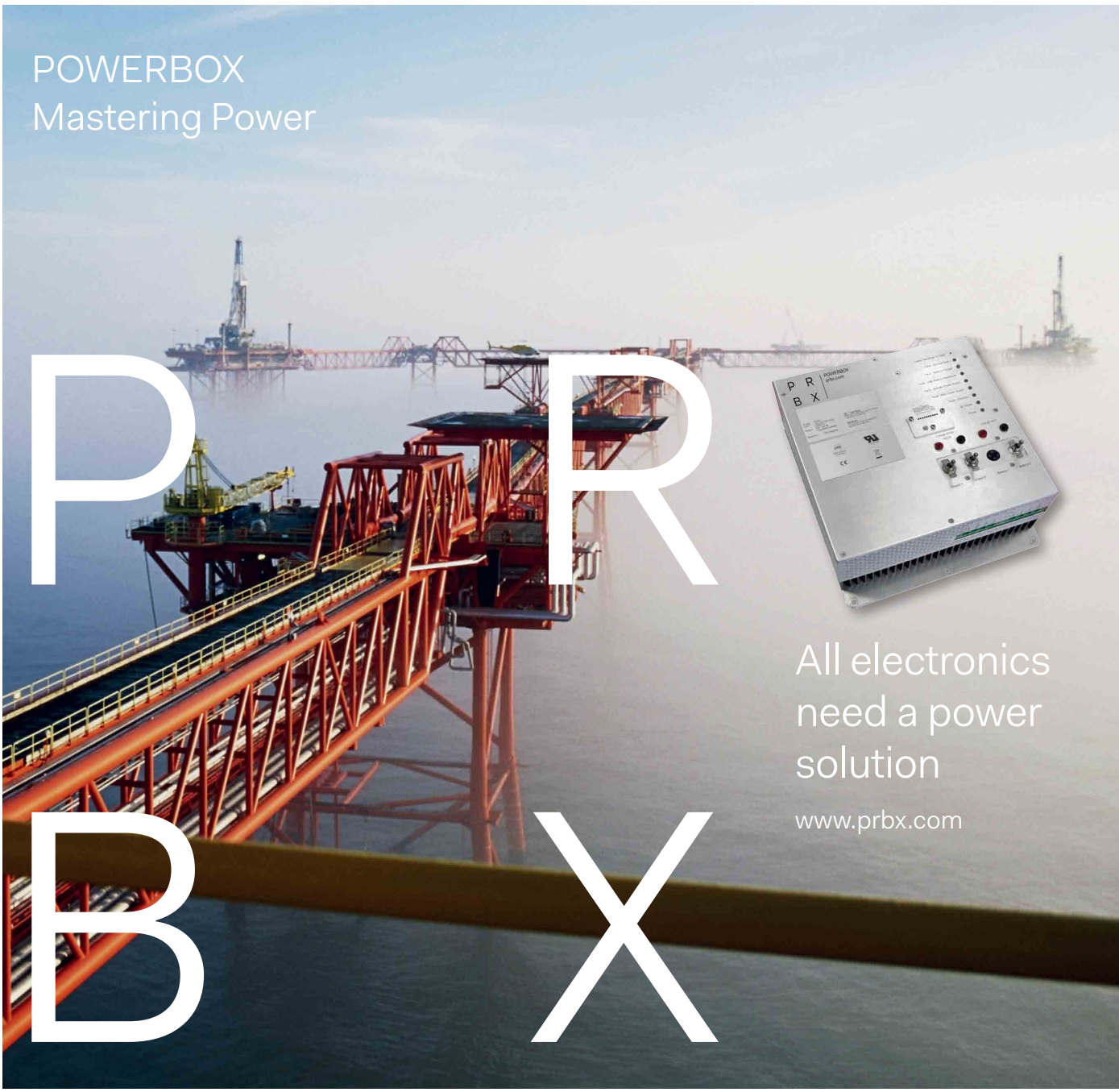
PSSD EUROPE
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October 2015



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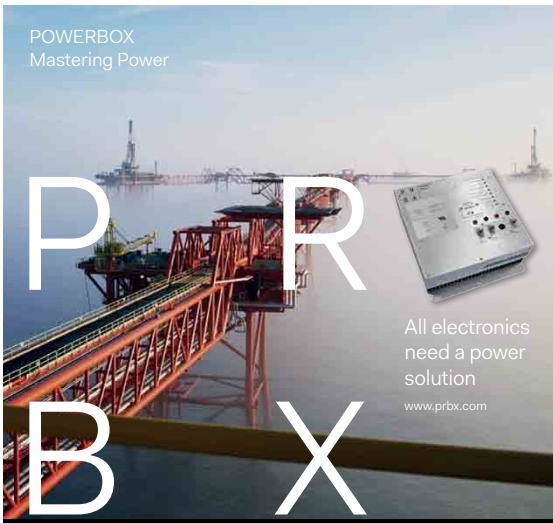
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Volume 12, Issue 8



Revolutionizing industry

Going through the throes of this latest wave of industrial revolution one sometimes feels like Charlie Chaplin in the factory scene from "Modern Times". From the designer to the consumer, and at every stage in between, how we create, make, store, and distribute products is changing so quickly many of us are having a hard time keeping up.

The design engineer feels this pressure quite acutely, caught between the pincers of client needs and application requirements, complicated by market and regulatory forces. Industrial production has never been as complex, never used more advanced technology, nor had more competitive and market forces acting on it as now. Creating the latest solutions for the most demanding problems in a timely fashion while staying cost-effective and efficient can perplex the best design and development team.

The advantage today is that the industry of industry is also more knowledgeable, more connected, and more interdisciplinary than ever. From parts vendors to distributors to customers, online communities and professional organizations stand ready to help one another solve problems by exchanging solutions amongst themselves. It is easier than ever to reach out to the engineering community and find assistance in developing, manufacturing, and deploying a product or service.

This online help doesn't stop at communities of like-minded people helping one another the way it is in other disciplines, creating industrial systems is an issue within the engineering community, so online help also extends to tools and software and cloud-based systems as well. One can not only order parts or ask for human assistance on a manufacturer's website, today one can also usually find design tools.

These online design tools available from the manufacturer are often so powerful one can use them in lieu of many of the traditional "off-the-shelf" design software packages. Often these manufacturer tools will actually work with the traditional software, enhancing the design process with product-oriented data and routines.

Having a strong grasp of these powerful solutions, products, and technologies is more critical than ever today because the designer of industrial systems doesn't have the luxury of designing from whole cloth the way their colleagues in other application spaces can. Industrial systems are not only deployed in new facilities in new racks with new lighting and environmental systems, an industrial design must often cram the solution into a grandfathered facility with lighting and environmental systems that also need to be (but often are not) updated and modernized as well.

It is this mix of old and new that can create serious problems in developing a solution for industrial systems, as many situations in legacy industrial environments demand a custom solution that forces both the designer and customer to make painful and sometimes expensive compromises, and it is in these compromises that a good engineer can shine by creating a solution that best fits the often conflicting needs and demands of the application, customer, and marketplace.

Best Regards,

Alix Paultre
Editorial Director, Power Systems Design
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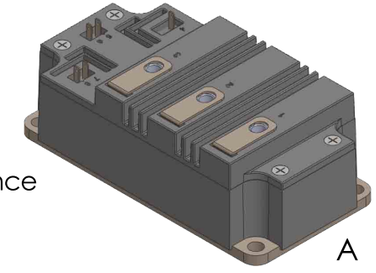
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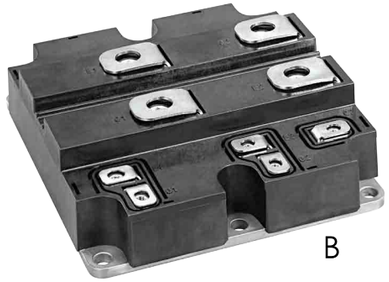
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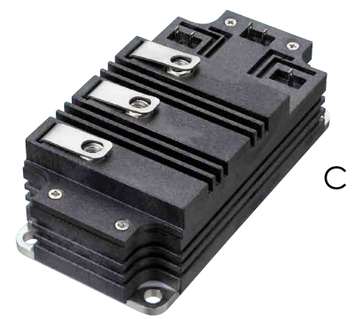
A
140mm x 73mm x 38mm

	Pkg. Type	Baseplate	Package Configuration	Amps
3.3 KV Dual Modules				
QID3320002*	C	Cu	Dual	200
QID3320004** (Expansion to 300A available upon request.)	A	Cu	Dual	200
QID3330001	C	Cu	Dual	300
QID3340001	B	AlSiC	Dual	400
QID3350001 (400A available upon request.)	B	AlSiC	Dual	500
4.5 KV Modules				
QID4515002	C	Cu	Dual	150
QID4515004	A	Cu	Dual	150
QIF4515002	C	Cu	Dual Com. Collector	150
QID4520002	C	Cu	Dual	200
6.5 KV Modules				
QIC6508001	C	Cu	Dual Com. Emitter	85
QID6508001	C	Cu	Dual	85

*Where CU baseplate is listed, an AlSiC baseplate can be substituted where required for demanding applications.
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C
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IPI's battery charging transformers support rugged industrial apps

With their novel perfect-layer coil winding technology, the new highly reliable Battery Charging Transformer Series from Innovative Power (IPI), a Datatronics company, is designed to support a wide range of standard and custom voltage battery-powered devices that operate in rugged industrial plant environments.

IPI battery charger transformers step down the AC input voltage to the required level of the battery charger, which is essentially a DC power source. They are high-power transformers that produce a high current output matched to the particular voltage lead-acid battery under charge.

The IPI battery charger transformers are available with standard 120/240 input voltages (60 or 50 Hz) to support 12/24/36/48 V lead acid batteries. Custom voltages are available from 10 to 5000 VA. They are ideal for the many different types of industrial battery chargers, which support industrial plant equipment such as fork lifts, tow tugs, factory carts, truck pallet lifters and more.

The Battery Charging Transformer Series from IPI features a flexible, modular design. Special and custom design configurations are available from the IPI Design Center. These transformers can be customized to meet individual application requirements for vibration, temperature, humidity and shock to ensure accurate performance and reliable operation.



Features

- Modular Design for Application Flexibility
- Input Voltages: 120/240 V, 60 Hz or 50 Hz (Custom Options: 10 to 5000 VA)
- Supports Standard Battery Voltages: 12-24-36-48 V (Custom Options Available)
- Short & Overload Resistant Designs
- UL Insulation Class Certifications Available
- Optional Mounting Brackets
- ISO 9001:2008
- Meets RoHS Requirements

IPI's Battery Charging Transformer Series is manufactured according to world class standards in IPI's cellular manufacturing facility, which meets ISO 9001-2008. IPI provides strict quality control procedures and testing in its own Environmental Test Laboratory to ensure performance and life.

In single piece quantity, the Battery Charging Transformers Series is available beginning at $5.00 each to $80.00 each depending on specific performance features and other customer requirements. Lead-time is stock to six weeks.

www.ipimagnetics.com



Electric buses: a crucible of change

By: Dr Peter Harrop, Chairman, IDTechEx

Buses are the demons of the piece when killing thousands of Londoners and making Oxford Street the most NOx polluted road on Earth as they belch nose to tail. Over broader areas, China is even worse but there the government is making the bus into a savior. It banned the very polluting two stroke engines on two wheel vehicles so pure electric bikes became the way 140 million people get to work. That was not enough, so electric buses and trains get the big money with the hybrid interim stage increasingly being leapfrogged with pure electric versions of even double deckers.

This story is full of paradoxes. The largest number of lithium-ion battery manufacturers in the world is in China but some Chinese bus companies have seen their batteries die in only two years so Hybrid Kinetics recently ordered $1bn of bus traction batteries from XALT of Michigan, USA with their superior quality and cycle life based on a titanate anode and nickel metal cobalt cathode, plus state of the art new manufacturing facilities. Indeed buses are now a crucible of change, often adopting new technology before cars. The in-wheel motors of the Chinese BYD K9 bus are part of the reason why they took the world record in order size this year with one order for 2000 vehicles. This has been followed by smaller orders all over the world, including South America, where it is setting up one of its many new factories for making electric buses. It even has a solar roof option. In China success with that may have to await the sun reappearing as the notorious Chinese smogs abate.

BYD makes batteries too and faced with the recent announcement of the Tesla Gigafactory in the USA, BYD says it will install more than that production capacity for vehicle batteries. A lot of testosterone is flowing.

Meanwhile, back in the USA, pure electric bus maker Proterra has won plaudits and several orders for its latest pure electric buses. This year it raised a useful $55m in investment. Run by an ex-Tesla executive, it has been hailed as "the Tesla of buses".

So where will much of the next wave of technology appear, from silicon carbide power components and new motors to lithium-ion capacitors, structural electronics and regenerative shock absorbers? Probably in a bus near you because buses are not bought on up-front price and, unlike military vehicles, the other cradle of innovation, they offer larger numbers. China alone may have 11 million electric buses by 2025 or not long after. Just look at the British high-speed lightweight flywheels for grabbing braking energy. Straight from Formula One racing they are being trialed in 500 electric London buses this year with full production next year. Read more in the new IDTechEx reports,"Electric Buses 2015-2025" and "High Power Energy Harvesting: Off-Grid 10kW-100kW 2016-2026".

The topic is far broader than just buses. Electric vehicles will eventually be dominated by a few giants; however, the components and enabling technologies are applicable to many other types of vehicles – land, sea and air.

The author of this story has sold his S Class Mercedes. He now goes on the bus.

www.idtechex.com



Powering industrial electronics

By: Kevin Parmenter, Power Systems Design Contributor

Several years ago it was my privilege to be selected to write the introductory section on Industrial power for the PSMA PTR –Power Technology Roadmap. Part of what I said about the characteristics of the industrial market was that it was as close as you can get to automotive electronics without wheels attached, and that the market goes on forever.

This is completely opposed to the "driver" consumer market in which something that takes 100 Phd's 2 years to design is soon a commodity being sold by the pound like wheat in 6 months only to be discontinued and replaced by something better fast – processors and anything in the handset market follows this trend.

Fortunately the industrial market is not impressed by the latest new "whizzy-whiz hotness" they want long-term predictability and reliability. Industrial environments can be very hostile, electrically as well as environmentally. Surges and transients in excess of the normal IEC specifications are routine and since the transients cant read specifications they just go ahead and destroy things anyway.

Equipment in oil field production areas on oil rigs at sea are often powered by long runs of power mains connections and or they are lighting targets– meaning its not if a lighting strike will occur during product operational lifetime its how many times a month. I've seen PCB traces vaporized off the board by transients and surges many times so external protection for the power supply inputs is often needed and rarely added!

System cooling is often an issue. Equipment is often in NEMA enclosures and sealed – the cabinets are very often "cleaned" by high-pressure steam hoses or salt water fire hoses. In Machine tool and Aluminum Smelting applications the enclosures have to be to sealed to keep out metallic dust in the air from the processes.

What about the loads? Industrial loads are often as hostile as the environment. If the power electronics are developed on an electronic load in the lab – the industrial loads will look nothing like this. Industrial loads are routinely highly reactive – motors, fans – blowers, pumps, compressors, valves – solenoids, servos, large capacitor banks, battery banks and combinations of these and more on the same bus.

The right test equipment is needed to test for all these attributes while the test market itself is considered part of the industrial market as well! Moreover IEC60950 that has been one of the key standards for industrial power for a long time is being phased out to be replaced IEC62368-1 – likely being required in 2018. That does not mean that there are not a plethora of other IEC and other specifications that industrial power needs to meet but this is one of the major ones.

The good news is this market is stable and if you have what it takes to participate in it, there is plenty going on and the market simply continues on despite market conditions –ups and downs and twists and turns in the electronics industry. If you have the expertise, reputation for quality – reliability, stability and the patience to survive in it it's a great place to be.



Core Loss Modeling – Part I

By: Dr. Ray Ridley, President, Ridley Engineering

As modern power converters move towards higher efficiencies, it is essential to have better models for all of the loss mechanisms in your components. We have talked about winding loss effects in several articles. Magnetics core loss modeling is an area that needs improvement.

