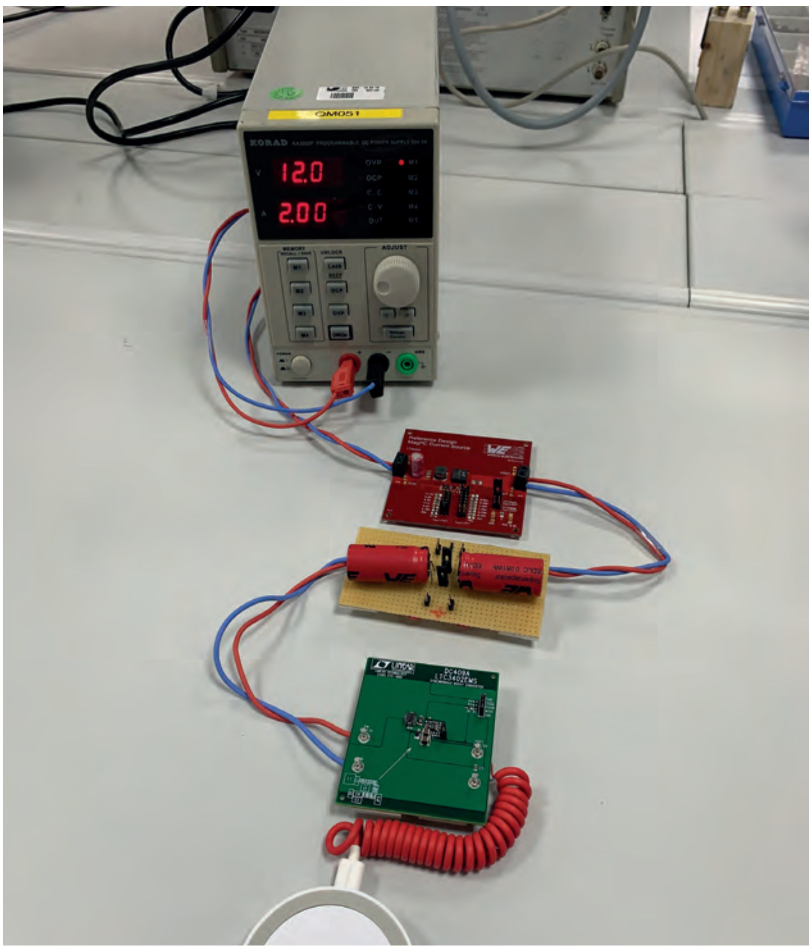
The circuit presented, with its charging and discharging behaviour, can serve as a blueprint for many applications in which "super" double-layer capacitors are to be used for short-term energy supply. It was shown that discharging with a step-up converter can be described very well as a discharging process with constant power. Capacitors are particularly suitable as energy storage devices, if it is possible to define exactly what power is required for what period of time.

Hot swap is a typical scenario here. More and more devices are classified as smart in that they have an operating system that should not be shut down and restarted with a change of power supply. Data loss or interruption of a wireless connection due to an interruption of the power supply can also be an argument in favour of a supercapacitor design. Such solutions are not only robust and technically easy to implement, but, as can be seen from the charging time, are quickly ready for use again.

**www.we-online.com**




**RIGHT Figure 4: Voltage (top) and current (bottom) characteristics for the supercapacitor for constant power discharge.**




**LEFT Figure 5: The complete application with the different power converters, the supercapacitor bank and the load (different voltage source than in the schematic representation).**

# EPC release three laser driver boards for Advanced Automotive Autonomy

EPC introduces three evaluation boards - EPC9179, EPC9181, and EPC9180 - featuring pulse current laser drivers of 75 A, 125 A, and 231 A , showcasing EPC's AEC-Q101 GaN FETs. These FETs; EPC2252, EPC2204A, and EPC2218A are 30% smaller and more cost-effective than their predecessors. Designed for both long and short-range automotive lidar systems, these boards expedite solution evaluation with varied input and output options.

