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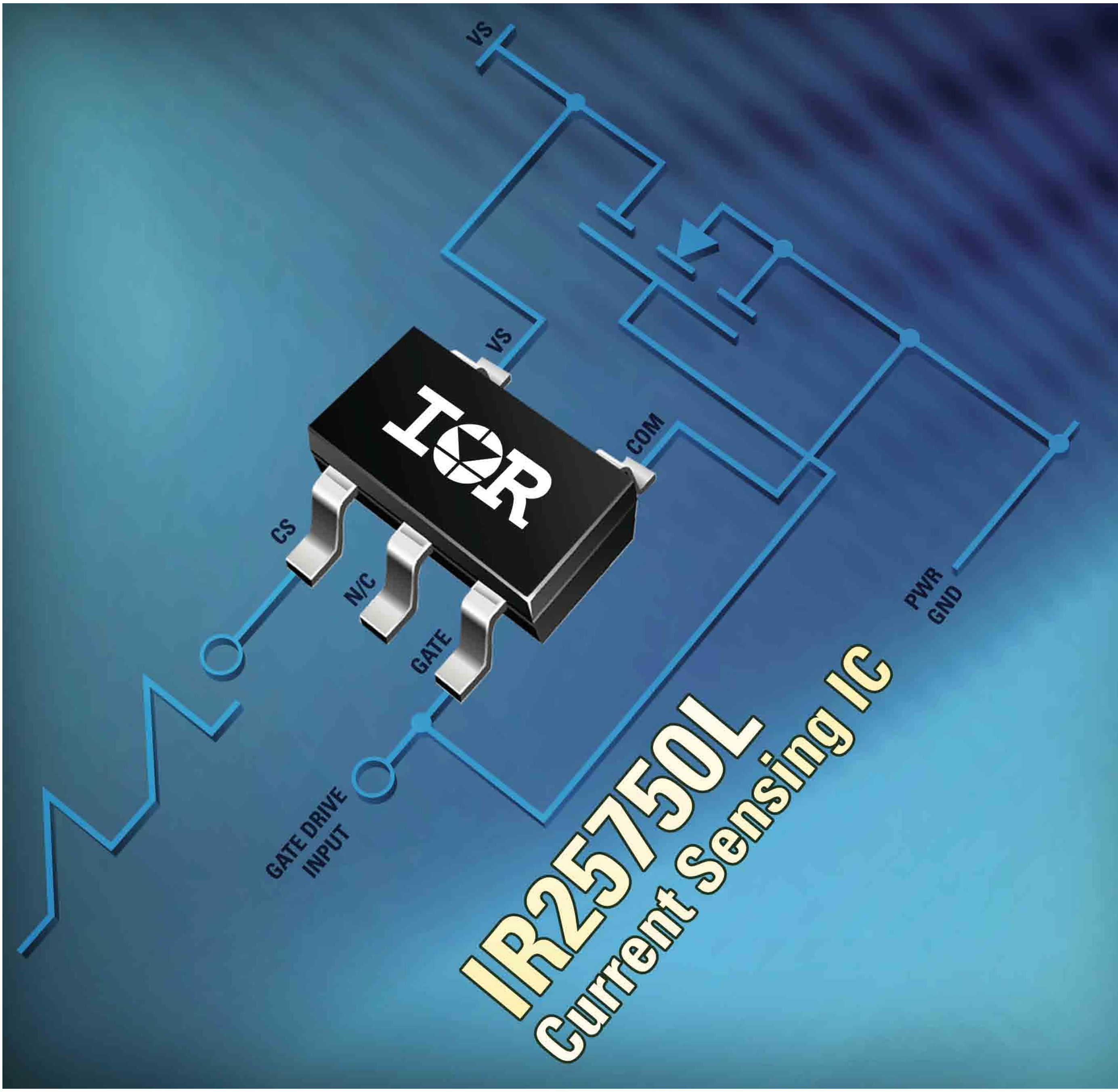
April 2014



Special Report: Motors & Motion Control (pg 33)

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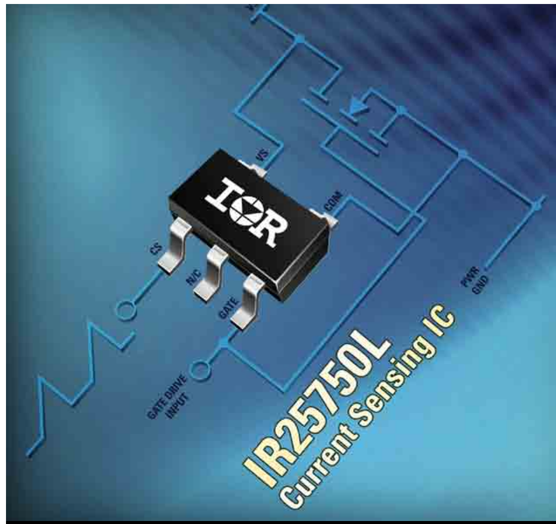

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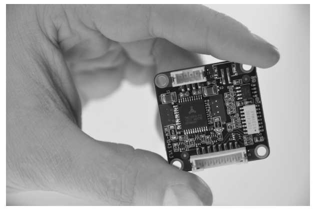

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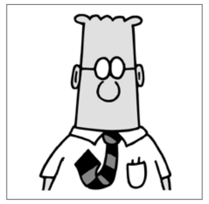

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Making better motors and controls help move the world forward

Making tools that move has been a part of human development since the wheel and lathe, and the drive to make our tools and moving devices more precise, accurate, and easier to operate has been an almost continuous process since the first complex tool was created. Every one of those aspects are vital to the nature of a useful tool, and each is as important and the next.

Motors are a core technology, the core of and the building block for a range of tools and machines addressing a range of applications, and they and the systems that control them are critical parts of our modern infrastructure. My favorite yardstick for technology assessment is how precisely that technology can control and apply power, and motors and motion control is an elegant expression of that philosophy.

There were presentations and discussions on the subject of motors and motion at both the recent embedded world conference in Nuremberg, Germany and the following APEC event in Ft Worth, Texas. The answer to the question on everyone's lips about some of the driving trends in the industry included (among other technologies like wireless power and wide-bandgap semiconductors) motors and motion control, and the application space was one of the high-interest areas of both events.