Magnetics B-H Loops

As frequencies climb beyond 50 kHz, core losses can start to become a significant source of loss in power supplies. Each time the core material is cycled around its B-H magnetization loop, there is energy loss. This is illustrated in **Figure 1**.

The green curve shows the core being driven all the way to saturation in each direction, positive and negative. Typically, this will not happen in a converter, and the flux excursion is stopped short of 0.3 T, well before the top of the curve flattens out.

The blue curve of **Figure 1** shows a minor B-H loop with a DC bias. Notice that the loop is not as wide as the green curve, and the losses incurred each time around the loop are lower. This is a characteristic of magnetic cores. The harder they are driven, and the faster they are driven, the more the B-H curve opens up, and the higher the loss. The different magnetics in various different topologies will have great variations of excitations of their cores.

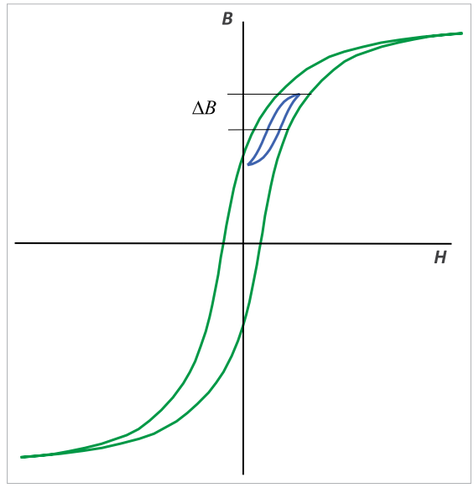


Figure 1: B-H Loop for a High-Frequency Material

Measured core loss and the steinmetz equation

While the mechanisms for core loss have been the attention of much analysis and research in the past, there has not yet been a way to accurately predict the loss from just the chemical structure and physics of a material. Each time a new material is created for use by the power electronics industry, there must be extensive and careful characterization of the losses in the core material. This can only be done empirically.

The measurement of high-performance ferrite cores is a procedure that needs very accurate instrumentation in order to get good data. Calorimetry is still used as the most accurate technique. Extracting loss data from just electrical measurements does not have enough precision.

Figure 2 shows a family of loss measurements for Magnetics R material. To generate these curves, the core is driven sinusoidally to different flux levels over a range of frequencies from 25 kHz to 1000 kHz. Beyond 1 MHz, this material

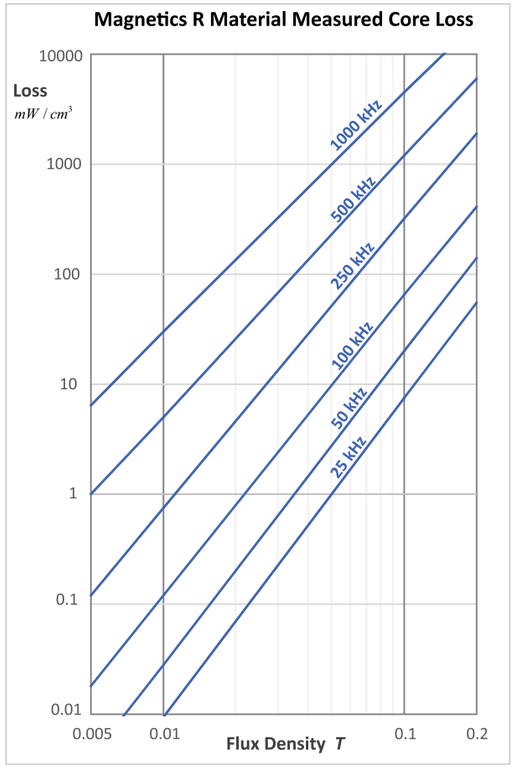


Figure 2: Typical Core Loss Measurements for Magnetics "R" Material

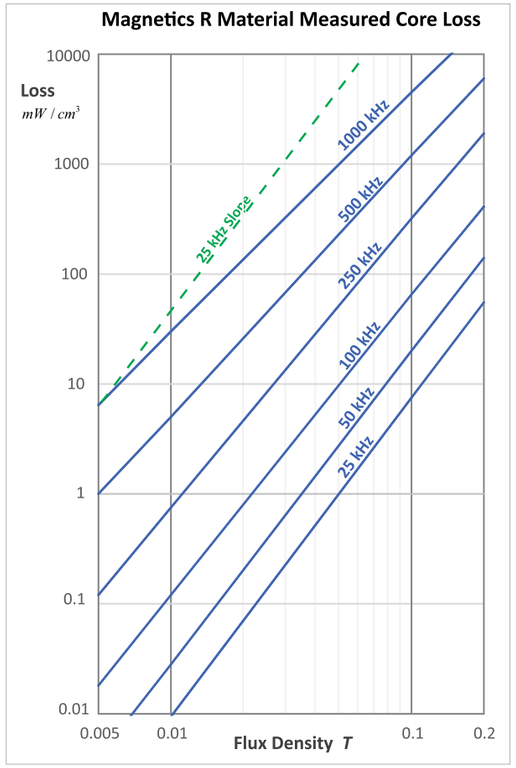


Figure 3: Typical Core Loss Measurements for Magnetics "R" Material, Showing Slope Variations

is not the best one to choose, although it can certainly still be used if the excitation levels are not too high.

Empirical results for each core material give the most accurate data that can be obtained. Usually we rely on the core vendors to provide this data and it is not a process that you are likely to try and do yourself. However, curves are not particularly convenient to work with when trying to do computer-aided design.

In order to address this shortfall, we have the Steinmetz equation to predict what the core loss will be. Due to the nonlinear nature of core loss, this equation is somewhat unusual. The frequency exponent, c, in the equation is usually a number somewhere between 1 and 2. (A value of 1 would result if the BH loop shape was fixed with frequency, but as mentioned before, it will grow larger at higher frequencies.)

$$P_c = af^c \Delta B^d$$

Equation 1: Steinmetz Equation for Core Loss

The ΔB exponent, d, in equation 1 would be equal to 2 if the only losses were due to classic core hysteresis. However nonlinear effects result in an exponent between 2 and 3.

Despite the popularity of the Steinmetz equation, it is of limited use in its normal fixed form. The frequency exponent is only fixed if the separation of frequency multiples is always the same. That is, the distance between the 25 kHz and 50 kHz curves of **Figure 1** should be the same as the separation between the 500 kHz and 1000 kHz curves. This is clearly not the case. The separation is much larger at the higher frequencies. The exponent for ΔB would be a constant value if the slopes of the loss curves were all the same, and at first glance, the curves of **Figure 1** appear to be parallel to each other. However, this is something of an optical illusion. If you look at **Figure 3**, you will see the slope of the 25 kHz loss line, shown in green, compared to the 1000 kHz loss line. They are very different.

	a	c	d
<100 kHz	0.074	1.43	2.85
100-500 kHz	0.036	1.64	2.62
>500 kHz	0.014	1.84	2.28

Table 1: Variable Coefficients Needed for Different Frequency Ranges

Since both of the exponents need to change with frequency, Magnetics Inc. provides a table of changing values, depending on the frequency range that is being used. This is repeated for you in **Table 1**. While this improves accuracy, it is cumbersome to use, and significant differences will be predicted in loss when the frequency changes from 99.9 kHz to 100.1 kHz.

Figure 4: Comparison of Measured Core Loss and Predicted Core Loss with Ridley-Nace Formula

Core Loss and Ridley-Nace Modeling Formula

Another approach is possible to avoid using discretely-changing values for the exponents of the core loss equation. In 2006, we conducted research into better ways of modeling core losses with a continuous equation for all frequencies. This results in a fixed term for the frequency exponent, and frequency-dependent expressions for the constant and the ΔB exponent.

$$P_c = (-3.626 \ln f + 28.32) f^{-1.729} \Delta B^{(-0.00076 f + 2.8332)}$$

Equation: Ridley-Nace Formula for Core Loss

For the Magnetics R material, the resulting equation is shown below.

Figure 4 shows the result of using this equation. It isn't perfect, but at the high-loss end of the curves, the fit is very good. Further refinement of the equation could be done, but this may not be the best immediate thing to do. Verification of the data would come first.

In **Figure 5**, you can see the curve-fitting procedure used to find the frequency-dependent constant of the new formula. This logarithmic function provides a good fit overall, but you can see that there are some data points that don't seem to make complete sense, and they don't complete a smooth curve. Before trying to improve the curve fitting, it would be important to verify the accuracy of the data. As mentioned before, this loss data is very difficult to measure accurately, and it is not surprising to see spurious results in the data points.

Figure 6 shows the curve fitting used to find the flux exponent.

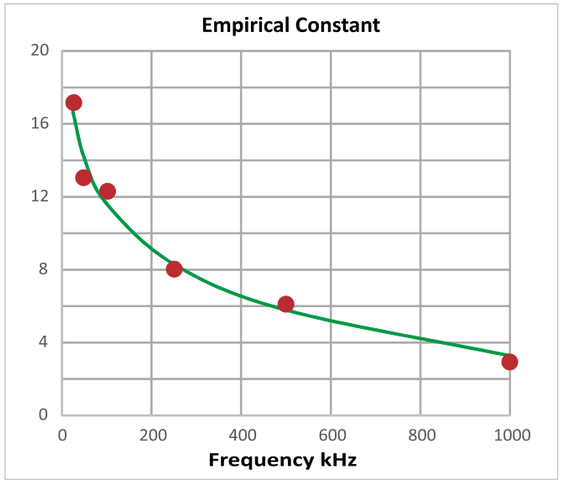


Figure 5: Curve Fitting Used to Find the Constant for R Material in the Ridley-Nace Formula

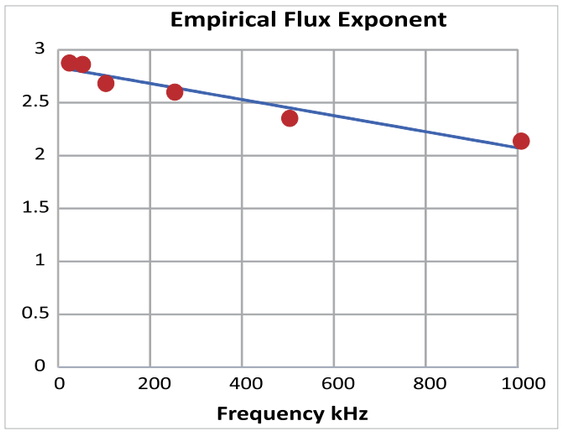


Figure 6: Curve Fitting Used to Find Flux Exponent for R Material in Ridley-Nace Formula

Again, there are a couple of frequency points that seem to be outliers, and verification of the data would help improve the approximation to the measurements.

The curve-fitting processes shown in **Figures 5 and 6** can be done for any set of data for core loss. This has been done for many of the popular core materials, and the results have been incorporated into the program POWER 4-5-6.

Looking forward

An improved form of the Steinmetz equation has been given for the R material ferrite. This new equation has a frequency-dependent constant, and a frequency-dependent exponent for the flux. Having a single expression for the core loss is tremendously useful for working with design programs and spreadsheets. As we will see in the next part of this article, it is invaluable for estimating the change in losses when non-sinusoidal waveforms with different duty cycles are encountered.

www.ridleyengineering.com

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2. Power supply design articles http://www.ridleyengineering.com/design-center.html

3. Join our LinkedIn group titled "Power Supply Design Center". Noncommercial site with over 5600 helpful members with lots of theoretical and practical experience. https://www.linkedin.com/groups?&gid=4860717

4. See our videos on power supply design at http://www.youtube.com/channel/UC4fShOOg9sg_SIaLAeVq19Q

5. Power supply design workshops including magnetics design http://www.ridleyengineering.com/workshops.html

Powering safety gear in demanding apps

Industrial power is a fascinating world, especially when designing customized solutions combining multiple disciplines

By: Patrick Le Fèvre, Powerbox

Industrial power is a fascinating world, full of amazing projects requiring from designers a large range of competences as well as a tight intimacy with customers and related industries. Powering safety equipment in gas, oil and hazardous substances is a very good example of an area where power designers have to combine knowledge of power, safety and regulation, software, and a full understanding of the application area and connected devices. Let's dive into the amazing world of Industrial Power to understand the connections between the electrons, the gas, oil and hazardous substances that make our world better and safer.

Facing challenges

The production, transportation and distribution of gas, oil, and hazardous substances require high levels of monitoring, guaranteeing safety and environmental protection at every step. It is critical to prevent any leakage, and if that happens, to detect and report faults without delay, requiring that sensors, monitoring station, communication, and other connected devices are powered with stable "always available power."

That might sound obvious but considering the entire chain, from production to distribution; the quality of power delivered from grid and micro-grid is not always optimum, which could compromise safety. That's why a very specific type of power solution including local energy storage, power monitoring and communication towards the host system and site-manager is a must.

We will come back to the power solution in detail, but challenges facing demanding industries include the aging of installed equipment, some are in operation for more than 20 years, powered by linear power sources with low efficiency and backup batteries, not dynamically monitored, and having as consequence to request, for safety reasons, preventive battery replacement on calendar basis.

At the very least there are cost implications for operators, as well an environmental impacts, if we consider the low efficiency of the power supply and the recycling of batteries that could be in a perfect condition; reducing energy consumption and battery life-time motivated companies to upgrade the installed base of power supplies with higher efficiency power sources, battery monitoring and real-time based communication between the power unit and the supervising center.

Site modernization is an important process; but, in the case of the gas industry, not enough to reach the objectives fixed by the different governments to reduce methane emissions that may result from gas leakage throughout the overall process, as reported by the Clean Air Task Force [**see Figure 1**].

In the U.S.A, the White House published the Climate Action Plan "Strategy to reduce methane emissions" in March 2014. This document covers a large range of areas where methane emissions must be reduced; from agriculture, to oil and natural gas sector, highlighting the

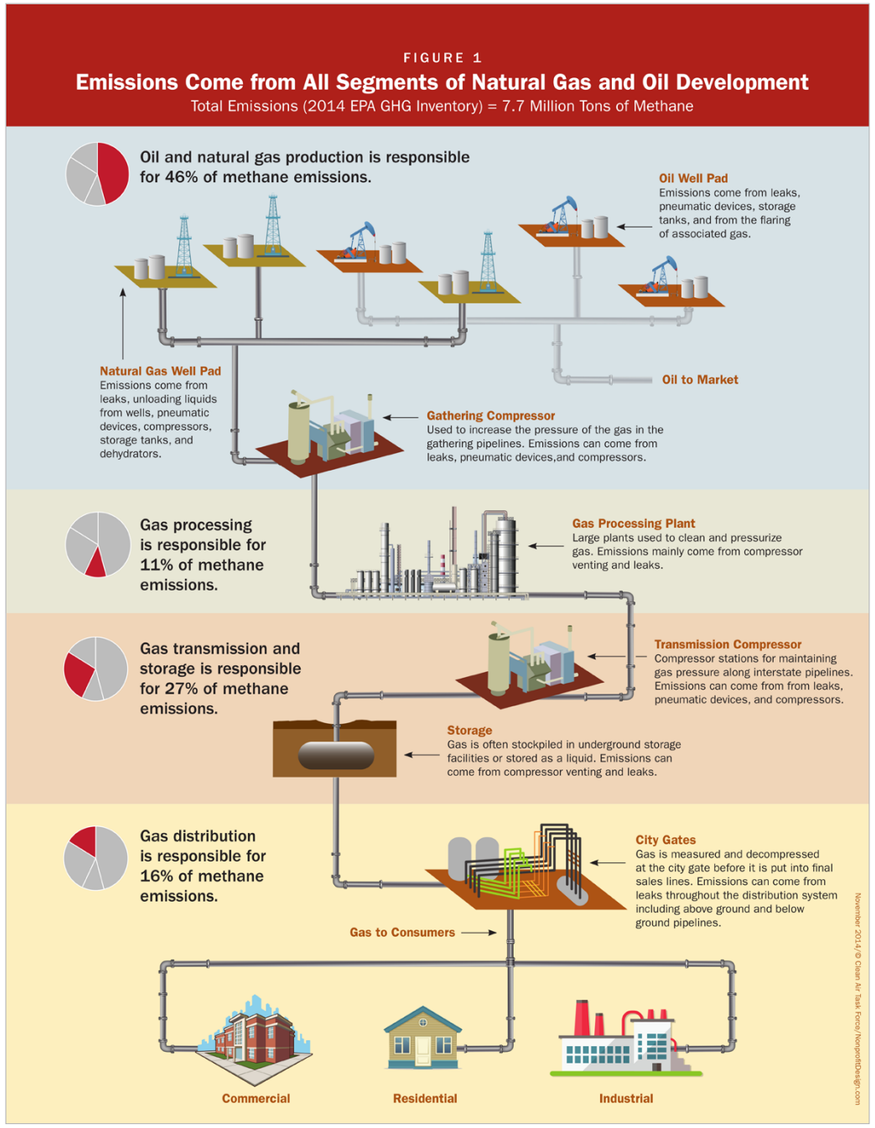


Figure 1: Oil and Natural Gas emissions throughout the overall process (Source Clean Air Task Force)

need to improve measurement methods (e.g. by developing new measurement technologies, including lower-cost emissions sensing equipment) and for operators to initiate activities to reduce gas leakage throughout the overall process.