All boards share identical functionality, differing only in peak current and pulse width. Utilizing a resonant discharge power stage, they employ a ground-referenced GaN FET driven by LMG1020 gate driver. The GaN FET\'s ultrafast switching enables rapid discharge of a charged capacitor through the load\'s stray inductance, enabling peak discharge currents of tens to hundreds of amps within nanoseconds. The printed circuit board is designed to minimize power loops and common source inductance while offering mounting flexibility for laser diodes or alternative loads. To enhance user-friendliness, all boards ship with EPC9989 interposer PCBs, featuring various footprints to accommodate a variety of laser diodes or other loads. Customers can choose one that meets their needs to evaluate the GaN solutions.

The EPC9179/81/80 boards are designed to be triggered from 3.3V logic or differential logic signals such as LVDS. For single-ended inputs, the boards can operate with input voltages down to 2.5 V or 1.8 V with a simple modification. Designing an automotive lidar system is complex, and finding a reliable solution is challenging. The purpose of these evaluation boards is to simplify the evaluation of powerful GaN-based lidar drivers that switch faster and deliver higher pulse current than other semiconductor solutions. For technical details, EPC offers full schematics, bill of materials (BOM), PCB layout files, and a quick start guide on EPC's website.

"To meet the growing demand for automotive lidar, these cost-effective boards, featuring our latest AEC products, streamline evaluation, reducing time-to-market with exceptional switching performance," said Alex Lidow, CEO, and co-founder of EPC.

**Visit: epc-co.com**

# Innoscience Technology releases low voltage HEMTs in FCQFN packaging

he new FCQFN devices are easy to mount on PCBs using standard assembly equipment and processes, says the company, although all discrete devices are also still offered in wafer scale packages for module users.

The 40V-rated FCQFN devices are available with an on-resistance value of 4.3mΩ and the chip size is 3.0 x 4.0mm. The 100V HEMTs are offered with RDS(on) of 2.8mΩ and dimensions of 3.0 x 5.0mm and a 1.8mΩ model which has a chip size of 4.0 x 6.0mm. The 150V-rated parts measure 4.0 x 6.0mm and are available with 3.9mΩ and 7.0mΩ RDS(on).

The 1.8mΩ 100V HEMTs are packaged in FCQFN 4.0 x 6.0mm and is therefore pin-for-pin compatible with the 3.9mΩ and 7.0mΩ 150V parts.

The 40V parts, using Innoscience's latest GaN processes, achieve industry-leading performance, claims the company, with best in class FOM (figure of merit) values for Qgg*Ron and Idss*Ron.

Low drain and gate leakage currents enable the HEMTs to be used in mobile markets and direct battery-connected applications as well as USB Type C buck-boost converters in laptops. Innoscience says that its latest generation process enables it to maintain very tight control of the epitaxy, resulting in a very uniform threshold voltage and on-resistance, leading to a very high wafer yield.

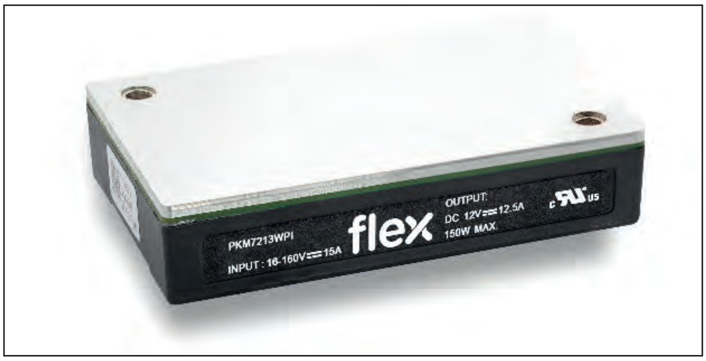
100V HEMT devices are suitable for DC/DC conversion at power levels of up to 2kW and can achieve up to 8kW when used in parallel configuration.