Think of a sharpshooter dialing in a new scope. How tight the shot group is displays the weapon & shooter's precision; how close that shot group is to the desired target point shows the accuracy. The two together, combined with the ease of use of the system, define that system's usefulness to the user. In this example, how tight the tolerances are in the mechanism, how precise and well-engineered the action is, and how easy the weapon is to operate defines how "good" a weapon it is. In some cases it depends on the application; one wouldn't expect a heavy-caliber weapon to be light (relatively speaking).

In the realm of motors and motion control, this has been expressed in both the mechanical sophistication of the motors and mechanical aspects of modern systems, the sensors that given them the ability to perform to the extremes of their capabilities, and the software that takes the input of one to control the output of the other. Each facet of the system is critical, and each can benefit from a pursuit of quality in the areas of precision, accuracy, and ease of use.

The best functionality of an item cannot be realized by the user if it is too complex, cumbersome, or otherwise difficult to use. Conversely, a device that is too "dumbed down" to make user access easy may miss important functionalities that would be accessible with a small learning curve or with an advanced user. It is a fine tightrope (in most cases) to walk.

Best Regards,

Alix Paultre

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TRINAMIC offers customizable embedded driver for NEMA 17 stepper motors

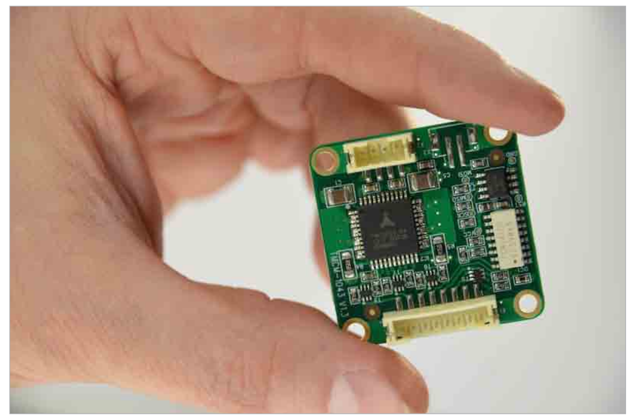

Figure: TMCM-1043 embedded driver stage custom designed for direct mounting on NEMA 17 stepper motors

TRINAMIC Motion Control, a leading developer of motor and motion control technologies, announced a smart, energy- and cost-efficient embedded driver stage custom designed for direct mounting on NEMA 17 stepper motors. Pre-programmed and pre-configured with all operating parameters to support standard 1.1A (rms) motors, the TMCM-1043 is intended for rapid design-in and off-the-shelf use without any additional programming required.

With no programming required for a quick and easy out-of-the-box experience, and full parameterization options including a high volume production programmer, the TMCM-1043 is a smart and customizable solution for embedded motion control and mechatronics.

The TMCM-1043 incorporates the TMC2660, TRINAMIC's latest stepper motor driver IC, which integrates power MOSFETS with the industry's lowest RDS(on) specification, resulting in minimal power dissipation. The PCB also integrates all required protection circuitry and interface hardware into a compact and robust assembly. The TMCM-1043 is pulse controlled for 16 microsteps per fullstep. TRINAMIC's patented proprietary interpolation processor interpolates these steps to a resolution of 256 microsteps per fullstep, allowing for a smooth and noiseless movement.

With its optional programming kit, the TMCM-1043 becomes a fully customizable smart driver stage allowing for adaption to a broad range of embedded motion control and mechatronics requirements. In addition to a desktop programmer kit with an intuitive GUI for evaluation and ideal parameter selection, a volume programmer for quick parameterization of production scale quantities will also be available.

"Some of our customers are asking for a plain vanilla stepper driver that also includes all the features of TRINAMIC ICs," said Michael Randt, TRINAMIC CEO and founder. "The TMCM-1043 is our simple yet elegant answer to that customer request."

Stepper motors are cost-effective solutions for applications that require high-torque at low speeds and precise control of motor axis rotation. Widely used in printers, scanners, robotics, medical and scientific equipment and other applications, TRINAMIC estimates that more than one billion stepper motors are shipped ever year. NEMA 17 is the most popular stepper motor size, accounting for more than 50% of the total stepper market.

The TMCM-1043 is a smart and customizable solution for embedded motion control and mechatronics, with a very high microstep resolution, smooth motor movement, and an error output.

www.trinamic.com

The Smart Grid needs muntzing

By: Edward Herbert, PSMA Energy Efficiency Committee

Increased monitoring and automation of The Grid will significantly improve stability and reliability, avoiding blackouts and allowing a better response to anomalous line conditions. However, things get out of control over the ambitious goal of reaching through the Smart Meter to monitor and control everyone's appliances, connecting it all to the Internet with powerful processors and full-featured communications.

Mr. Muntz stripped circuits of extraneous parts to save money, with the added benefits of reducing size, weight, and power. Processors and communication circuits are cheap, so the tendency now is to pile on the functionality and connect everything to the Internet of Things (IoT) so that all can be controlled remotely.

The control is seductive, and the risks are largely unrecognized or ignored. When this concept is linked to the mantra that it is necessary to stabilize the grid, avoid blackouts, and save building new power plants, it has been accepted, hook, line and sinker. So, what's the problem?

Issues & questions

It requires a very extensive and expensive hardware and software infrastructure to control everything in the IoT. What are our chances of getting it right? If we build a grid that relies on a computer-based infrastructure, do we get a blackout when the computer crashes? It is very profitable for those who make the equipment, so they will promote it aggressively – at least until they face product liability and recalls.

Anything connected to the Internet can be hacked, as we've seen in the news. In one recent incident smart appliances were hacked to send SPAM, and we've all heard of the infamous case of Target being hacked to steal millions of credit card numbers and PINs. The list goes on. Security is an issue that will only increase in importance as the grid develops.

What if they get it wrong? Utilities should think twice about the liability in controlling millions of appliances. There has already been an increase in demand for insurance to cover energy firms, but many are being denied because their cyber-security is inadequate. There are also reports that Smart Meter sales have plummeted over security concerns, with large-scale layoffs.

Is it needed? Are there alternatives? Largely ignored is the need for a robust default mode to control the grid when the computer crashes, which could eliminate the need to micro-manage appliances. An infrastructure that is more responsive to line conditions may provide better power management with a faster response than is possible with a command-response protocol from remote computers.