The modernization process is very well aligned with the requirement but considering the scale of the overall chain [see Figure 1] additional measuring stations will be required to detect early leakage triggering action to repair as soon as detected. In that industry, time matters and the sooner a default identified, the lower the environmental impact; and for that reliable power sources are mandatory! What is the best power solution for serving gas, oil, and hazardous substances leakage-detection?

Safety and regulations

Many applications are using uninterruptable power supplies (UPS); though considering the nature of the industry segment, and potentially explosive environments, power designers have to consider a number of technical parameters, including specific legislations and regulations related to countries the final equipment is installed.

Gas detection is very much connected to business segment 'Fire Alarms' and, from the early days, power solutions designed for those types of applications have had to follow safety standards related to that segment.

In Europe, the EN 54 Fire detection and fire alarm systems is a mandatory standard that specifies requirements and laboratory tests for every component of fire detection and fire alarm systems, allowing free movement of construction products between countries of the European Union market.

The part 4 (Power supply equipment - EN54-4:2007) specifies requirements, methods of test and performance criteria for power supply equipment of fire detection and fire alarm systems. Included in the standard are functionality tests, electrical and mechanical design requirements, as well environmental tests such as cold, vibration, impact, damp heat, and electromagnetic compatibility.

In the USA, the product must comply with the National Fire Protection Association standard NFPA 72-2010 and to the FM



Figure 2: FM certification mark

Approvals - standard for fire alarm signaling systems – class 3010 (FM3010). When certified equipment are stamped with a specific certification logo [see **Figure 2**].



Figure 4: Powerbox PBUKW6004 AC/DC Power solution for monitoring critical industrial applications.

In other countries, additional standards may apply, which in close cooperation with equipment manufacturers, power designers have to consider at the early stages of the product development, e.g. in UK, the BRE Global Loss Prevention Certification Board



Figure 3: BRE Global Loss Prevention Certification Board logo

(LPCB) verify and certify products operating in Fire Safety, stamped by the LPCB logo [**see Figure 3**].

Power supply – battery and monitoring and communication in focus

Standard power supplies powering Fire Alarms are usually dimensioned for small systems requiring limited current, 1.5A to 5.5A at 24V output. That is enough to power fire detectors, sensors and monitoring equipment but not sufficient for larger systems such as the ones deployed in the gas, oil and hazardous substance industry; especially when upgrading legacy systems.

This is where custom power solutions are considered by equipment manufacturers, requiring more power, higher battery capacity, and extra features such as advanced monitoring and communication [**see Figure 4**].

Power Supply - High power EN54-4 power solutions are supporting high capacity lead acid batteries; in this example up to 200Ah. High capacity batteries are requiring special attention on the way the power is balanced between the

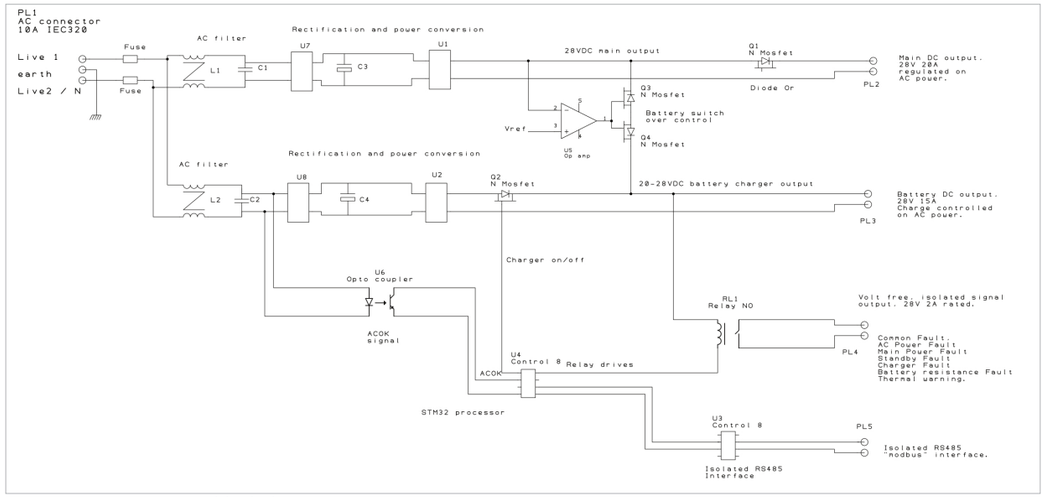


Figure 5: PBUKW6004 block diagram

system bus voltage and battery charging.

The most optimized solution is to build a power system that includes two independent power supplies; the first one (28V/20A) to power the applications (e.g. infrared cameras) and the second (28V/15A) to charge the batteries as its main purpose [**see Figure 5**].

Enclosed in an IP30 case, the power supplies and supervising circuitries require special attention on layout, to optimize free air convection, which is the case in the vast majority of applications. Thermally controlled fans can always be added for high temperature environments but designers have to develop the product based upon free air convection, dimensioning components and thermal management for such conditions. Conduction cooling is the rule, and technology such as passive heat-pipes are often considered.

Battery and Monitoring - As we mentioned earlier in the article, the reliability of EN54-4 power sources, supplying voltage to strategic applications and securing power to vital functions, in case of AC disruption, has no compromise. We used to say "Failure is not an option and battery integrity a must." That's where battery monitoring becomes a science, making the overall power system highly reliable.
Different methods exist to test battery integrity/capacity:
Full load test - For this test a constant current is drawn from the battery for an extended period of time (typically 20 hours). Measurements of current and voltage are taken periodically from which the capacity of the battery can be calculated.

Reduced load or Maintenance load test - Similar to the full load test, except that the period is reduced (usually performed by operating the system on battery for a shorter period of time than for a full load test).

Momentary load or Pulse load – The test meter loads the battery with a pulsed or momentary series of loads. The duration and repetition of the load test cycle varies depending on the battery type and size.

Battery voltage reading - Typically the voltage of the battery is measured and compared to the optimal value expected; a small variation to this test is to allow a current to be drawn from the battery for a period of time to eliminate the surface charge.

Each method has advantages and disadvantages and the best method is a combination of all. Considering the application and environment, system power designers have developed complex algorithms (part of companies' secrets), integrating battery specific parameters, in-situ operating conditions and predictive failure simulation, based on calculation and field data.

As the Fire Industry Association presented in "FIA Guidance Testing of lead acid batteries used in Fire Detection & Alarm System Power Supplies," one of the most critical parts in this process is the calibration.

As the battery ages, chemical degradation causes reduction in the battery's maximum chemical capacity, limiting performance and risk of failure. Defining the point when an alarm signal should be generated to request maintenance is very important and that can only be done with detailed battery knowledge.

In a perfect world, a calibration profile should belong to the battery, but unfortunately that is not always the case. Currently the technical information available is not good enough for demanding applications, requiring power manufacturers to build their own databases, which are then integrated into the algorithms.

Calibration requires a large amount of data to establish the performance profile of the battery. That data are is based upon voltage at the cells under different conditions of load and temperature, the internal resistance (measured value from a large population), the dynamic behavior under load transient and few more part of the magic receipt.

When in operation, the EN54-4 power system permanently monitors the 'State of Charge' (Remaining battery capacity / Full charge capacity), the 'State of Health' (Full charge capacity / battery design capacity) and other parameters defined during the design process. In the case of the product presented as example, the PBUKW6004 tests the internal resistance and other parameters every 3 minutes with 10 cycles. The data is then compared with the calibration table and, if a deviation identified, the fault reported via the communication bus, as well as being communicated via a local LED on the front panel.

Communication – Power supplies used in Fire Detection & Alarm System are usually not embedding communication interface. When a default detected, a LED is lit on the front of the power unit and a relay (e.g. open collector transistor) switched to trigger an alarm.

In the case of gas leakage control, equipment could be deployed in remote areas or limited access during site operation. It is very important for the System Supervisor to know the state of each station in real time, requiring the power supply to communicate information to host/supervisor.

Adding an Internet RS-485 with Modbus protocol to the power unit makes it possible for the System Supervisor to tightly monitor the health of each individual site and the state of the batteries and, from data collected, to initiate technical maintenance when necessary.

Information collected through the communication bus is not limited to the battery, it could also include other useful information such as temperature, bus voltage condition and load condition, adding important information when monitoring safety in such operation.

The way forward
Powering demanding applications such as gas leakage monitoring is very interesting and new technologies such as low power consumption sensors will require power designers to explore new territories in future, which is very exciting.

In the semiconductors domain, Gallium Nitride, Silicon Carbide or Gallium Arsenide are opening a full range of new applications and, as listed in the White House report under "Improving Methane Measurement" - developing new measurement technologies, including lower-cost emissions sensing equipment, an invitation to Power Designers to investigate harvesting energy.

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Choosing the correct capacitor

It is important to have the right device to protect the things that are important and valuable to us

By: Pierre Lohrber, Würth Elektronik

A good insurance plan is not just good to know about, in many aspects of daily life it is indispensable. In the case of Class X and Class Y capacitors, they are required to function reliably in all parts of mains-connected electrical devices, as they offer a form of insurance — we expect them to protect things that are important and valuable to us. X capacitors protect the electrical device itself, whereas Y capacitors protect the user by capturing smaller, still acceptable stray currents in case of malfunction.

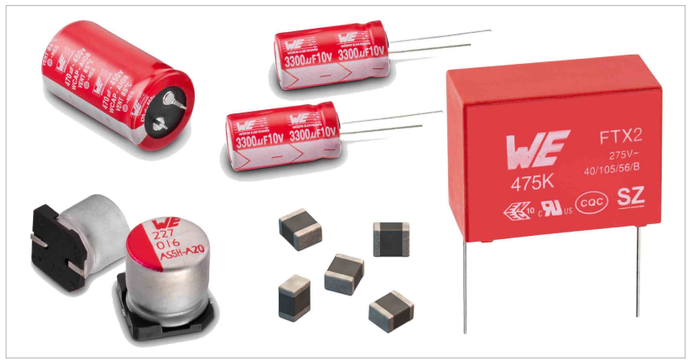


Figure 1: X and Y capacitors for reliable circuit protection are available on the market in different configurations (SMD, THD) and designs

Going broke saving money

False economies here can leave a lasting impression. On average, these components are required to reliably filter over 1,000 noise spikes from the mains per year. Cheaply made capacitors with unevenly metallized plastic film, inadequate safety gaps or weak pin contact on the Schoop layer, to name just a few potential issues, can sharply reduce the component's service life, not to mention being a major safety risk that could start a fire in the event of failure. X and Y capacitors for reliable circuit protection are available on the market in different configurations (SMD, THD) and designs. Look for official certification under applicable standards by VDE/TÜV and UL to ensure the safety of your application (see **Figure 1**).

Dealing with stress and impact

Multilayer ceramic capacitors (MLCCs) generally possess a highly-limited resistance to mechanical stress. When mechanical stress occurs, MLCCs are often the weakest link in the chain of susceptible components in your application. In addition, capacitors are at risk from drops, and not only in mobile devices. Even in production, poorly laid out design specifications, with ceramic elements placed too close to broken or cut edges of circuit boards or fasteners, can lead to damaged components. As circuits grow ever smaller, developers often find themselves shaving the mechanical safety tolerances of their designs ever closer. The result is cracks in the ceramic body of the MLCC at the solder point. If these flaws are not detected in final electrical testing (ICT), since mechanical stresses can create an intermittent electrical contact, discovering a sporadic failure can require painstaking and costly troubleshooting.

Because multilayer ceramic capacitors are susceptible to mechanical stresses, manufacturers offer various solutions that can significantly improve their durability and help minimize the risk of a short circuit and its consequences (see **Figure 2**). One such option is introducing a polymer layer between the ceramic body and the MLCC's terminals, which can multiply the component's robustness against mechanical stresses by a large factor. Because of their more complex construction, capacitors like these are at a cost disadvantage compared to conventional components, but in many cases this is more than offset by their safety advantages.



Figure 2: Manufacturers offer various solutions that can significantly improve system durability and help minimize risk

Other mechanical solutions include "open mode" and "floating electrode" MLCC designs. Where the solution described above is designed to prevent mechanical damage to the capacitor, construction modifications in the latter types are designed to prevent a short circuit in case of failure. In open-mode capacitors, the internal active area is decreased so that a crack does not result in a direct short circuit between layers. Floating electrode capacitors use a serial circuit configuration as already successfully implemented in film capacitors. A break at one of the MLCC's contact points results only in a local short there.

The requirements for components in various types of high-frequency signal transmission processes are particularly stringent. One of the most important criteria here is minimizing the MLCC's parasitic inductance, which in turn raises the component's resonant frequency. One very effective design modification of this sort is offered by reverse-geometry capacitors (RGCs), i.e. MLCCs whose terminals are placed on the long rather than the short side of the component. This achieves a sharp reduction in the length of the signal path through the capacitor, and thus significantly lowers inductive behavior. In addition to keeping the MLCC's terminals as short as possible in the circuit board design, this component geometry makes it possible to reduce the capacitor's inductance by over 50%.

Aging

Despite all their advantages, both technical and economic, ceramic capacitors also have various disadvantages. It is essential to keep these in mind in circuit design so that the initial advantages are not transformed into disadvantages that may be difficult to overcome. MLCCs are theoretically available in four classes, of which only classes 1 to 3 are relevant in practice. There are major technical differences among them.

Aging behavior is one, if not the essential factor influencing the choice of component. Only those MLCCs categorized in Class 1 and designated NP0 or C0G show practically no aging behavior. The smallest tolerances (<1 percent or 0.1 pF) and the lack of voltage-dependent change in capacitance offer the greatest available precision during the whole application lifetime.

It is crucial for developers to keep this point in mind: by comparison, the ceramics used in Class 2, most commonly X5R and X7R, can display a significant drop in capacitance (greater than 30%) after only 1,000 hours of operation. Similar behavior occurs when Class 2 ceramics are operated at higher than half of the designated rated voltage.

Aluminum electrolytic capacitors, heat, and stress

Conventional aluminum electrolytic capacitors are filled during the manufacturing process with a liquid electrolyte that actually needed to ensure the flow of electrons during operation. This fact is a key factor in the aging



Figure 3: The appeal of aluminum polymer capacitors on the market has been growing steadily for the past several years

process as such and in the actual performance of these components. If manufacturing process reliability in combination with the materials used have a decisive impact on the quality of the capacitor, the circuit design has at least a great effect on the durability of the application.

A compromise is often required between keeping the connection of the electrolytic capacitor short, especially in the power element of a circuit, and the waste heat produced there, which accelerates the component's aging. Aluminum electrolytic capacitors placed too close to a heat sink in a power supply or heat flow from a fan can age extremely rapidly in relation to other components. Not only does the evaporation of the electrolyte (and the resulting drastic loss of capacitance) practically guarantee a failure, the now-dry capacitor is a significant safety risk and may even disintegrate explosively.

Aluminum electrolytic capacitors can attain large volumes due to the size of the capacitance value required. Those with a snap-in design have highly durable solder connections. Often the bent contacts are not only required to withstand large amounts of energy, but also to connect the capacitor reliably to the circuit board. The mass of these components can range from a few grams to far over 100 grams.