The 150V models are suitable for industrial applications, including solar installations. They have been designed to be rugged so they do not need the industry-standard 80% derating to be applied (i.e. they are rated at 100% of their voltage), explains Innoscience.

All of the new HEMTs have been tested to and exceeded JEDEC and the GaN-specific JEP 180 standards.

**www.innoscience.com**

# PKM7200W series of DC/DC converters meet worldwide rail applications




The PKM7200W series has a wide input range of 16 to 160V (185V/second), which is suitable for rail applications around the world, says the company. Modules provide 150W continuous output power and 12, 24 or 54V DC fully regulated single outputs in a 62 x 40 x 13mm (2.44 x 1.57 x 0.51 inch) case. Efficiency is up to 89% and the modules feature 4kV DC isolation, meeting the requirements of EN 50155 for rail, as well as IEC/EN/UL 62368-1 for IT and audio/visual applications.

The PKM7200W series has a VBUS pin. This input-referenced connection is boosted to around 100V, irrespective of the input voltage. This can be used to charge a user-supplied capacitor which the DC/DC switches in when the input power is interrupted. This feature enables long hold-up time with a relatively small capacitor, to meet the 10 to 30ms requirements of the rail standard EN 50155.

The products comply with the rail fire safety standard EN 45545-2 and have been qualified to EN 61373 and the IEC 60068 series of standards for environmental testing. EN 50121-3-2 for EMC in rail applications is met, as well as EN 55011 and the EN 61000-4 series of standards for EM immunity. EMI conducted emissions meet EN 55032, CISPR 32 and FCC part 15J 'Class B' with an external filter.

The PKM7200W series operates from -40 to 100°C baseplate temperature

with derating, depending on attached heatsink and airflow. Typically, the parts provide full load with a 20mm attached quarter brick heatsink up to 60°C ambient air temperature in natural convection and to around 90°C with 3m/s airflow.

There is also programmable input under-voltage lockout, remote control, output trim and remote sensing. Comprehensive protection includes over-temperature, and output short-circuit, over-voltage and over-current.

**www.flexpowermodules.com**

# Nordic Semiconductors' Intelligent nPM1300 Power Management IC now available from Farnell


Farnellhas added Nordic Semiconductors' nPM1300 Power Management IC to its semiconductor portfolio to enhance the offering for connectivity of devices.

The nPM1300 offers a simplified solution to system design by integrating essential functions that are necessary for embedded designs into a single, compact package. Its high efficiency power regulation provides designers with longer run times and efficient battery charging, while reducing the number of required components.

The nPM1300i integrates many intelligent system management functions, including integrated hard reset functionality for one or two buttons, accurate battery fuel gauging, a system-level watchdog, power loss warning and recovery from failed boot. These functions are typically added using discrete components in Bluetooth Low Energy (LE) embedded designs, while the nPM1300 includes them in a single package.

Key features of the nPM1300 Power Management IC include:
32 - 800 mA battery charger.
Two 200 mA buck DCDC regulators.
Two 100 mA Load switches, alternatively 50 mA LDO.
Five GPIOs.
★ Three LED drivers. ★ Controlled via I2C compatible TWI.
★ USB-C compatibility.

**For more information, visit http://www.farnell.com/corporate**

# Multi-Channel Remote Temperature Sensors by Microchip

Thermal management is a critical aspect of automotive design, yet compared to many other components, there is a noted lack of options when it comes to multi-channel remote temperature sensors. Microchip Technology has launched the MCP998x family of 10 automotive-qualified remote temperature sensors. The MCP998x family is perported to be one of the largest portfolios of automotive-grade multi-channel temperature sensors in the industry and is

designed for 1°C accuracy at a wide operational temperature range. The device family includes five sensors with shutdown temperature setpoints that are designed not to be overwritten by software or maliciously disabled.