A homeowner who wants smart appliances controllable from his smart phone should have that option, but for the utility, the Smart Meter should be a firewall, not a conduit for hacking.

Muntz! Remove what isn't useful or is potentially dangerous. (It will be less expensive, too).

This article reflects the opinion of the author, not necessarily that of the PSMA.

Key component costs inhibit Chinese robotics supplier growth

By: Wilmer Zhou, IHS Technology

The Chinese market for industrial robots was estimated at $810.4 million in 2012, and is predicted to grow with a CAGR of 9.6% to $1.3 billion in 2017. International robotics companies dominated the Chinese market with a combined market share of over 85%, and the top four (Fanuc, KUKA, ABB, and Yaskawa) accounted for nearly 60% in 2012. Local Chinese robotics suppliers have trouble competing internationally, mainly because they cannot remain price-competitive due to their relatively higher costs for key components.

Midstream robotic builders are located in the low end of the robotics industry value chain if they cannot manufacture their own key components, or if they do not offer system integration services. This is the case with most of the local Chinese robotics suppliers.

ABB, Fanuc, KUKA and Yaskawa have significant advantages in regards to their supply of key components, as they can build their own components or outsource the components at a relatively low price. Because of their limited production volume, the purchase price of key components for local Chinese robotics suppliers is much higher than that of their international counterparts, preventing them from being price-competitive.

Servo motors and servo drives used in industrial robots are more stable, have faster dynamic response, and are more precise than standard devices. The major robotics suppliers have customized their servomotors and servo drives to establish a technological barrier. European suppliers (e.g., Siemens, Bosch Rexroth, Beckhoff, B&R, and KEBA) and Japanese suppliers (e.g., Yaskawa, Fanuc, Sanyo Denki, and Panasonic) dominate this market. Local Chinese robotics suppliers GSK, Estun and STEP Electric produce their own servo drives and servomotors as well.

Precision gearboxes consist of any kind of gearbox used in industrial robots, such as harmonic gearboxes and precision cycloidal gearboxes. The precision gearboxes in SCARA robots and parallel robots are harmonic gearboxes. Precision gearboxes in articulated robots are mostly precision cycloidal gearboxes. Harmonic Drives is the market leader for harmonic gearboxes. Nabtesco dominates the precision cycloidal gearbox market both in China and globally. Local Chinese suppliers, such as Leaderdrive and Nan-tong Zhenkang, are just starting to develop precision gearboxes.

Controllers used in industrial robots are more precise, more stable, have a faster dynamic response, support networks with higher speeds, and are more flexible and extensible than those in average applications. Most industrial robot suppliers develop their own controllers; however, some local suppliers are not able to develop their own controllers. Instead, these local suppliers have to purchase controllers (sometimes as part of a complete solution) from controller suppliers, such as B&R, KEBA, Beckhoff and Yaskawa. Googoltech is a local motion controller supplier developing the motion controller for robotics industry.

www.ihs.com

Power Supply Failure Survey – Part III

By: Dr. Ray Ridley, President, Ridley Engineering

In this third article about power supply failures, the magnetics are examined for their contribution to the failure rate. These are usually the least understood of all components, and poor magnetics design can lead to many different failure mechanisms in power supplies.

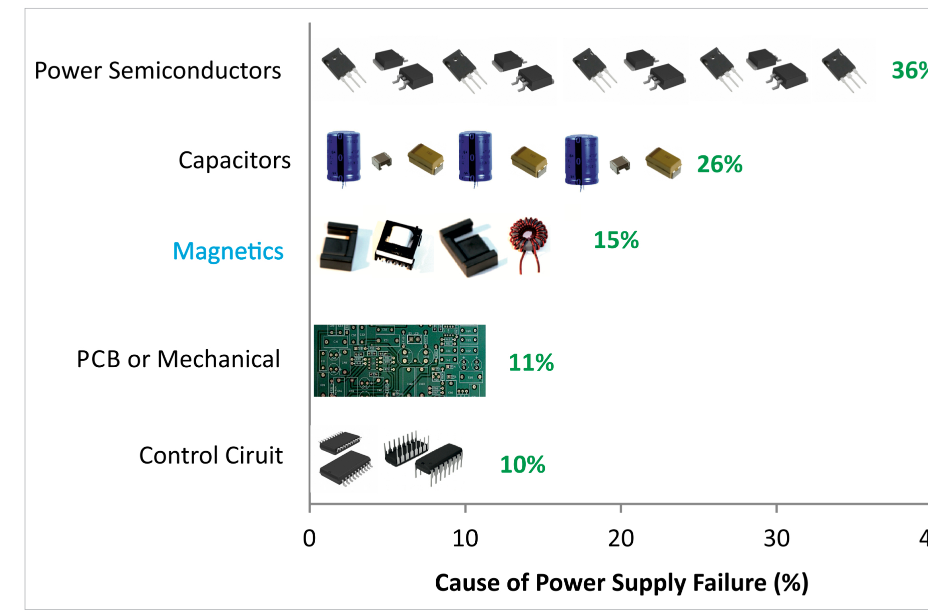

Figure 1: Survey Results for the Cause of Power Supply Failures

Power Supply Failure Survey

The LinkedIn site "POWER SUPPLY DESIGN CENTER" [1] is a valuable source of design information with over 3500 members contibuting to discussions. We surveyed the group members on "Why do power supplies fail?", and the results of the survey are repeated in Figure 1 below.

As shown in **Figure 1**, the survey group saw semiconductors as the main cause of failures, and this was discussed in the first article of this series. Second on the list are capacitors, discussed in the second article. Magnetics are key to successful operation of a power supply, and these are next on the list for causing failures.

Magnetics Failures

Magnetics are the key component in a power supply. Without proper design and manufacturing of these parts, a power converter can be unreliable, inefficient, or it may simply not work. It is usually the least understood of all components in a power supply and simulation models are woefully inadequate. Very few engineers receive any formal training in design and testing of magnetics leading to many misunderstandings and mistakes being made. **Figure 2** shows the main reasons for failures in magnetics components, according to our survey.

<u>Thermal Stress: 33%</u>. As with capacitors, thermal stress is at the top of the list for causing magnetics failures. This can be due to excessive dissipation, lack of accommodation for high-frequency losses, or simply poor heat removal. Reliable magnetics design is very much a function of experience of the engineer.