Depending on the variant and application, capacitors can be protected from vibrations and other mechanical stresses by attaching additional dummy contacts in addition to the two solder contacts between the capacitor and the board. These give the component greatly enhanced stability against vibrations. Despite this enhanced safety, the capacitor should not be used as a brace for fitted components, as the tensile forces through the connector pins act directly on the aluminum foil of the component, where they can cause microscopic damage and a sharply reduced service life.

An alternative: aluminum-polymer capacitors

The circuit engineering requirements for passive components are becoming ever more demanding. For high-capacitance aluminum capacitors in particular, the key factor is the call for ever-lower ESR values, and the associated ripple current rating (see **Figure 3**).

While choices were few when these components first reached the market, especially for voltages below 25 V, the range of available options on the market has been growing rapidly. Development has moved in several different directions, with SMD and THD configurations available.

The evolution of ESR values is tending towards a few milliohm (≤10 mΩ), while in wired components voltages of up to 100 V are already available in series production. There is a strong push in aluminum polymer capacitor development. Once used more in consumer products, these components will increasingly make their way into industrial applications as well.

In the future, conventional aluminum electrolytic capacitors with an added wet electrolyte will see increasing competition from dry aluminum polymer capacitors. The main difference between them is also what is responsible for the aluminum-polymer capacitor's significantly longer service life.

Where the wet electrolyte in the traditional type tends to dry out over time, leading to an increased risk of failure, solid polymer capacitors can last up to ten times as long. Due to their design these components have very low ESR values, resulting in very low intrinsic heat generation in combination with the ripple current impinging on the circuit.

Conventional aluminum electrolytic capacitors also have advantages when compared to polymer capacitors. Whereas voltages of up to 600 V are currently technically possible with the electrolytic type, aluminum polymer capacitors are only available on the market in series production up to 100 V. Aluminum electrolytic capacitors also offer smaller leakage currents and lower prices than aluminum polymer capacitors, although the price difference is reversed when the latter's much longer expected service life is considered.



Figure 4: Proper testing can be a highly effective procedure for determining the quality of construction and materials used in film capacitors

Moisture-proof foil capacitors

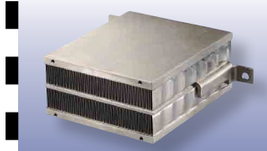
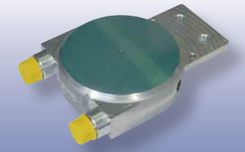
Metallized film capacitors, in which the charge is stored in a metal layer applied to a plastic film as a winding element or in a layered structure, are significantly influenced by two physical measures. Temperature and moisture represent major challenges for capacitors of this type.

Along with numerous variants, the so-called "85/85 test", in which a component is tested for up to 1000 hours at a temperature of 85°C and relative humidity of 85%, can be a highly effective procedure for determining the quality of construction and materials used (see **Figure 4**). If the seal is insufficiently resistant to temperature fluctuations, moisture can penetrate the capacitor more quickly, leading to a chain reaction in which the insulation resistance declines, voltage spikes damage the metallization and a high influx of energy ultimately destroys the component altogether.

Moisture-resistant (or THB, for "thermal humidity bias") film capacitors are available on the market, although their modified design and the special materials used generally put them at a price disadvantage compared to standard versions. The higher price is only a disadvantage at first glance, however, as it is outweighed over the long term by performance gains.

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Creating a better travel adapter

A simpler approach to designing for higher power density in a small form-factor

By: Scott Brown, Dialog Semiconductor

Travel adapters step down the input line voltage (90Vac to 265Vac) to a usable voltage for portable devices. The most cost-effective off-line conversion topology for this is a simple, non-synchronous flyback converter, which provides high enough efficiency to meet current international power supply regulations.

New, higher power travel adapters designed to charge high capacity batteries using the same non-synchronous flyback converter topology will dissipate a significantly higher amount of heat resulting in unacceptably high case temperatures. Also, as the minimum efficiency required by international external power supply regulations increases, the non-synchronous approach reaches a practical limit where it may no longer be able to hit the minimum efficiency targets.

The typical 10W (5V, 2A) output power travel adapter currently on the market complies with power supply regulations by maintaining an average efficiency of approximately 75-80%, while dissipating 2-2.5W under peak loading conditions.

The adapter definitely gets hot, but remains manageable and the non-synchronous flyback used in these adapters works fine. At 15W power levels, the same 80% efficiency causes 50% more power loss and significantly higher adapter case temperatures. And, the new standards taking effect in 2016 will require minimum efficiencies >84%, a very difficult target for standard flyback converters.

Changing to a synchronous rectification topology on the secondary side can improve the efficiency beyond the minimum required levels and keep the travel adapter case temperature to a manageable level. Secondary-side synchronous rectification requires some considerations to minimize the number of external components needed.

Analyzing power loss

To illustrate this better, a quick analysis of power loss by both a low forward voltage drop diode vs that of a synchronous rectifier (SR) MOSFET clearly shows the differences. The losses in the non-synchronous case are relatively clear. The forward voltage of the diode and the average current through the diode set the majority of the loss in the non-synchronous approach, while the losses in the MOSFET of the synchronous approach are more complex.

Figure 1 shows the difference between the power loss in a non-synchronous rectifying diode and a synchronous rectifying MOSFET. The sum of conduction losses, gate drive losses, body diode losses and switching losses creates the total power loss when using a synchronous FET. Conduction loss depends upon the on-resistance of the synchronous FET, gate drive losses are mostly dependent upon the parasitic characteristics of the FET and switching frequency, and switching losses depend upon a combination of various factors, but most importantly the amount of time it takes to transition the MOSFET from on to off.

Finally, there is a body diode (BD) term that has two loss terms in a DCM topology. The first is a measure of the current that flows through the body diode of the synchronous FET during the time between when the primary-side FET turns off and current begins to flow in the secondary

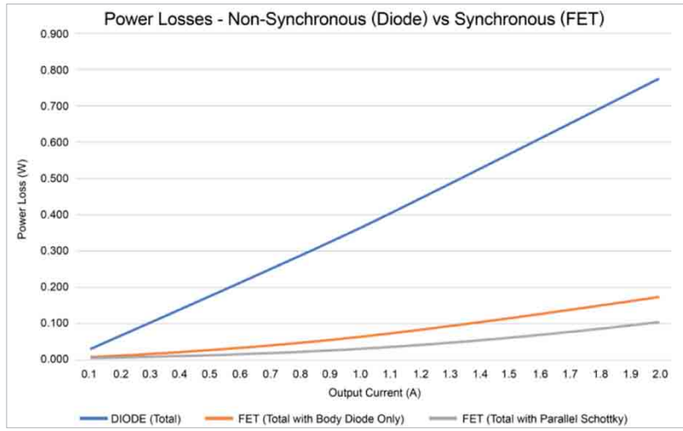


Figure 1: Power loss of diode vs. secondary-side MOSFET

of the transformer prior to the SR FET enabling. The second is the measure of time when the secondary-side synchronous rectifier controller disables the SR FET and the current in the secondary discharges to zero.

This dead-time in some implementations can be a significant amount of power. Typical secondary-side converters that are self-driven (no direct control from the primary) depend upon simple control techniques and the characteristics of the SR FET to determine when to disable the SR FET and often disable the secondary-side FET prematurely. During that dead-time, the output current continues to flow, but through the body diode of the MOSFET instead of the MOSFET itself. The forward voltage of a body diode is much higher than that of even a standard diode, on the order of 1V.

With the secondary current flowing through that body diode, even for a limited amount of time per cycle, the loss term adds up to a significant amount of power. The most common way to resolve this issue is to use a parallel Schottky diode across the SR MOSFET to reduce the forward voltage drop during this dead time and therefore reducing the power loss.

Figure 1 shows a comparison of power loss between the non-synchronous and synchronous approach. There are two power loss curves for the synchronous case, one using the body diode of the synchronous MOSFET with a standard timing scheme and the second using a parallel Schottky diode. The power savings is evident, but this has the obvious implications of adding size and cost to the design.

An alternative approach uses intelligent digital control to monitor the voltages on the drain and source of the secondary-side synchronous MOSFET to control the turn-off of the synchronous FET and disable the FET leaving a minimum amount of dead-time to minimize loss in the body diode. For example, the iW671 secondary-side synchronous rectifier controller from Dialog Semiconductor integrates a digital adaptive turn-off control circuit that closely monitors the drain-source voltage of the MOSFET and, as it approaches a threshold that determines when to disable the synchronous MOSFET, it disables the FET and makes sure that the MOSFET stays off, even during potential high voltage ringing on the FET.

This adaptive turn-off control limits the dead-time to as low as 50ns, eliminating the need for a parallel Schottky diode across the MOSFET, maintaining the benefits of high efficiency while minimizing cost and size. The adaptive nature of this technology allows it to work with varying types of MOSFETs, eliminating the need to optimize the FET selection to reduce the power loss through the body diode. **Figure 2** shows how the power loss term of the secondary-side MOSFET using the iW671 emulates the use of a parallel Schottky diode by minimizing the body diode loss, without the added cost and size of adding the component.

Operation at low voltages

An important advantage of the digital technology in the iW671 is the ability to operate correctly

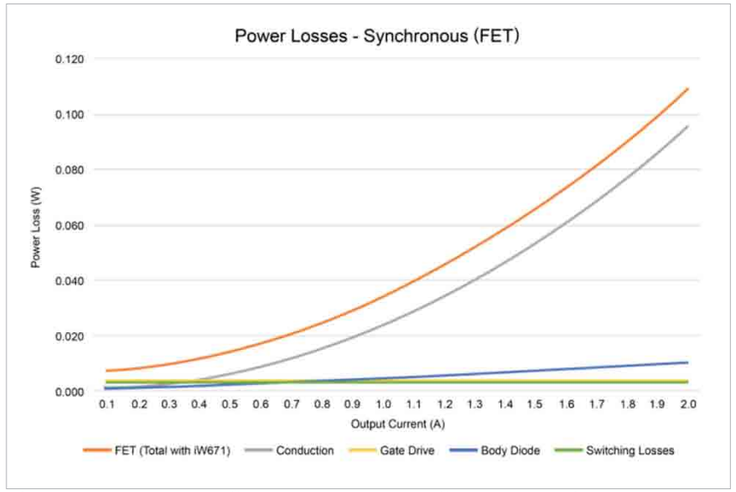


Figure 2: Breakdown of Power Loss Terms of Secondary-Side Synchronous MOSFET

down to low voltages, important in constant-voltage, constant-current travel adapters. Most secondary-side control circuits derive their power supply from the output of the converter and therefore only work down to a fairly high voltage, limiting the effectiveness of the converter in charging applications such as travel adapters.

The iW671 integrates a pulse linear regulator circuit that allows the device to power itself directly from the unrectified output of the secondary, peak detecting the voltage and enabling the SR circuit to work correctly down to an output voltage as low as 2V. This feature enables proper operation in CC-CV travel adapter circuits without the need for any additional components.

Using the iW671 SR control IC, designers can create travel adapters with efficiency approaching 90%.

This Quick Charge Class A design provides three different output voltages, 5V, 9V and 12V at up to 15W output power,

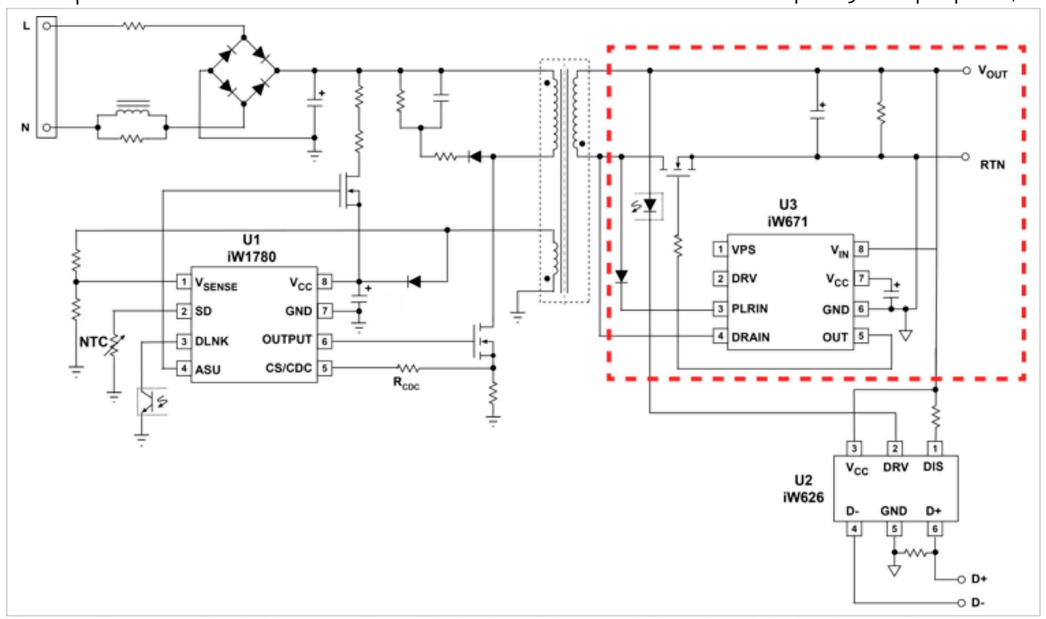


Figure 3: Qualcomm Quick Charge 2.0 Class A Technology Adapter with Secondary-Side Synchronous Rectification

with an average efficiency of 81% at the 5V output voltage setting. By adding the iW671 secondary-side synchronous rectifier control (**Figure 3**), the average efficiency at 5V increases to 86%, a 5% increase over the non-synchronous approach.

There is a clear improvement in efficiency, sufficient to enable compliance with the DoE level VI external power supply regulation and the EU Code of Conduct version 5, tier 2 voluntary standard, both of which take effect in 2016. By increasing efficiency, thermal management becomes easier as less heat is generated. Assuming the physical size of the adapter is approximately the same, the 86% efficiency solution will have a lower case temperature and maintain lower temperatures on key components.

Representative units tested under real-world operating conditions show an 8°C reduction in case temperature from the circuit in figure 4 compared to figure 5 simply by changing to the synchronous approach. The peak temperature difference measured on key components on the board is as high as 12°C, a significant reduction in temperature from a small improvement in efficiency.

The use of intelligent digital synchronous rectification on the secondary of flyback converters in adapters for charging portable electronics enables power supply regulation-compliant solutions with lower case temperatures. All of this while maintaining the minimum BOM cost and adapter case size by eliminating the need for a secondary-side parallel Schottky diode.

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Evolving eGaN FETs for power electronics

Key changes have come to pass that can change the way we use GaN devices

By: Johan Strydom, Efficient Power Conversion

When I started working with eGaN FETs almost six years ago, I had no idea what to expect from this technology. We had our first preliminary datasheet and even though I had no idea what to expect, it was obvious that, on paper, these devices were much better than your typical MOSFETs – already beyond the theoretical silicon limit.

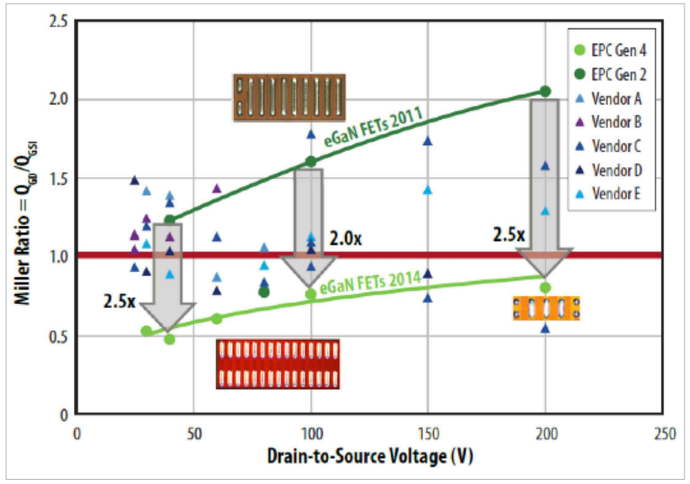


Figure 1: Miller Ratio (QGD / QGS1) comparison between current and initial eGaN FETs relative to state-of-the-art MOSFETs

Since then, many improvements have been made to both the devices and to the overall structure of the power conversion stage of which they make such an integral part. This article will discuss some of the key changes that have come to pass, as well as the impact they have had on the way we use GaN devices and applications that have been enabled through their existence.