With up to five channels of monitoring and several alert and shutdown options for security, this product family claims to support systems that supervise more than one thermal element. The remote sensors also integrate resistance error correction and beta compensation, eliminating the need for additional configuration for improved accuracy. Monitoring temperatures at multiple locations with a single, integrated temperature sensor reduces board complexity and size and simplifies design for a lowered bill of material (BOM).

Claimed More accurate where it counts, designed for 2.5°C accuracy up to 125°C, the MCP998x device family can be used at the high end of the traditional temperature range where many competitors are challenged. This high temperature tolerance makes them well-suited for automotive applications where operating temperatures for electronics is a major factor. The MCP998x sensors are designed to support vehicle functions including HID lamps, advanced driver-assistance system (ADAS), automotive servers, video processing, infotainment systems, engine control, telematics and body electronics such as seat control, lighting systems, mirror control and power windows. Visit the website to learn more about Microchip's full portfolio of temperature sensors.

**see more at: www.microchipdirect.com.**

# 10MBd optocouplers save energy in industrial applications

The optocouplers provide low power consumption to save energy in industrial applications. The single-channel VOH260A, VOIH060A, and VOWH260A and dual-channel VOH263A and VOIH063A have a wide voltage supply range of 2.7 to 5.5V and an open collector output. They are for use with with low voltage microcontrollers and I?C and SPI bus systems, says the Vishay Semiconductors.

Offered in DIP-8, SMD-8, and SOIC-8 packages, the optocouplers use an efficient input LED coupled to an integrated photodetector logic gate with a strobable output. The optocouplers combine a low supply current of 5mA maximum per channel with a low typical turn-on threshold current of 2mA typical, which simplifies designs by eliminating the need for an additional driver stage for a direct microcontroller connection.

All five devices are suitable for data communications, high speed A/D and D/A conversion, level shifting and providing high voltage safety in automation equipment, motor drives and tools. They feature an internal shield that provides a guaranteed common mode transient immunity (CMTI) of 15kV/?s minimum. This means the optocouplers are also suitable for noise isolation and breaking up ground loops in these applications.

The RoHS-compliant devices offer maximum rated withstand isolation voltage up to 5,000V RMS and provide isolation distances from 5.0 to 10mm to cover a wide range of requirements, including those of applications with working voltages exceeding 1,000V.

Samples and production quantities are available now, with lead times of six weeks.

**www.vishay.com**

# Recom adds 400W DC/DC converters for on-board conversion in mobility applications

The cost-effective, regulated DC/DC converters are the RMOD400-28-13SW, RMOD400-60-24SW and RMOD400-80-13SEW. They are intended for on-board power conversion in mobility and industrial vehicles, mounted in unprotected areas, all parts are IP69K rated for protection against water and dust. They are supplied with sealed plug-and-play connections.

The RMOD400-28-13SW has a 16.8V to 56V input range with 13V output. The RMOD400-60-24SW operates from 33.6 to 96V (125V peak) input with 24V output. The RMOD400-80-13SEW has an extra-wide input continuous input range of 33.6 to 125V, with a 13V output.

The RMOD400 range is chassis-mounted with baseplate cooling and achieves high efficiency, maintained down to light loads, in a compact size of 115 x 203 x 61mm. It operates with baseplate cooling to ambient of 85°C without derating.

The rugged parts also feature input reverse polarity, over temperature and output over-current and short circuit protection. Isolation rating is 2.5kV DC 'Basic' grade and the modules are certified to IEC/EN/UL/CSA 62368-1. The DC/DC converters are also qualified to EN 60068 for resistance to temperature cycling, shock and endurance, humidity/heat cycling, vibration, mechanical shock and salt spray.

Marco Kuhn, Plug & Play DC/DC product manager of Recom, says the DC/DCs converters are 'ready to use' in a wide variety of mobility applications with different nominal battery voltages. "Because of their comprehensive qualifications, you can fit them anywhere with confidence in a high-reliability solution," he adds.