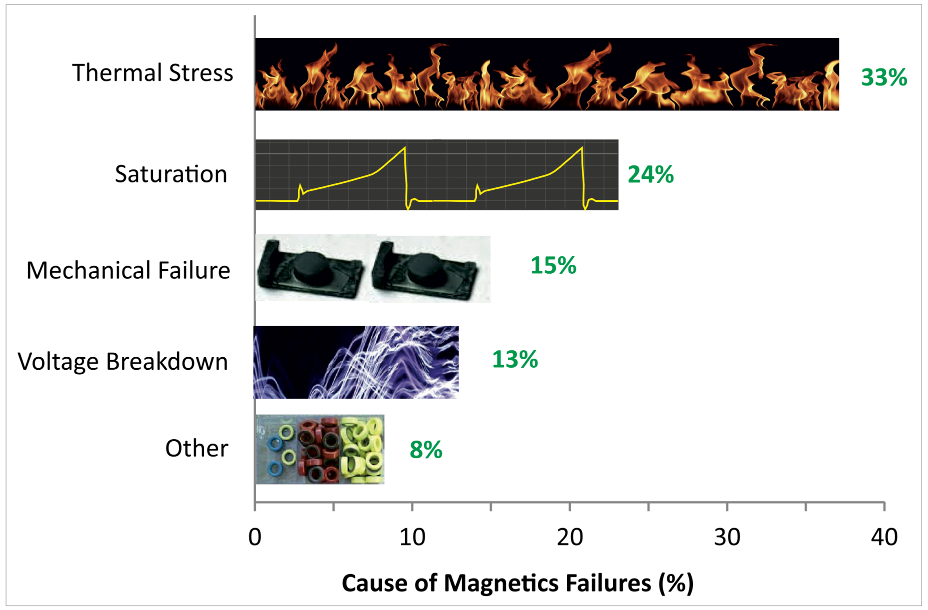

Figure 2: Survey Results for Causes of Magnetics Failures

In this article, we thought it best share the opinions of our LinkedIn members to illustrate the numerous problems that are encountered with magnetics.

"It's interesting to note that most semiconductors are typically placed on a heatsink to remove the 1W or more of dissipation and keep the junction below 125C. How many magnetics do you know that are placed on heatsinks in order to remove the heat from the core and the windings? Some of these magnetics have a lot more than 1W of dissipation and they are just on FR4 boards. The thermal coefficient is over 30C/W. What do think the life of such magnetic is at 80C or 100C ambient? Thermal, in my opinion and experience, is the number one factor for magnetic failures in power application." (Via LinkedIn)

Saturation: 24%. Second in the list is core saturation of transformers and inductors. Many designers these days are not familiar with proper test procedures of power supplies, and this leads to the omission of crucial current measurements. When saturation occurs, a power supply may continue operating, but current stresses are greatly increased. The best way to detect the saturation current is to observe it directly with a current sensor under a wide array of test conditions.

"I see saturation occurring in perhaps 25% of offline converters that I review. It usually happens during transients due to inadequate design margins.

For bridge converters, there are many reasons why saturation can happen – inadequate number of turns, poor layout, noisy controls, and so on. Once you see saturation, failure is usually just a matter of time. But if you don't look at the waveforms, you won't know the problem is there. " (Via LinkedIn)

Figure 3 shows saturating current in an inductor. The characteristic sudden change in slope of the current is due to saturation of the core, and the resulting reduction in permeability. These waveforms should be avoided at all costs if you want to ensure a reliable power supply.

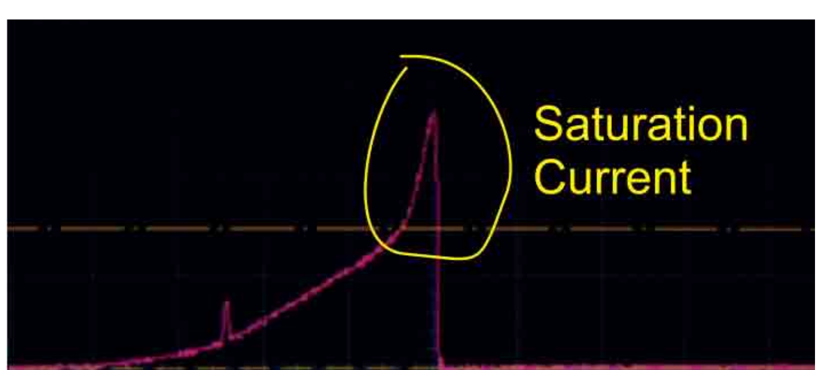

Figure 3: Inductor current waveform with saturation.

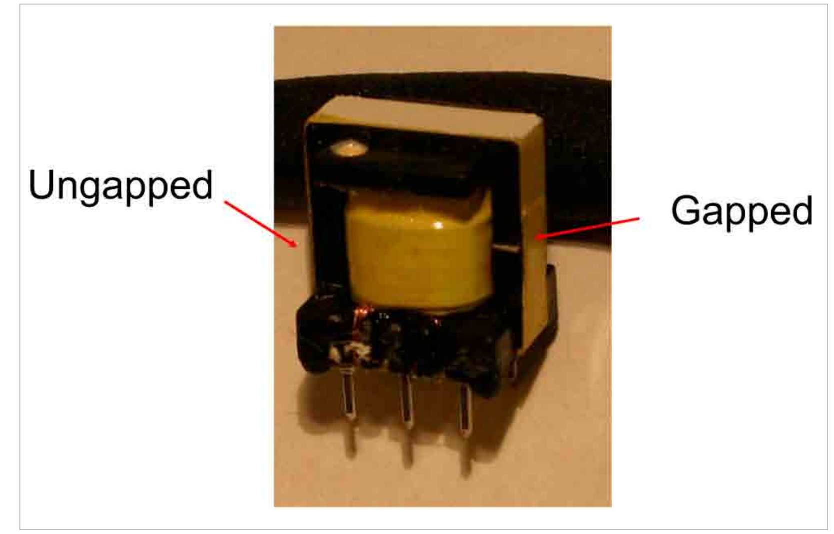

Figure 4: Flyback transformer gapped on just one side.