From a simple beginning

EPC's very first part, the EPC1001, was an enhancement-mode GaN FET. It was a 7 mOhm (max), 100 V device that exemplified the strategy of developing products that looked and behaved just like enhancement-mode power MOSFETs. The choice of using a wafer level chip-scale package (WLCSP) came just as much out of necessity, as it did out of realizing the limitations that packaging has on device performance. Having a high voltage lateral device allowed all three terminals of the FET to be directly connected to the PCB, thus removing the need for two-sided packaging that not only increases a device's parasitic inductance, but increases the overall cost and thermal impedance as well.

Device improvement

The initial offering of the device was in two sizes and spanned a voltage range from 40 V to 200 V. Over the next five years, a large number of device improvements have been made. The first major course of action, improving the Miller charge ratio (QGD/QGS1) to below one, was achieved on the ultra-high frequency EPC8000 series products and has been maintained for all subsequent parts, as shown in **Figure 1**. This achievement is significant, as a ratio of less than one for the Miller charge ratio will guarantee theoretical dv/dt immunity [6]. The products in the EPC8000 series also have a pad layout with a separate gate-return connection that minimizes the common source inductance. These products are ideally suited for multi-megahertz hard-switching operation.

The next major improvement was the creation of our fourth generation parts that resulted in a significant increase in maximum die size as shown in **Figure 2**. These products also extended the voltage range down to 30V, with a 1 mOhm (typical) on-resistance. At the same time, the new footprint of these devices was created with a 'slot' along the center of the die, which allowed for the placement of PCB vias directly under the die. This location minimizes the impact of PCB busing. As shown in **Figure 3**, the improvements in Miller ratio translated into improved Figures of Merit (FOMs) for these devices.

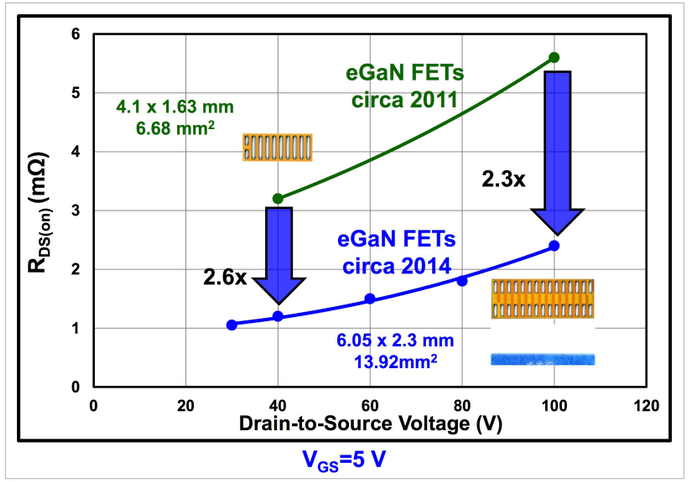


Figure 2: Minimum on-resistance (RDS(on)) vs. maximum drain-to-source voltage improvement over time

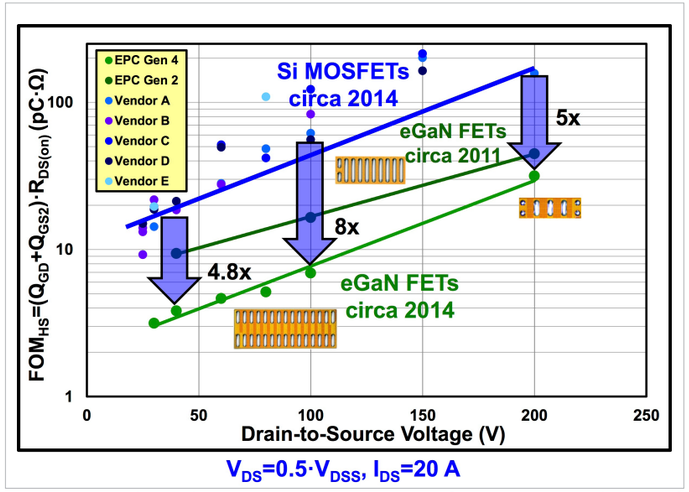


Figure 3: Hard-switching FOMHS comparison of eGaN FETs and state-of-the-art Si MOSFETs showing improvement over time

Probably the most important development that followed these improvements was the monolithic integration of multiple devices capable of voltage isolation between them. The flagship product, the EPC2100, allowed the creation of devices with high aspect ratios, which are not practical as discrete devices (see **Figure 4**). This not only lowered overall power-loop inductance to below 200 pH, but improved thermal performance of the smaller device with the addition of a lateral thermal path through the larger and cooler neighboring device. Considered the world's fastest power switches, they are capable of switching 12V at 20A with voltage rise times under 700ps.

Following the introduction of these products, further levels of integration, up to three devices,

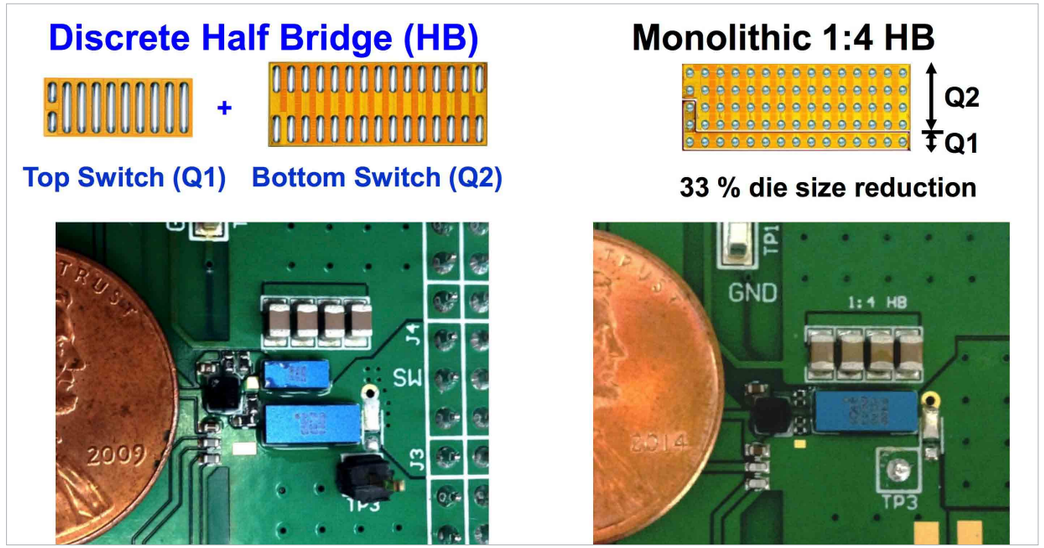


Figure 4: Implementation of eGaN FET-based half bridges with discrete transistors (left) and an integrated monolithic GaN IC (right)

and expansion into higher voltage up to 450 V, have been made. Most recently, overall advances in device performance have allowed the creation of wider-pitch connection parts. These products are coined 'Relaxed Pitch' and have a 1 mm pitch between pins that are suitable for high copper ounce thickness PCBs. The device developments are only one side of the story; in parallel, a number of key power system changes have been made.

System changes

Although our initial intentions were to develop direct replacements for existing MOSFET devices, it was quickly realized that significant system-level changes would be required to extract the most value out of these new high performance devices. In an effort to share our experience with our customer base to these requirements, we published our first text book, GaN Transistors for Efficient Power Conversion, on how to best use GaN transistors for power conversion.

We continued to share our experience with the publication of a second edition of our textbook. Apart from addressing the gate driver requirements of the eGaN FETs and minimizing common source inductance through layout, the development of a more 'optimum' power loop within the PCB was required. Unlike with traditional MOSFET packages, the parasitic inductance of the PCB dominates the overall loop inductance when using high performance eGaN devices.

A unique characteristic of eGaN FETs is that they do not exhibit any 'body' diode reverse-recovery. This results in the diode reverse recovery of the bootstrap supply diode becoming a bottleneck at multi megahertz switching frequency, which cannot readily be addressed with silicon devices. The solution to this limitation came by using eGaN FETs themselves as synchronously-switched bootstrap diodes. This, in turn, led to the synchronous bootstrap diode being integrated within a monolithic eGaN integrated circuit for high frequency half-bridge applications.

Enabled applications

The multi-pronged approach of developing superior performance power FETs using GaN, while simultaneously reducing the parasitics inherent with both device packaging and PCB, resulted in circuit performance that is unmatched by silicon MOSFETs. The benefit is that a number of key applications are being enabled through the use of eGaN FETs, for example:

LiDAR (Light Detection And Ranging)

The use of LiDAR for spatial mapping is not new, the improved resolution systems make this technology suitable for virtual reality gaming and autonomous vehicles. Both of these applications require the generation of multiple ampere current pulses with durations of only a few nano seconds. GaN offers improvements in both edge rate and peak amplitude, which directly impact LiDAR performance.

Envelope Tracking (ET) for Cellular Base Stations

Modulating the supply voltage of the Radio Frequency Power Amplifier (RFPA) by tracking the RF envelope has been successfully developed for cell phones to improve battery life. Achieving the same for the much higher power and voltage levels of base stations are not possible with silicon, but the potential to reduce an ever-growing information and communications technology (ICT) energy consumption by reducing the RFPA losses by up to two-thirds is vital for addressing global energy consumption. With eGaN FETs, envelope tracking supply efficiencies of over 92% at power levels up to 120 W to 4G LTE bandwidths are now possible.

Wireless power transfer

The drive for wireless power transfer with spatial freedom, such as the standard championed by the Alliance for Wireless Power (Rezence) that requires multi-megahertz switching amplifiers at ever-increasing power levels. The use of eGaN FETs not only enables these higher power levels, but also allows multi-mode compatibility using a single amplifier.

Looking forward

The combination of lower on-resistance, faster switching speeds, lower thermal impedance, and smaller physical size of eGaN FETs continues to raise the bar for power transistor performance. As GaN technology matures, not only does the performance of these transistors rapidly improve, but significant reductions in cost are also realized. Not only will GaN devices continue to enable new applications, they will replace silicon power transistors in cost-sensitive applications as well. As a matter of fact, the first signs of this happening are already here.

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Selecting primary-side MOSFETs for LLC resonant converters

Switch-mode power supplies are operating at ever-higher switching frequencies

By: Wonsuk Choi, Fairchild Semiconductor

Today's industrial applications demand power supplies capable of delivering ever-higher levels of power density. That trend is escalating as regulatory agencies around the world impose new regulations to achieve higher efficiency, not only at full load, but also in standby mode and across the entire load spectrum. To meet these new requirements and maximize power density, power supply designers have turned to switch-mode power supplies operating at ever-higher switching frequencies.

Increases in switching frequency are limited by switching losses, however. To minimize switching loss, power supply designers have adapted soft switching techniques such as zero voltage switching (ZVS) or zero current switching (ZCS) for high switching frequency converters. Increasingly, designers are turning to resonant switching topologies as a solution for efficient switch mode power designs. In particular, LLC resonant half bridge converters are gaining attention.

Unlike conventional resonant converters, an LLC resonant converter gives designers advantages such as:
-Wide output regulation range with a narrow switching frequency range.
-Guaranteed ZVS even at no load.
-Utilization of all essential parasitic elements to achieve ZVS.

For these reasons, LLC resonant half bridge converters have become an essential topology for designers attempting to maximize efficiency and lower profile in industrial power supplies for telecom systems, servers, base stations, battery chargers, and solar inverters.

Solar inverters, where the photovoltaic (PV) needs to use renewable energy with maximum efficiency, are a perfect example for using the LLC resonant half bridge. Generally, for string level distributed MPPT (maximum power point tracking) structures, a transformer-less inverter achieves higher efficiency more easily, but achieving PV module grounding can be difficult; whereas inverters with transformers can achieve PV side grounding more easily, but they may suffer from lower efficiency. For string level distributed MPPT applications, a DC/DC step-up converter connected to a PV string can accomplish MPPT control. As a DC/DC converter, the high efficiency LLC resonant converter is used to interface the PV panel and produce DC link voltage.

Super-junction MOSEFTs

Power supply designers typically use super-junction MOSFETs to implement LLC resonant converters because of their extremely low $R_{DS(ON)}$ and E_{OSS}. Unfortunately, the reverse recovery performance of a super-junction MOSFET's body diode isn't ideal for these applications. However, a new generation of 650V fast recovery super-junction MOSFETs, utilizing charge balanced technology, now offer a more rugged body diode, ultra low on-resistance, low stored energy in output capacitance, E_{OSS}, higher threshold voltage (V_{th}) and fast switching speed.

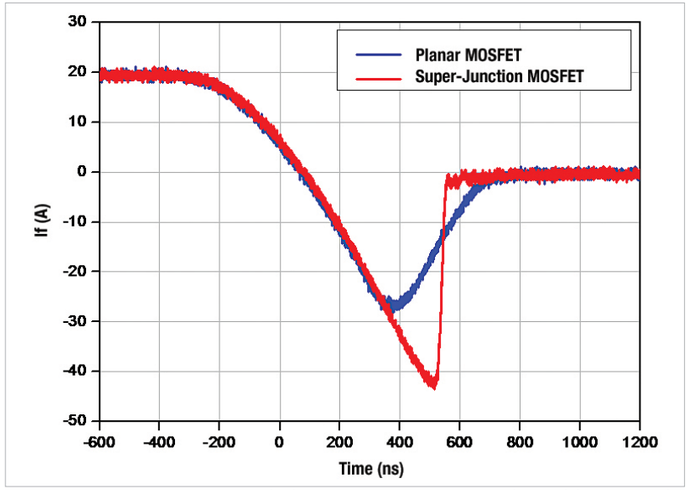


Figure 1: Reverse recovery behavior comparison under Vdd=400V, di/dt=100A/us, Isd=20A

Increases in efficiency and power density are enabled by the continuous development of novel resonant topologies and power devices which allow designers to move to higher switching frequencies at relatively low switching losses. That, in turn, leads to smaller converter dimensions. However, power MOSFET failures have been an issue in LLC resonant topologies.

As shown in **Figure 1**, the reverse recovery of a planar MOSFET is relatively softer than that of a super-junction MOSFET. When all conditions are the same, "snappy" body diodes always produce higher voltage spikes and dv/dt, which can cause device failure. While the soft body diode of a planar MOSFET is suitable for resonant topologies, low $R_{DS(ON)}$ and E_{OSS} are critical for maximizing system efficiency in an LLC resonant converter.

Furthermore, low QRR and robust body diode characteristics play a key role in reliability. Therefore, fast recovery super-junction MOSFETs are better suited than planar MOSFETs because they can effectively minimize the resonant energy required to achieve soft switching, and therefore improve system efficiency and reliability.

Low EOSS in LLC resonant topologies

Output capacitance plays an important role in LLC resonant converters. It determines how much inductance is required to achieve ZVS operations. ZVS is achieved by using the energy stored in the inductor, the leakage inductance or magnetizing inductance of the transformer, to discharge the output capacitance of the switches through resonant action. The inductance should be designed to prevent hard switching that causes additional power losses. The following equations (1) and (2) show ZVS requirements for an LLC resonant converter.

$$\frac{1}{2}\cdot L_{eq}\cdot I_p^2 \geq \frac{1}{2}\cdot 2\cdot C_{OSS(er)}\cdot V_{IN}^2$$

$$\frac{1}{2}\cdot L_{eq}\cdot I_p^2 \geq 2\cdot E_{OSS}$$

Where, $C_{OSS(er)}$ is energy related output capacitance of the high side and low side MOSFETs at V_{IN}, L_{eq} is equivalent inductance.