Samples and OEM pricing of the RMOD400 range are available from all authorised distributors or directly from Recom.

**www.recomsolutions.co.uk**

# STMicroelectronics adds 200W and 500W devices to MasterGaN family

The next-generation of integrated MasterGaN bridge devices are claimed to simplify power supply design. The MasterGaN family combines 650V GaN high electron-mobility transistors (HEMT) with optimised gate drivers, system protection and an integrated bootstrap diode that helps power the device at start up. This level of integration means designers do not have to tackle the complex gate drive requirements of GaN transistors, says the company.

The integra200W and 500W devices contain two GaN HEMTs connected in a half-bridge configuration. The arrangement is suitable for building switched-mode power supplies, adapters and chargers with active clamp flyback, active clamp forward and resonant converter topologies. The MasterGaN1L and MasterGaN4L are pin- compatible with MasterGaN1 and MasterGaN4 respectively. They have a newly optimised turn-on delay that allows working at higher frequency and higher efficiency with low load, especially in resonant topologies, according to the company.

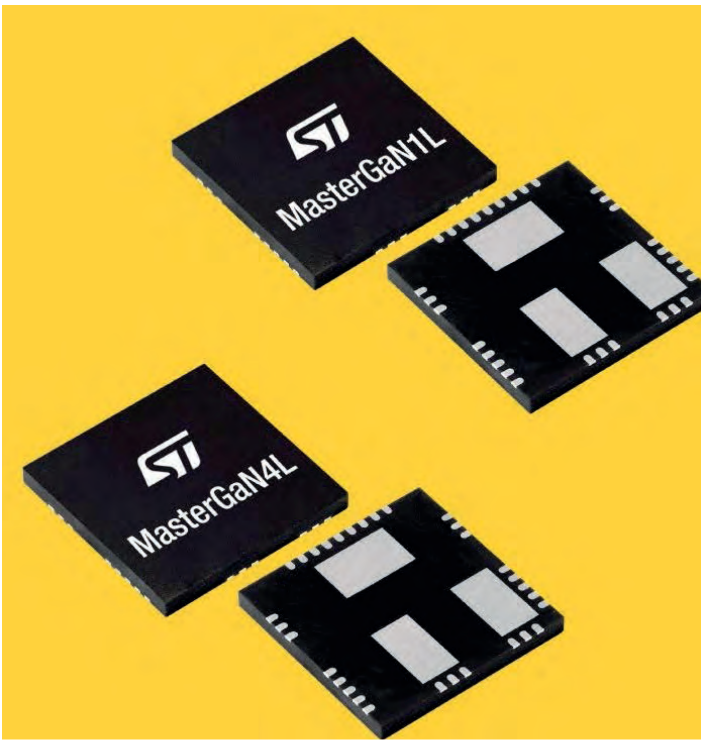
The inputs accept signal voltages from 3.3V to 15V, with hysteresis and pull-down that facilitate connecting directly to a controlling device such as a microcontroller, DSP or Hall-effect sensors. A dedicated shutdown pin helps designers save system power and the two GaN HEMTs have accurately matched timing with an interlocking circuit to prevent cross-conduction conditions.

The MasterGaN1L HEMTs have 150mΩ RDS(on) and 10A rated current, for use in applications up to 500W. Power consumption at no load power is 20mW and high conversion efficiency enables designers to meet stringent industry targets for standby power and average efficiency. The MasterGaN4L HEMTs target applications up to 200W, with 225mΩ RDS(on) and rated current of 6.5A.

ST also supplies the EVLMG1LPBRDR1 and EVLMG4LPWRBR1 demonstration boards containing a GaN-based half-bridge power module fine-tuned to work in an LLC application to help designers create new topologies leveraging the new devices without needing a complete PCB design.

The MasterGaN1L and MasterGaN4L are in production now in 9.0 x 9.0 x 1.0mm GQFN packages.

**www.st.com**



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