Mechanical Failure: 15%. Mechanical failure can mean many things for a transformer or inductor. Ferrite cores are made of extremely hard materials, but they are prone to cracking with mechanical stress. Proper handling and shock and vibration stress release can be key.

The following statement appears on a ferrite manufacturers website, and should be taken to heart in your manufacturing process.

"CAUTION: The edge of the surface of ferrite core is sharp. Minute burrs may be present. Ferrite cores are weak and prone to shock damage. Shock may cause cracking and chipping in cores. Inspect ferrite cores for cracks prior to use.
If ferrite cores are used without inspecting for cracks, deterioration of characteristics and heating may result." (Via LinkedIn)

Since the performance of magnetics is very much dependent on mechanical arrangements of copper, tape, and cores, it is very common for poor design and construction to lead to mechanical failures.

Voltage Breakdown: 13%. Since transformers are the isolating elements in high-voltage applications, voltage breakdown is a primary concern. Voltage breakdown can cause catastrophic failures and safety hazards. The mechanisms of voltage breakdown can range from the very simple, involving inadequate spacing, to very complex, involving corona effects and material physics.

"Some of the voltage breakdown cases I saw might have been triggered by core losses, where the enamel of the wire becomes so hot that the insulation it provides eventually fails. But hard to say because by that time the converter was long dead and everything was cooled off." (Via LinkedIn)

Other: 8%. A multitude of reasons make up the last category. Primary under here is the quality of manufacturing. The modern manufacturing world will send magnetics design and construction work to the lowest bidder, and this can easily result in the obvious results for a component that requires much skill and experience to get right.

"The problem is getting the transformer manufactured correctly. I've seen many transformer houses swear they know how to do vacuum potting and HV insulation and so on only to have the part fail in seconds."

"In my world of aerospace consulting, a lot of problems are caused by unrealistic size requirements from the customer coupled with the company insisting on using the "cheapest" outsource vendor."

"I agree 100%. The biggest problem transformer houses have is unskilled labor, poor QC and inadequate testing to weed out failures. My previous company did mostly high voltage supplies and transformers were designed and wound in-house. Once they decided to outsource for cost savings, the failure rate increased dramatically. " (Via LinkedIn)

Figure 4 shows a classic manufacturing error for a power supply transformer. The core has been gapped on only one side. This transformer will meet all of the electrical test specifications, but once in the circuit, a changing inductance will be observed even with light load.

The one-sided gapping creates an edge contact between the two core halves on the ungapped side, and this will progressively saturate as current is applied. While this may not be a problem electrically, and the control system may absorb the changing value, it is a poor way to construct a transformer. There is a lot of mechanical stress on the edge contact, and this can easily lead to cracking of the ferrite with time and vibration.

Apart from this, the transformer was well-built, no doubt a copy from some other vendor. The manufacturer simply did not have the experience to know that this technique is to be avoided.

In virtually every design of a custom transformer for power supplies, there are iterations with the manufacturer to eliminate all of the problems that may arise when large quantities are built. Close attention is needed when ramping up quantities, changing vendors, and tracking quality during ongoing production.

Summary

The survey results in this article highlight the major causes of magnetics failures in switching power supplies. There are many reasons why this often hand-built component can cause a power system to fail, and they must be well understood if you want to have reliable power supply products. Experience is key, both from the design engineer's point of view, and from the manufacturer.

Very few engineers receive formal training of any kind in magnetics design, and learn the art piecemeal from hard-won experience. If you want to improve your skills in this area, Ridley Engineering offers a hands-on workshop where you build and test your own magnetics for power circuits [3].

www.ridleyengineering.com

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Enhancing switch-mode power performance with RDS(on) current sensing

This eliminates current-sensing resistors or transformers and their associated power losses

By: Tom Ribarich, International Rectifier

Typical switched-mode power converters today include circuitry for monitoring the current flowing through a switching power MOSFET or IGBT for regulating or limiting peak current levels. This is necessary to protect the switch against high peak currents that can damage components or saturate inductors. A low-ohmic resistor is typically placed in between the source of the MOSFET (or emitter of the IGBT) and ground for sensing the current.

However, the power losses across this resistor can be high and system cost and size can increase significantly, especially if very high currents are being switched and heat-sinking is required. This article describes a new circuit that instead uses the $R_{DS(on)}$ of the MOSFET itself to directly sense current. This allows for traditional current-sensing resistors (or current-sensing transformers) and their associated power losses to be eliminated.

Traditional current sensing

The most common circuit used for sensing current flowing through a switch includes placing a low-ohmic resistor in between the bottom of the switch and ground (see **Figure 1**). During the switch on time, current flows through the switch, the sensing resistor, and to ground. As the current flows through the sensing resistor, a voltage drop occurs across the resistor (VCS), which is then used by another circuit for monitoring or detection purposes.

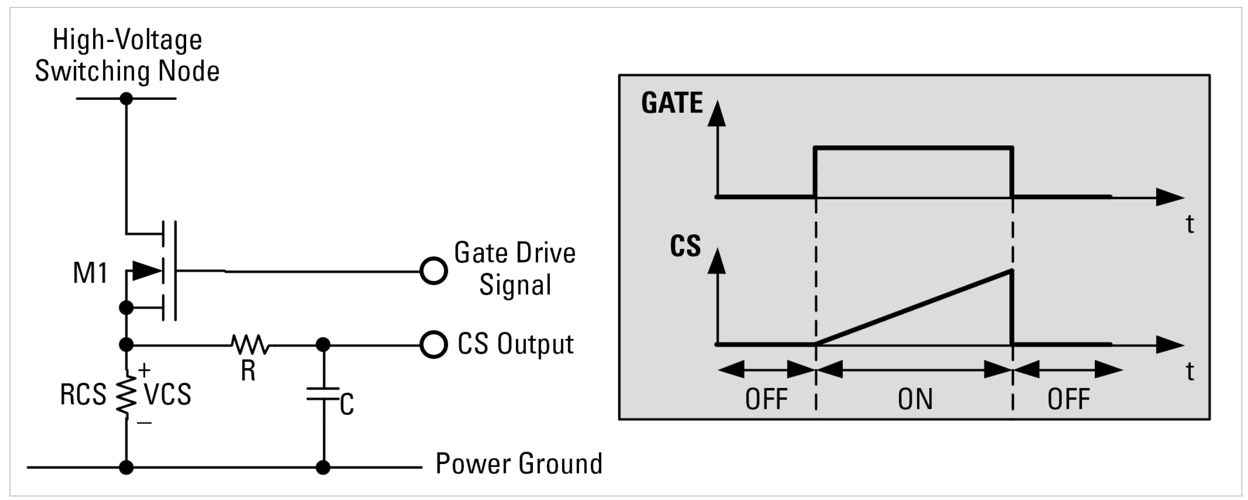

Figure 1: Traditional resistor current sensing.