Magnetizing current must be large enough to discharge the C_{OSS} of the MOSFET during dead time to ensure the ZVS turn-on as shown in equation (3) and (4). Low output capacitance can reduce the need for magnetizing current, less circulating energy, less turn-off loss and less dead time.

$$L_m \leq \frac{t_d\cdot T_0}{16\cdot C_{oss}}$$

The peak magnetizing current (Ip) shows in equation (4)

$$I_p \approx \frac{NV_o}{L_m}\cdot\frac{T_0}{4}$$

Where N is the transformer turns-ratio, V_O is the output voltage, Lm is the magnetizing inductance, t_d is dead time and T_O is the switching period. Turn-off current of the MOSFETs is determined by magnetizing inductance Lm. To achieve

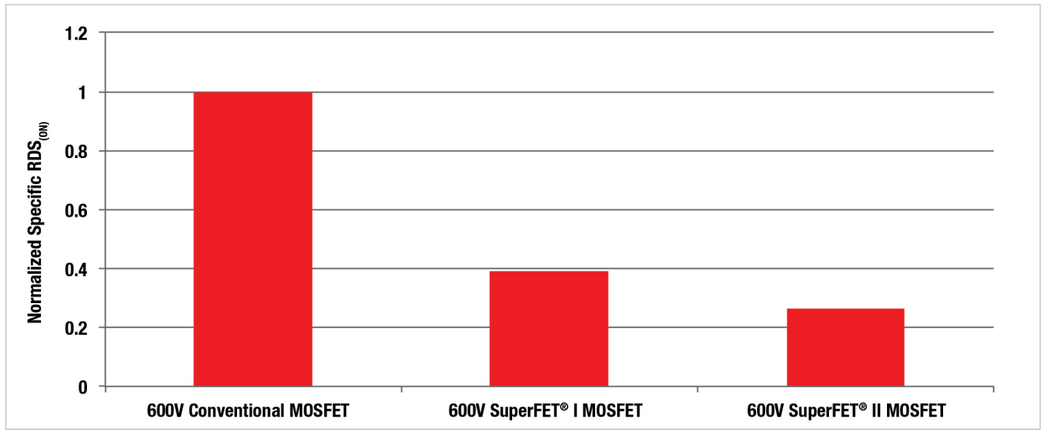


Figure 2: Normalized On-resistance per Specific Area Comparisons

minimum conduction loss and turn-off loss, a large Lm is preferred.

Robust body diode in LLC resonant topologies

The LLC resonant converter requires a device with a rugged-characterized body diode, which experiences hard commutation during start-up or output short conditions. Body diode reverse recovery is the switching process of the body diode from an on state to a reverse blocking state.

When reverse voltage is applied across the body diode, the stored charge should be removed to go back to the blocking state. The removal of the stored charge occurs via two phenomena: the flow of a large reverse current and recombination. This reverse-recovery current flows through the body diode of the MOSFET because the channel is already closed.

This reverse recovery current

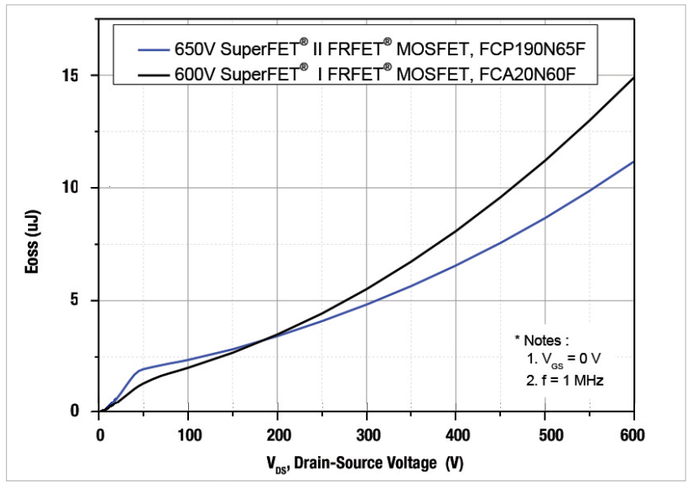


Figure 3: Comparisons of stored energy in output capacitance, EOSS

and displacement current can trigger the parasitic BJT. Once the parasitic BJT turns on, a hot spot is formed and more current crowds occur. More current flows through the parasitic BJT due to its negative temperature coefficient. Finally, the device fails.

In short, body diode conduction should be minimized to lower peak reverse-recovery current. As the di/dt becomes larger, peak reverse-recovery current goes up as well. Therefore, a fast recovery MOSFET can prevent this failure thanks to its robust body diode performance.

One of the more important advances in the reduction of on-resistance in high voltage MOSFET technologies has been the development of charge-balance technology. **Figure 2**

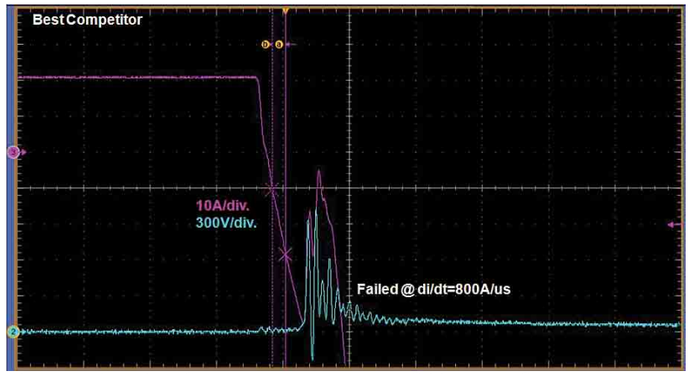


Figure 4: A typical fast recovery MOSFET's failing waveforms during body diode reverse recovery

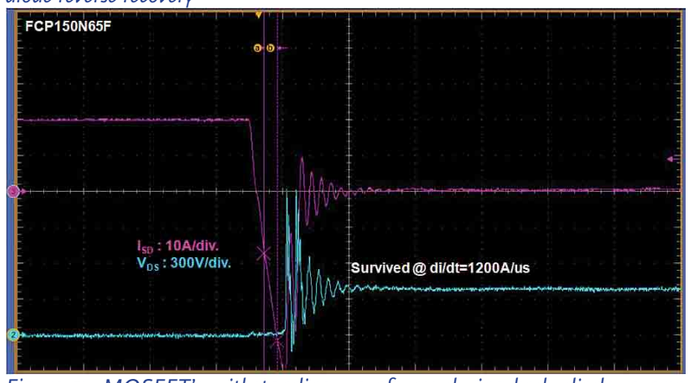


Figure 5: MOSFET's withstanding waveforms during body diode reverse recovery

compares the $R_{DS(ON)}$ of a SuperFET II MOSFET which uses an advanced charge balance technology with previous generation super-junction MOSFETs.

As shown in **Figure 3**, a SuperFET II FRFET MOSFET has approximately 23.3% less stored energy in output capacitance than a SuperFET I FRFET MOSFET at 400V across the MOSFET generated from a typical switching power supply bulk capacitor voltage. SuperFET II FRFET MOSFETs need less resonant energy to achieve soft switching without increasing the circulating energy in an LLC resonant converter compared to the previous generation.

Figure 4 shows a fast recovery MOSFET's failing waveforms during body diode reverse recovery. In this example, the failure occurs right after the current level reaches I_{rrm}, peak reverse recovery current at 800A/us. As shown in **Figure 5**, SuperFET II FRFET MOSFET did not fail at even higher di/dt(1,200A/us) conditions.

In the next chart we compare the efficiency of a SuperFET II FRFET MOSFET, FCH077N65F, 650V / 77mΩ and a comparable

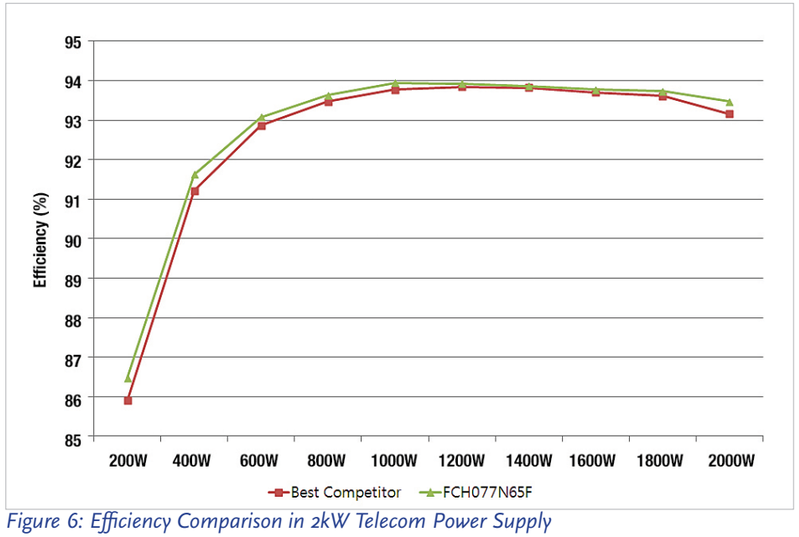


Figure 6: Efficiency Comparison in 2kW Telecom Power Supply

650V / 80mΩ fast recovery SJ MOSFET in a 2kW telecom power supply. The summary of the efficiency measurements is shown in **Figure 6**. Efficiency increases about 0.58% and 0.31% compared to earlier generation MOSFETs at light load and heavy load conditions respectively. The major reason for the boost in efficiency is the reduced switch-off losses and output capacitive loss because of lower Q_g and E_{oss}.

Key capabilities for successful LLC resonant converters

Designers building energy efficient industrial solutions using LLC resonant converters need primary MOSFETs that can deliver the following key capabilities:

-Low RSP to reduce conduction loss and high power density.

-Low COSS and EOSS is to achieve soft switching with less resonant energy to reduce circulating energy.

-Small TRR, QRR, and less snappy body diode to avoid MOSFET failure by hard commutation during abnormal condition.

-Higher threshold voltage to reduce turn-off loss in ZVS operation.

A new generation of high performance MOSFETs promise to meet these requirements. Combining a faster and more rugged intrinsic body diode performance with fast switching, these MOSFETs achieve better reliability and efficiency in a wide range of applications including resonant converters.

By reducing gate charge and stored energy in output capacitance, they boost switching efficiency while reducing driving and output capacitive losses. This new level of performance allows designers to significantly increase system efficiency and reliability, particularly for in-phase shifted full-bridge converters or half-bridge LLC resonant converters under abnormal conditions.

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Balancing lead-acid batteries

Replacing batteries unnecessarily can be a considerable expense

By: Aspiyan Gazder, Linear Technology

Lead-acid batteries are widely used in a broad range of industries and applications. The telecom industry uses a series stack of four lead-acid batteries to provide a 48V stack. Energy storage solutions (ESS) use lead-acid batteries in a variety of series and parallel configurations to store energy generated by renewable sources such as wind and solar.

Series-connected lead-acid batteries find extensive use in the UPS (uninterruptible power supply) industry to provide backup power when the mains power is lost. Golf carts and other industrial electric vehicles are typically powered by a stack of series-connected lead-acid batteries. In all the examples, two or more lead-acid batteries are connected in series. When a single lead-acid battery in the stack fails, all the lead-acid batteries in the series stack need to be replaced to maintain battery stack performance. This is a considerable expense.

Battery variations

When batteries are manufactured, they must conform to tight specifications for parameters such as energy capacity, ESR (effective series resistance), leakage current, and the number of discharge cycles before failure to ensure quality, guarantee a minimum lifetime, and meet various standards. Furthermore, these specifications only apply to a single battery.

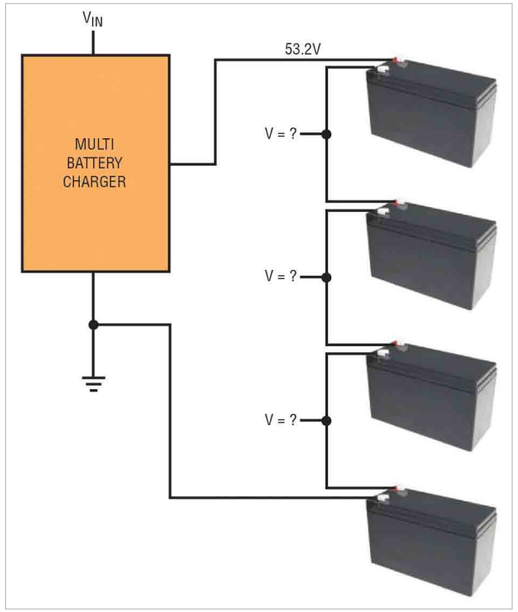


Figure 1: Top of stack voltage is not divided evenly across the batteries in the stack

There are variations in battery specifications due to limitations in the manufacturing process, and when multiple batteries are stacked in series these specifications no longer apply to the battery stack. Batteries connected in series will drift over time due to unequal leakage currents, and capacities of individual batteries may change over time.

Extreme operating conditions and frequent discharge cycles further exacerbate these problems, which eventually cause one of the batteries in the stack to fail. At that point, the entire battery stack is deemed to be bad, and all the batteries in the stack require replacement. Replacing a failed battery itself does not solve the problem, since the replacement battery's characteristics will be very different from the other batteries in the stack, and stack failure would recur. This problem is true for all battery stacks made with batteries of any chemistry, not just lead-acid batteries.

Managing measurements and charge

In most series-connected battery stacks, only the voltage at the top of the stack is measured, and it is assumed the batteries in the stack are matched and hence share charge equally. **Figure 1** depicts a scenario in which the top of the stack voltage is programmed to be 53.2V, but the individual battery voltages are unknown and may not all be 13.6V. Since not all batteries in the stack will share the charge evenly, some of the batteries in the stack might be severely overcharged while one or more of the other batteries in the stack may remain undercharged. Both the overcharging and undercharging of lead-acid batteries will cause battery life degradation.

Overcharging lead-acid batteries causes the electrolyte water to break into oxygen and hydrogen gas, which depletes electrolyte levels in the batteries. This has two effects. The concentration of the sulfuric acid in the electrolyte increases, which is damaging to the battery plates and reduces battery life. Furthermore, since the electrolyte level has dropped, a portion of the plates are now exposed to air, causing plate oxidation and reducing battery capacity. Sealed lead-acid (SLA) and gel batteries are particularly sensitive to overcharging, since any lost water cannot be replaced.

Undercharging lead-acid batteries causes plate sulfation, in which the sulfuric acid reacts with the plates to form lead sulfate crystals. This reduces the ability of the battery to accept a full charge, and undercharging worsens. This leads to premature battery failure.

Balancing the stack

To increase battery stack life, individual batteries in a stack need to be balanced. Conventional wisdom is that overcharging a series stack of lead-acid batteries achieves balancing of the individual batteries in the stack, which in theory helps increase battery life. However, this is a flawed approach.

The only way to ensure that all the batteries in a stack are at the same voltage is by employing a balancing solution in which overcharged batteries shed excessive charge, while undercharged batteries are given extra charge. An efficient battery balancing solution requires a switch network that can be used to move charge from one battery to another to achieve a balanced battery stack. The control circuitry is complex and a discrete implementation is large and costly.

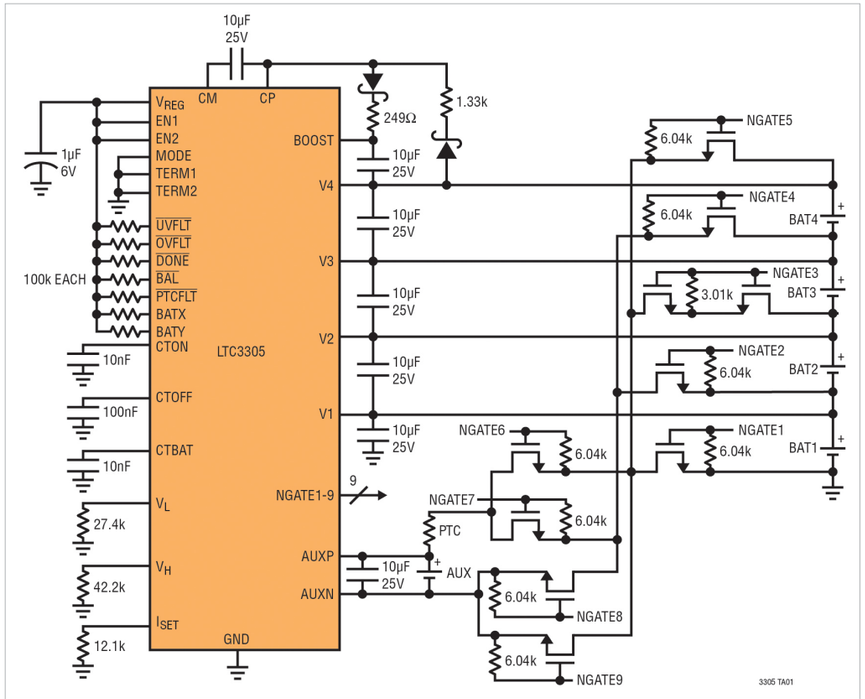


Figure 2a: Complete 4-battery balancer

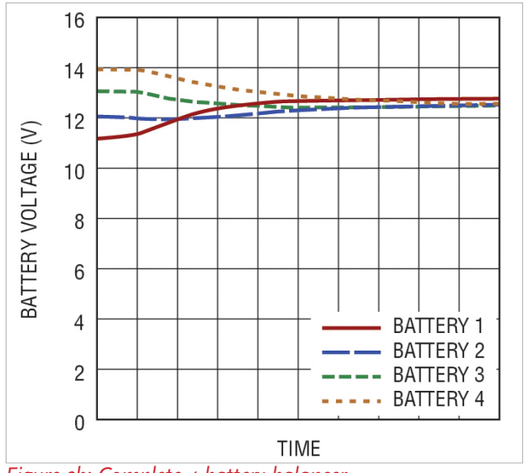


Figure 2b: Complete 4-battery balancer

The LTC3305 lead acid battery balancer is currently the only active lead-acid balancer that enables individual batteries in a series-connected stack to be balanced to each other.