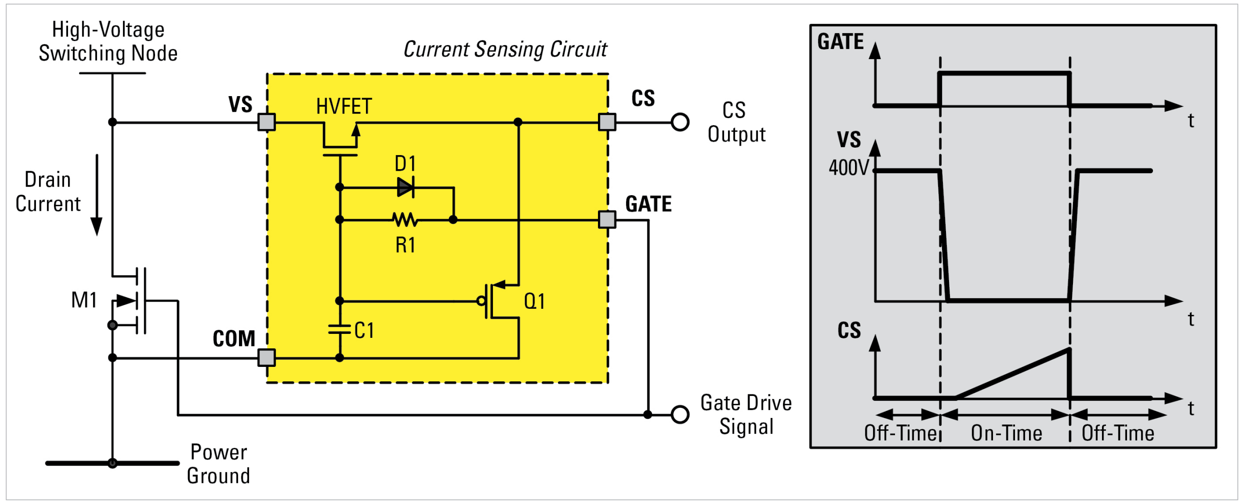

Figure 2: New RDS(on) or VCE(on) current sensing circuit.

Typically there is an inductor in series with the switch that causes the current to ramp up linearly during the on-time. There is also a turn-on "spike" due to the gate-to-source current that flows through the resistor during the rising edge of the gate voltage. When the switch is off, current no longer flows and the voltage across the sensing resistor drops quickly to zero. A turn-off "spike" can also occur due to the switch capacitance currents that flow momentarily when the voltage across the switch rises again. A small low-pass R-C filter connected between the top of the sensing resistor and ground is used to suppress these on and off spikes to avoid false triggering of the detection circuitry.

Any voltage drop produced across the sensing resistor during the on time of the switch will decrease the actual gate-to-source voltage of the switch. This can increase both the on-resistance of the switch and conduction losses, and, if the currents are high enough and the voltage drop across the sensing resistor is significant, the switch can enter linear mode. Also, any inductance between the switch and the sensing resistor due to the pcb layout will cause large inductive spikes that can cause unwanted EMI and possibly damage the switch or the gate drive circuitry. Finally, depending on the value of the sensing resistor and the current levels flowing through the sensing resistor, a given power loss across the resistor will result that will reduce system efficiency and produce heat that may require thermal management.

$R_{DS(on)}$ current sensing circuit

The new $R_{DS(on)}$ sensing circuit eliminates the traditional series-connected sensing resistor and is connected instead in parallel to the power switch. The circuit measures the $R_{DS(on)}$ of the switching power MOSFET, or $V_{CE(on)}$ of an IGBT. The sensing circuit has four external connection nodes (VS, GATE, CS, COM) and includes (see **Figure 2**): a 600V MOSFET (HVFET); an RC-delay circuit (R1, C1, D1); and a PMOS hold-down transistor (Q1). The circuit does not require a VCC supply node and instead utilizes the existing gate drive signal for powering and turning the circuit on and off. During the off time of M1, the gate drive signal is at COM, the HVFET is off, Q1 is on, and the CS node is held at COM.

Since HVFET is off, any high voltage occurring at the drain of the power MOSFET will be safely blocked by HVFET from the rest of the low-voltage circuitry. When M1 is turned on by the gate drive signal, the drain voltage of M1 will decrease to a level given by the current flowing through M1 multiplied by the $R_{DS(on)}$ of M1. After a short delay time set by the RC-delay block, the gate voltage of the HVFET rises up and turns the HVFET on. Q1 turns off, therefore releasing the CS output node. The drain voltage of M1 is then transmitted across HVFET to the CS output node. The voltage at the CS node then becomes the desired current-sensing signal from the $R_{DS(on)}$ or $V_{CE(on)}$ of M1.