Figure 2a shows an application in which a single LTC3305 is used to balance four series-connected lead-acid batteries. Each battery in the stack is individually and sequentially connected in parallel with an auxiliary cell using a network of 10 external low $R_{DS(ON)}$ NMOS transistors controlled by the LTC3305. If the voltages are different, current will flow in the appropriate direction until the voltages of the individual battery and the auxiliary cell are equal.

The LTC3305 then commutates to the next battery in the stack. This sequence continues (1, 2, 3, 4, 1, 2, 3, 4) until all batteries in the stack (and the auxiliary cell) are voltage balanced to within a specified threshold, as shown in the curve in **Figure 2b**. The maximum amount of current permitted to flow during any connection is limited by an external positive temperature coefficient (PTC) thermistor element.

The LTC3305 provides two modes of operation, which are programmable via the MODE pin and four termination thresholds, which are programmable via the TERM1 and TERM2 pins. The LTC3305 also has overvoltage and undervoltage comparators that monitor the battery voltage and report a fault if the battery voltage is beyond the programmed threshold. The undervoltage and overvoltage thresholds are programmable using the VL and VH pins, respectively, in conjunction with the ISET pin.

Multiple LTC3305 devices can be stacked to balance battery stacks consisting of more than four series-connected lead-acid batteries. In **Figure 3**, three LTC3305 devices are used to balance up to ten batteries in a battery stack. Each LTC3305 needs its own auxiliary cell for the balancing operation.

Balancing lead-acid batteries using the LTC3305 also offers other benefits. Low voltage circuits can be powered from intermediate stack nodes without creating an imbalance in the battery stack, as shown in **Figure 4**. This helps reduce solution costs since discrete components and IC costs scale with rated voltage. The capacity of the auxiliary cell supplements the stack capacity, resulting in longer run times.

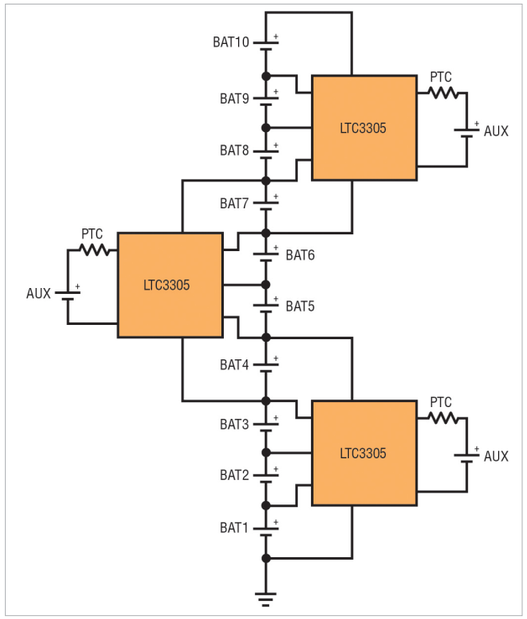


Figure 3: Multiple LTC3305 devices can be stacked to balance more than four series-connected batteries

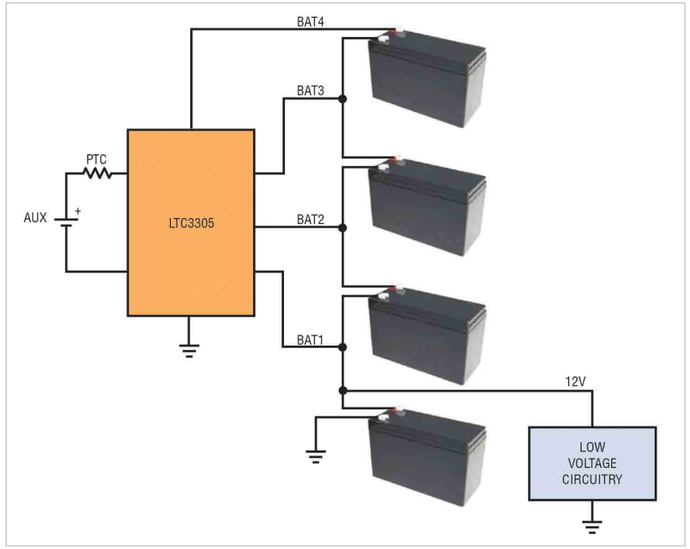


Figure 4: Low voltage circuitry can be powered from intermediate nodes

There is no argument to the fact that lead-acid battery packs benefit from being balanced, as balanced battery pack helps extend stack run time beyond that of the lowest capacity battery in the stack. Furthermore, battery life is also extended, reducing the expense of replacing batteries in the stack due to failure. The complete lead-acid balancing solution provided by the LTC3305 allows battery packs to be balanced with a minimum of design effort.

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Unlocking the Door to More Compact Designs

The latest designs demand highly reliable, low-cost motor controls that deliver higher performance in a smaller footprint

By: Michele Portico, Vincotech

The trend in power electronics is moving towards greater integration and more complex subsystems. On a related note, intelligent power modules (IPMs) have made major inroads into the market for motor control applications. These advanced modules combine high-performance IGBTs, diode power devices with integrated gate drives, and protection circuits in single housing. Demand for these IPMs is growing primarily because of the many benefits this power electronics technology brings to motor control applications.

Rising to the challenge

One example of the advanced systems now available to address these needs, the flowIPM product family from Vincotech addresses mechanical environments that demand high performance in a small footprint, for example, in embedded motor drives for fans, pumps, washing machines, air conditioners, and small industrial motor drives providing more than 4 kW electrical power at an 80°C heat sink temperature.

One of these additions to Vincotech's portfolio is the 1200 V flowIPM, an advanced power module that combines (see **Figure 1**):

- A three-phase input rectifier
- A three-phase motor inverter
- Current sensing with shunts in all low-side emitters
- Gate drives including all bootstrap power supply circuits, under-voltage lockout and over-current protection
- A temperature sensor

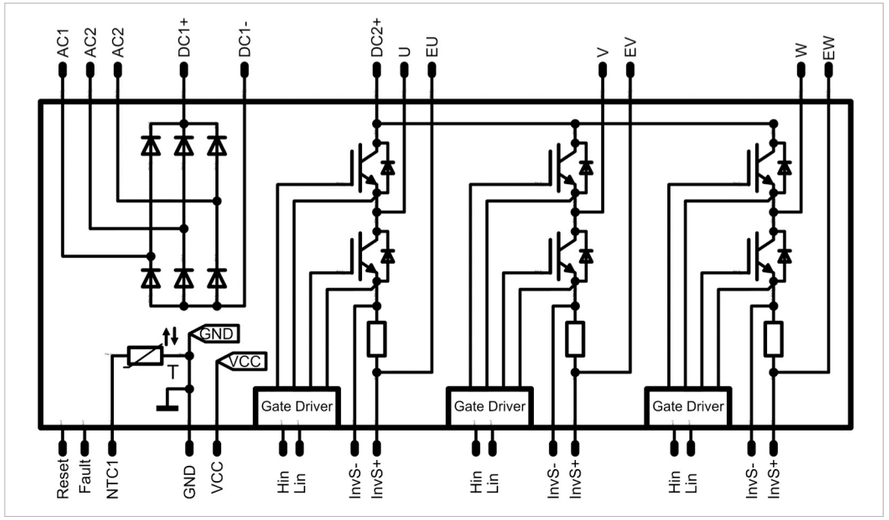


Figure 1: A streamlined schematic of the 1200V flowIPM

The three-phase inverter features an open emitter configuration and integrated shunt resistors for sensing the current in each leg, which results in vastly improved motor control.

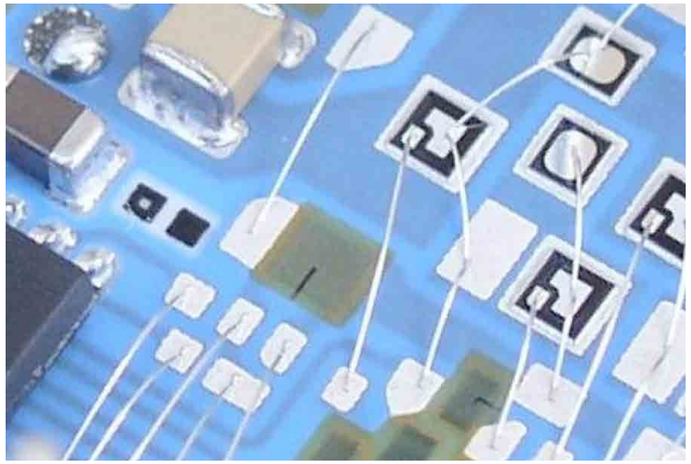


Figure 2: IPMs in thick-film technology

Thick-film technology takes integration to a whole new level (see **Figure 2**). To this end, different layers of conduction and isolating materials are printed on a ceramic sheet. These layers serve to build tracks, pads and resistors that may be laser-trimmed to achieve high levels of accuracy.

This technology achieves high thermal conductivity and accommodates PCB-like layouts. Thick-film is a very mature technology. It has already been used for several years, especially for critical applications, for example, in the automotive industry.

Vincotech's 1200V flowIPM comes in a compact flowIPM 1B housing equipped with Press-fit pins (see **Figure 3**). Press-fit technology reduces PCB assembly time and effort considerably by eliminating the need for soldering. This cuts process time and costs and boosts production output.

The module's creepage and clearance distances fulfill the applicable industrial standards. There are no special requirements regarding the shape of the heat sink. The thermal interconnection between flowIPM and the heat sink is vastly improved by pre-applying phase-change material. Vincotech's in-house screen-printing process deposits the material with great precision, achieving the proper thickness. The material can be optimized for maximum heat transfer capability.



Figure 3: Press-fit pins for solder-less mounting

Greater integration

Space is tight in embedded drive systems and their compact, hermetical design makes it difficult to dissipate the heat generated by so many electronic components. Vincotech's 1200V flowIPM is presented as having the highest level of integration of any power module available on the market currently, and is well-suited for such mechanical environments. The benefits of using a device like this highly-integrated module are considerable:

- The overall system's size, cost, and time to market can be slashed by integrating all of a motor drive's functional blocks, apart from the input filter, DC capacitor and microcontroller.
- Protection circuitry is tuned to match the power device's capability and factory-tested to improve the system's reliability.
- A lot of space is saved with highly integrated components and bare power chips to achieve a much smaller footprint than that of discrete designs.
- Motor drive assembly is streamlined and simplified with fewer external components and smart isolation techniques.
- The ceramic sheet used in thick-film technology improves the module's thermal performance by providing the best possible direct cooling for power components.

Ever smaller

IPMs provide the functional integration and power density that engineers need to design embedded drive systems. The outstanding level of integration achieved by products such as Vincotech's 1200V flowIPM enables system engineers to come up with more compact designs and to take advantage of a proven combination of power components and gate drive circuits, which happen to be the most critical elements in the inverter's design. This mitigates the risk associated with circuit design, speeds up development, and dramatically reduces time to market. Power semiconductors, integrated circuits, SMDs and resistors integrated into the substrate can all be combined with the benefit of thick-film technology, thereby maximizing the flowIPM power module's functional integration.

www.vincotech.com



System optimization – less is more

Efficient approaches are needed at all points of the system

By: Björn Rentemeister and Uwe Jansen, Infineon Technologies

The "Energiewende" (energy transition) has resulted in a shift in thinking not only about the generation of electrical energy, but its distribution and consumption as well. Efficient approaches are needed for energy production and transfer on the one hand, and consumption on the other. What plays a role here is not only mere electric power dissipation, but also considerations such as low weight due to a compact converter design, lower cooling costs for electrical supply, or identical parts concepts based on a platform idea for reducing system cost.

For example, Infineon's XHP platform, a new half-bridge module recently introduced during PCIM 2015, is the kind of device that can address the needs of future generations of converters. Such a half-bridge module enables the development of efficient converters that have been optimized for restricted installation spaces based on a platform concept.

As a result, the performance of the converter can be individually increased via a simple parallel connection to meet the requirements of the application, enabling the use of a half-bridge module in a wide range of applications. Examples of such include traction, energy transmission, renewable energy, and medium-voltage converters. Following is an explanation based on the example of converter topologies for medium-voltage drives (see **Figure 1**).



Figure 1: The XHP highly-insulated half-bridge module from Infineon for voltages from 3.3 kV to 6.5 kV

Optimal control

Electrical drivetrains are used in a variety of applications. Modern power electronics make it possible to optimally control motors according to the load profile of the particular application area. The requirements for a given drive differ can greatly from the respective use. One important application area for high-performance, variable-speed electrical drives is in passenger and freight transport rail vehicles of all types. In this area, modern power electronics enable rapid and smooth starting and braking, and because of the electrical braking capability, at a high energy-efficiency with low mechanical wear and tear.

Due to various service requirements and the way infrastructure has grown historically, a variety of electrical systems exist in the area of traction: Local transport systems often work with a DC voltage of 750 V or 1500 V, which is supplied via a catenary or third rail. In long-distance transport, however, it is customary to deliver AC voltage of 15 kV to 25 kV or a DC voltage of 1.5 kV to 3 kV through an overhead line. The manufacturers of rail vehicles and traction equipment are therefore forced to offer a wide range of drive equipment

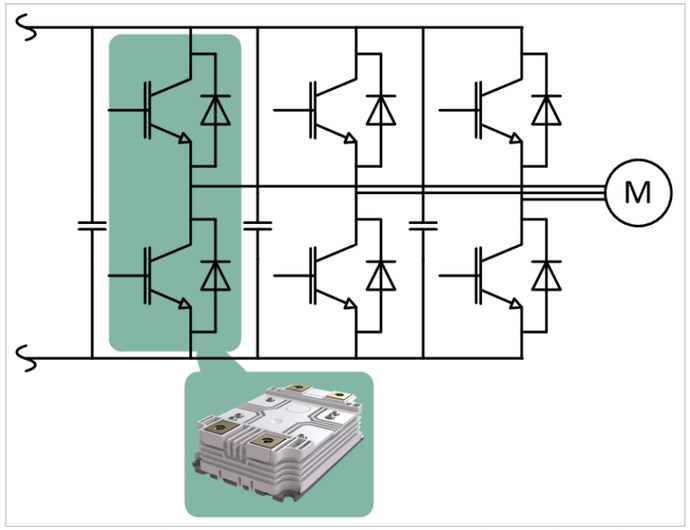


Figure 2: Two-level topology with the half-bridge module XHP from Infineon

in order to serve this diverse market effectively.

Since rail vehicles represent long-lasting investment goods, the demands on service life and electrical component reliability are high. It is also customary, however, to modernize older vehicles by replacing their electrical components. This is done not only to simplify the maintenance and upkeep, but also to achieve additional energy savings and improve passenger comfort. Such refurbishment projects demand a particularly high degree of flexibility from electrical equipment providers.