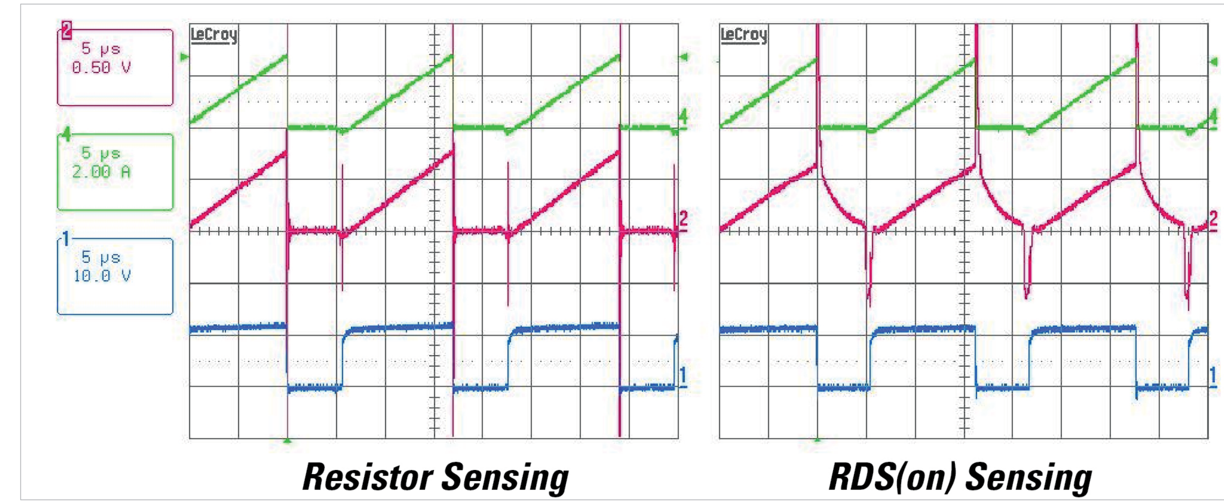

Figure 3: Resistor vs. RDS(on) current sensing waveforms. Switch drain current (upper trace), CS measurement (middle trace), gate drive signal (lower trace). Resistor = 0.27ohms, MOSFET RDS(on) = 0.25ohms.

When the gate drive signal of M1 goes low again, M1 turns off. The gate of HVFET gets discharged quickly through D1 and HVFET turns off to once again block any high voltage occurring at the drain of M1. The CS output node is then held at COM again through Q1. Assuming the drain of M1 is a typical high-voltage switching node that is connected to an inductor, the voltage signal produced at the CS output node will be the same sawtooth waveform that would result from using a traditional current sensing resistor placed at the source of M1. The CS output node can then be fed to a comparator circuit or other desired current-sensing functions of a PWM controller or MCU circuit.

The measured waveforms (see **Figure 3**) show the functionality of the new circuit and the desired current sense signal at the CS node at room temperature. Compared to the conventional resistor sensing method, both methods match

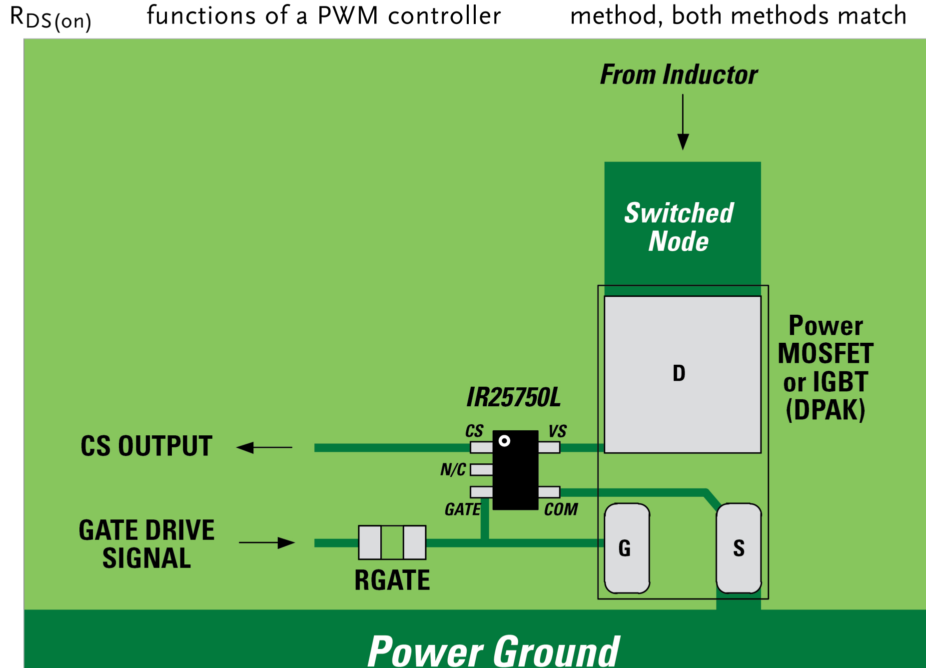

Figure 4: IR25750L typical surface-mount pcb layout.

the actual current shape and both exhibit noise spikes due to switching. Proper filtering or digital blanking of the final PWM or MCU current sensing circuit will easily ignore these noise spikes to prevent any false triggering. Also, it is well known that the $R_{DS(on)}$ of the power MOSFET will increase with increasing ambient temperature and therefore cause an error in the CS measurement. Therefore, on-going application work is currently being done to compensate for temperature with additional circuitry.

Since no VCC node is required for this circuit, the pcb layout becomes very simple to design (see **Figure 4**). The new current sensing circuit has been realized in a tiny SOT-23 IC, the IR25750L. The IR25750L can be placed conveniently next to the power MOSFET or IGBT and connected easily to the existing pcb traces that are already used for the power switch (GATE, DRAIN, COM). Only the CS trace needs to be routed back to the main PWM controller or MCU of the power supply.

Conclusion

The IR25750L current sensing IC offers a novel method for sensing current and eliminating traditional series-configured current sensing resistors or current transformers. This parallel-connected configuration and small SOT-23 package enables ease of pcb layout and routing, especially if several switches are being monitored. The uses for this new current-sensing device spans across all applications of switched-mode power electronics and the benefits of eliminating cost, shrinking board space, reducing power losses, and increasing overall efficiency are enormous.

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Semiconductors as key components in the smart grid

Addressing communication and security issues is key

By: Martin Schulz, Infineon Technologies

The classical, centralized power supply grids today face a transition into a so-called smart grid. This smart grid can be understood as a system of systems or the sum of interlinked minigrids with massively decentralized energy generation, storage and consumption. Though today's large-scale power plants will remain the major backbone of these grids for the years to come, the change will allow the more efficient use of a growing portion of renewable energies, finally eliminating the usage of fossil fuels and nuclear power. Besides the power generation and transmission, storing of energy, communication and security issues will be part of this change, making semiconductors in all ranges the dominant key component of these new megastructures.

Transition to smart grid

Centralized power generation as done today benefits from plants with huge power densities that predictably operate on demand. Regulation strategies are well established and throughout the last 50 years, an interconnected European power grid grew to become one of the most complex technical achievements. Generators, rotating at fixed frequencies and controlled using the external excitation, provide stable frequency, constant voltage and the amount of reactive power needed.