The area of electrical drives for industrial applications is also far from being uniform. Electrical drives for feed pumps, such as those used worldwide under a wide variety of operating conditions in the oil and gas industry, are subject to different requirements than stationary drives in steel mills. In the first case, it is essential to enable operation in a wide range of ambient temperatures and guarantee non-damaging transport from one operational site to the next even under adverse conditions. In the second, the important thing is high and easily predictable ruggedness to alternating loads to ensure years of trouble-free operation for such complex systems. What both scenarios have in common is the demand for a solution that is as efficient as possible. There is a special focus not only on the motor itself, but also the converter and the converter topology used.

Two-level topology

The classic two-level topology is the standard one for applications in the area of traction. It is also used in special industrial medium voltage converters such as mining converters for underground use (see **Figure 2**).

In traction applications where the catenary has a voltage of 1500 V, or where the intermediate circuit voltage ranges, for example, from 1800 V to 2200 V, it is customary to use a half-bridge that consists of at least two separate individual 3.3 kV switches. Depending on the required output, the parallel connection of several individual switches increases the nominal current. This requires a complex external circuitry for the modules.

A device such as the half-bridge module from Infineon significantly reduces this complexity, since an internal connection of the two individual switches to form a half-bridge and the separation of the load terminals into DC and AC greatly simplify the external busbars. On the DC side, the number of busbar layers is thus reduced to two. The optimized internal circuitry of the two switches also reduces the leakage inductances by about 50 percent. The connection of the switches to form a half-bridge in a single housing also has a positive effect on ohmic losses in the external busbars.

For the same output current and external busbar thickness, ohmic losses are only 75%

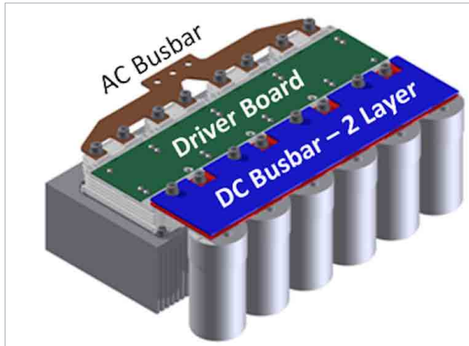


Figure 3: Air-cooled quadruple parallel connection with busbar and capacitor bank

of those in a typical single-switch solution. This is advantageous especially because the associated thermal losses cannot usually be diverted directly into a liquid cooling circuit, and are instead released into the interior air of the converter housing. In devices with a high protection class, the removal of this dissipated heat requires especially high system expenditures in the form of heat exchangers or even air-conditioning units.

The Infineon half-bridge module also allows an increase in the nominal current by means of a parallel connection of the individual half-bridge modules. The scalable concept enables a finely graded equipment program that uses largely identical parts for all essential system components. The area on top of the module is intended for installation of the driver electronics and simplifies the parallel connection; it is designed to enable positioning in the tightest of spaces. This makes a compact converter design possible (see **Figure 3**). Such a solution allows a compact, high-power-density construction of a half-bridge configuration for a phase leg with a two-level topology. Four additional aspects are particularly advantageous for traction applications:

- Half-bridge modules with a low nominal current are well-suited for vehicle concepts



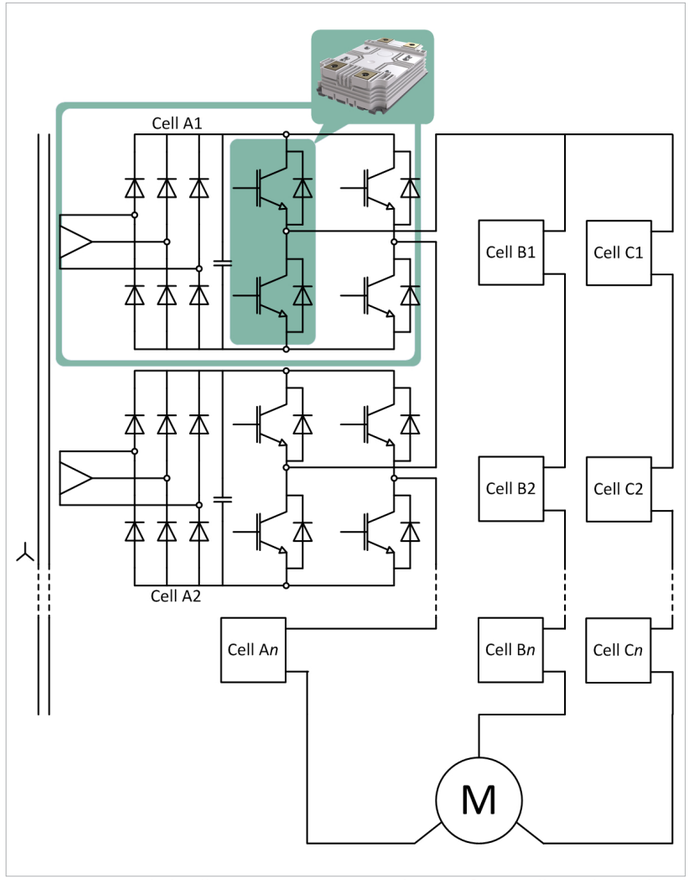


Figure 4: Cascaded cell inverter. A compact design of any cell can be realized with a device such as the half-bridge module from Infineon.

with individually controlled single axles.

- In general, the same modules can also be used for the auxiliary power converters.
- If energy storage units are to be used on the vehicle to improve recuperation, they can also be connected to the intermediate circuit through these half-bridge modules.
- The planned portfolio with different voltage classes in a uniform housing makes it possible to develop equipment for the different applications with a uniform converter design.

Multilevel topologies

In addition to the classic two-level topology, multilevel inverters are used in some applications. These topologies enable higher output voltages and a more precise adjustment of the AC output voltage to the sinusoidal shape. Only a fraction of the entire output voltage is supplied to the individual semiconductor switches [1].

The cascaded cell inverter is an example of a multilevel topology that is now used in drivetrain technologies. Developed by Robicon in the 1990s [2], the separate DC links for each cell are a special feature of this kind of topology. This requires a transformer with a corresponding number of output windings. Nevertheless, because of the simple structure relative to other multilevel medium voltage converters, this topology is very popular. It can be used to make inexpensive converters, especially for pump and ventilator drives with motor voltages between 2.3 kV and 13.8 kV. In this process, at least three cells are set up in series and IGBT modules with a nominal voltage of 1700 V are used (see **Figure 4**).

For motor voltages of 6 kV or higher, the use of IGBTs with a higher nominal voltage is also reasonable, since they allow the number of cells and insulated transformer windings to be limited. The module from Infineon allows very compact construction of identical cells and enables an identical parts concept that optimizes system costs across a broad performance spectrum.

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Podcast highlights

Recent podcasts from Power System Design's live coverage of the latest trends and tech in the electronic design industry

By: Alix Paultre, Editorial Director, PSD



KEI Solar

Jens Kautzer of KEI Solar on optimizing panel performance (Podcast)

In this podcast Jens Kautzer of KEI Solar talks to Alix Paultre of Power Systems Design about the safety and optimal performance of solar panels. Often the supporting and enhancing infrastructures are what make the difference between a given technology succeeding in the marketplace or not. In the case of solar panels, ensuring the panels are mounted properly, operate as intended, and do it safely are critical issues.

tinyurl.com/PSD-OCT01 | KEI Solar | www.keisolar.com



Cree

Paul Kierstead of Cree on the availability of SiC MOSFETs

In this podcast Dr. Alex Lostetter, Vice President, Cree Fayetteville, and John Palmour, CTO and a co-founder of Cree talk to Alix Paultre of Power Systems Design about the recent APEI acquisition and the state of the power semiconductor industry. Normally relatively conservative, the power industry is in flux due to wide-bandgap semiconductors and the guests from Cree explain some of the challenges and opportunities involved. (Cree Power & RF is now Wolfspeed)

tinyurl.com/PSD-OCT2 | Cree | www.wolfspeed.com



Maxim

Dave Andeen of Maxim Integrated on the IoT

In this podcast Dave Andeen of Maxim Integrated talks to Alix Paultre of Power Systems Design about the IoT and wearable technology. Since there is no precision without feedback it is critical to have intelligent monitoring and sensor systems in order to maximize device functionality, especially in the area of sport and medicine personal devices. Among the devices and solutions in this conversation is Maxim's recently-released reference design on a galvanic skin-response sensor to enable such devices to better determine the status of the user during operation.

tinyurl.com/PSD-OCT03 | Maxim | www.maximintegrated.com



Glassbeam

Puneet Pandit of Glassbeam on electric vehicle charging

In this podcast Puneet Pandit, CEO of Glassbeam, talks to Alix Paultre of Power Systems Design about the issues surrounding electric vehicle (EV) charging. A vital core infrastructure to the acceptance and success of EVs, a proper charging infrastructure requires a grasp of both hardware and software systems. "Smart" stations are capable of streaming data in real time to provide information on when parts or systems will fail—before they fail—or provide details on what needs maintenance without human intervention--and even determine how new stations can be improved.

tinyurl.com/PSD-OCT04 | Glassbeam | www.glassbeam.com



TE Connectivity

Nathan Tracy of TE Connectivity on the IoT infrastructure

In this podcast Nathan Tracy, Technologist, System Architecture Team and Manager of Industry Standards at TE Connectivity, talks to Alix Paultre of Power Systems design about the challenges in creating an effective architecture and infrastructure to support their latest products. TE connectivity recently released their Mini-SAS product family, a high-speed, multi-lane interconnect for both internal and external solutions, including both receptacles and cable assemblies. The system is designed to be compliant to SFF-8086, 8087, and 8088 standards, and supports SAS 2.0 applications.

tinyurl.com/PSD-OCT05 | TE Connectivity | www.te.com



AEG

Stefan Kempen of AEG on grid-level storage

In this podcast Stefan Kempen of AEG Power Solutions talks to Alix Paultre of Power Systems Design about grid-level storage and energy managment. Intelligent grid-level storage is a critical core technology of an advanced smart grid, and it involves more than just putting some batteries on street corners. The company was recently chosen by UniEnergy Technologies (UET) to supply Protect SC.600 storage converters for their Uni.System. In particular, the systems are able to help overcome challenges in adding renewable energy sources to the public grid, including grid stabilization and grid leveling.

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Back to the cottage?

By: Alix Paultre, Editorial Director, PSD

Once upon a time, many skilled crafters worked from their homes. Their skill and profession was often protected by a guild, and their finished goods and devices were funneled to merchants and factors, who either sold them-as is or integrated them into larger products.

As technology progressed and industrial processes could be made precise, reliable, and cheap enough to supplant those home industries, skilled workers became factory employees working directly for an employer who now owned both the intellectual property and the specialized tools required. Skilled work became more and more an element of the executive suite and design shop, instead of the shop floor and the production process itself.

The latest industrial revolution (the roman numeral for this portion of the wave is still being debated) can be seen as either a progression of electronic automation or a new wave of intelligent devices and systems, but the result is that not only is the shop floor is getting smarter, the tools and technology behind those smarts is now migrating back out of the factory and into homes and garages again.

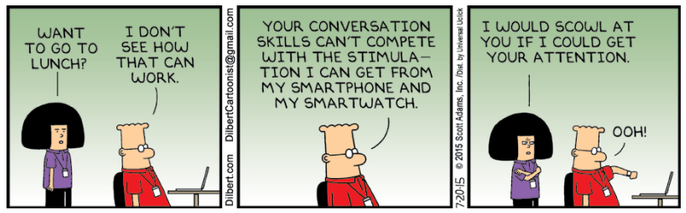
One of the biggest signs of this is the new entrepreneurial creative and development environment created by the Maker movement. Far more than a bunch of "Burning Man" wannabees, the Maker movement is made up of an interesting and eclectic mixture of engineers, hobbyists, artists, and cross-discipline professionals, who have taken advantage of the powerful development and manufacturing tools and capabilities now available to everyone.

The new players in this space aren't just designers using already mature fabless manufacturing or contract manufacturing, they are using the latest production tools and techniques, like 3D printing, to not only design and develop their products, but also manufacture and distribute them as well. These new players are changing the way we look at creating, developing, and producing the next generation of products and services.

The new tools, capabilities and procedures provided by the latest industrial revolution are the significant enablers, putting control of every aspect of a process back into the hands of the entrepreneur and risk-taker. Where it once took a team of engineers in a suite of offices and labs to develop a product, independent designers in widespread locations using digital desktop tools can now create designs for new products and prototype them in a digital environment, creating fab-ready designs that can be made by a contract manufacturer or the designers themselves.

The rise of online communities to support these entrepreneurs, some industry based, some association based, and some just grassroot gatherings of like-minded engineers, has also been an essential enabler, as this virtual community enables an engineer working by themselves to still tap into the minds of their peers and gain insights, get advice, and create partnerships in a way not previously possible.

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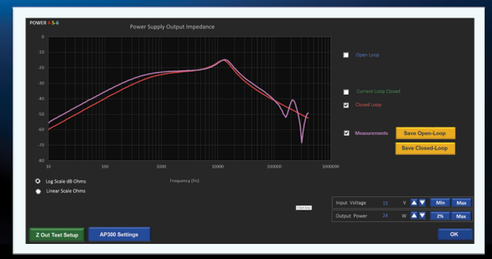


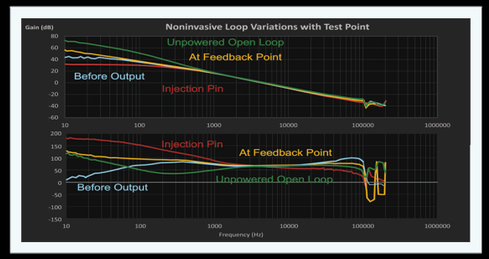
Frequency response analysis for power supply design

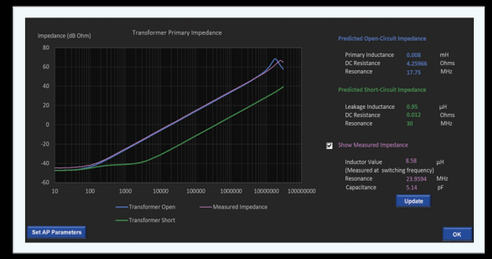
The AP300 Frequency Response Analyzer has a 0.01 Hz to 30 MHz range. It is the best choice for all gain-phase measurements for power systems, including switching power, digital power, PFC circuits, EMI filters, and passive components.







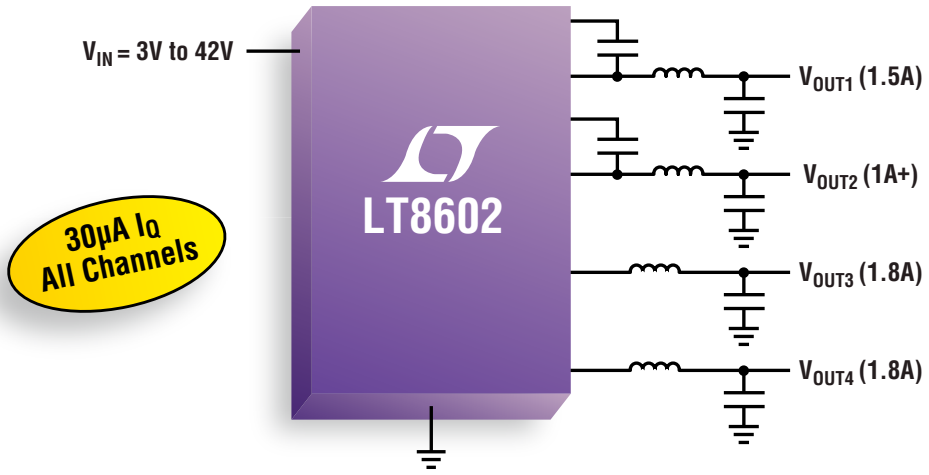




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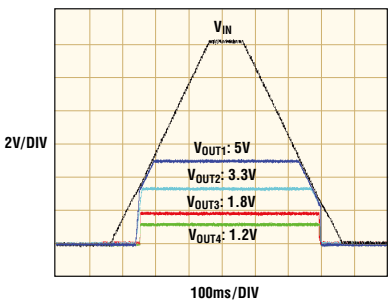
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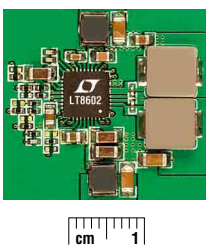
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