With the urge to make use of renewable energy to fight global warming and reduce CO_2 emissions, windmills and solar arrays started to become a growing fraction of power sources. However, both generate electricity stochastically, depending on the availability of their particular primary energy. As their output voltages are of fluctuation nature and in case of solar cells are of DC-character, power electronic became necessary to transfer the power delivered into a form that can be fed into the grid.

Inverter Technology based on Insulated Gate Bipolar Transistors (IGBT) became the industrial standard for this particular task. Additionally, the transport of and use of electricity will change in a smart grid compared to today. Locally generated power will be used locally, thus eliminating the losses during transportation. Energy storage will at least partially compensate the lack of continuity in power generation. This will contribute to cutting peak power demand. At the same time, transport across long distances has to be achieved at maximum efficiency to interconnect offshore wind parks to the continents or transfer energy on a global scale as envisioned in the Desertec Project. This is the domain of High Voltage Direct Current power transmission (HVDC), a typical application for thyristors and bipolar diodes.

Regenerative energy generation

Sun, wind and biomass are three major sources of renewable energy to generate electricity. Especially photovoltaic solar applications and wind power plants benefit from the use of power electronics.

Photovoltaics

PV-Collectors generate a DC-voltage and the magnitude of output power is a function of

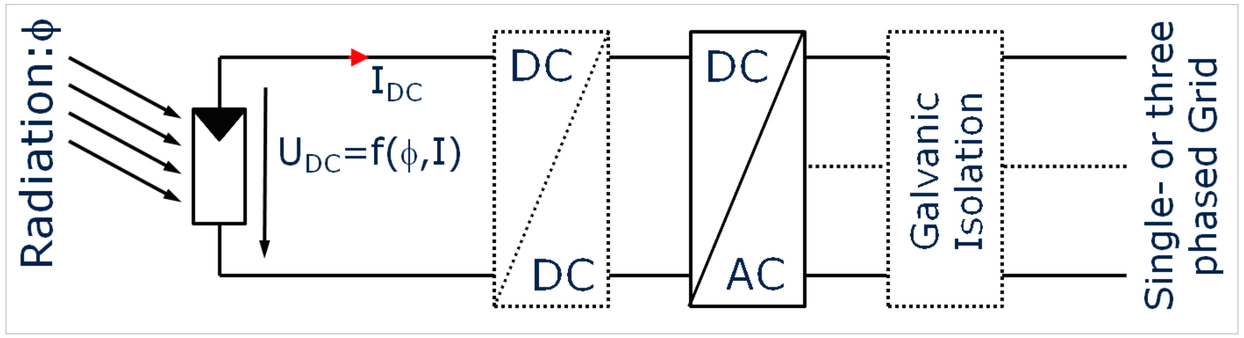

Figure 1: Schematic view to a solar power plant

solar radiation. To feed energy into the grid, a minimum voltage level is required. Furthermore, the DC-voltage has to be transferred to an AC voltage compatible to the mains. This is a classical task for power electronic components. Schematically, **figure 1** hints out the blocks, a solar power plant may consist of. The dashed lines denote optional components. The DC-AC-converter is a mandatory component and essential to generate a grid-compliant AC output.

Today, solar plants are installed from several hundreds of watts up to the megawatt scale. This requires a wide range of power semiconductor components. The driving force in improving existing solar inverters for the European market during the last years has been advancement in system efficiency. Modern solar converters thus have reached maximum efficiencies of more than 98%.

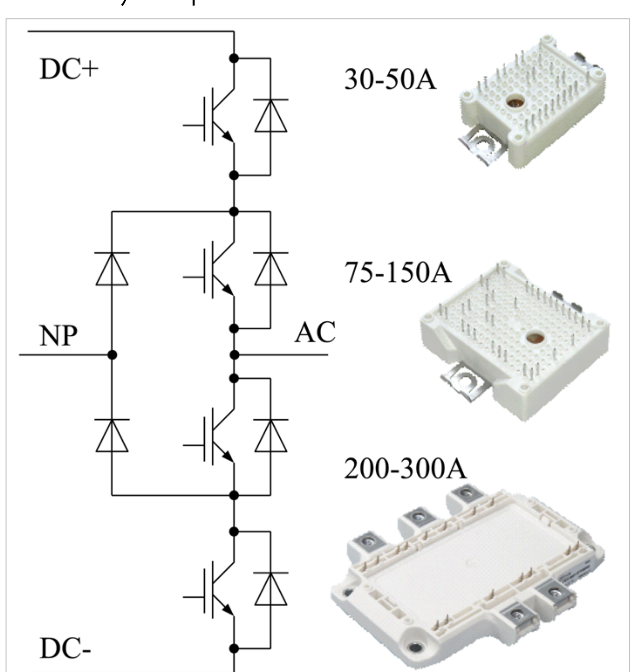

Figure 2: 3-Level NPC-1 topology and power semiconductors from 30 to 300A to support the design of 3-level converters

Recently, a visible trend is the step away from 2-level converters towards multilevel topologies. Mainly the 3-level inverter is more and more in focus. The so-called Neutral Point Clamped (NPC)-topologies are preferred in higher power levels. This leads to systematic advantages regarding electrical losses and physical sizes of wound goods in filter components. **Figure 2** depicts the often-used NPC-1 topology which is well established in solar inverter designs. It is predestined for a power range up to several hundreds of kilowatts.

Wind Energy Generation

In 1983, German energy provider RWE was involved in building the first 3MW windmill Grosse Windkraft Anlage (engl.: Large Windmill System) called Growian. It used a Leonard Converter to feed energy to the grid. Today, windmills feature output powers of up to 6MW per device. Double fed induction generators coexist with synchronous machines. Both, permanently and separately excited machines are in use.

Special requirements for the power electronics in use arise from the wide variety of boundary conditions as well as lifetime and availability of the installations. Depending on the location, the power plant may be subject to ambient temperatures from –30°C in cold regions to +50°C in warmer zones. Relative humidity can exceed 90%, sulfurous atmosphere, salty mists and dust in deserts are factors that have to be considered in power electronic design too. Especially components mounted in the nacelle or even the hub suffer from vibration, leading to further stress for the power semiconductors.

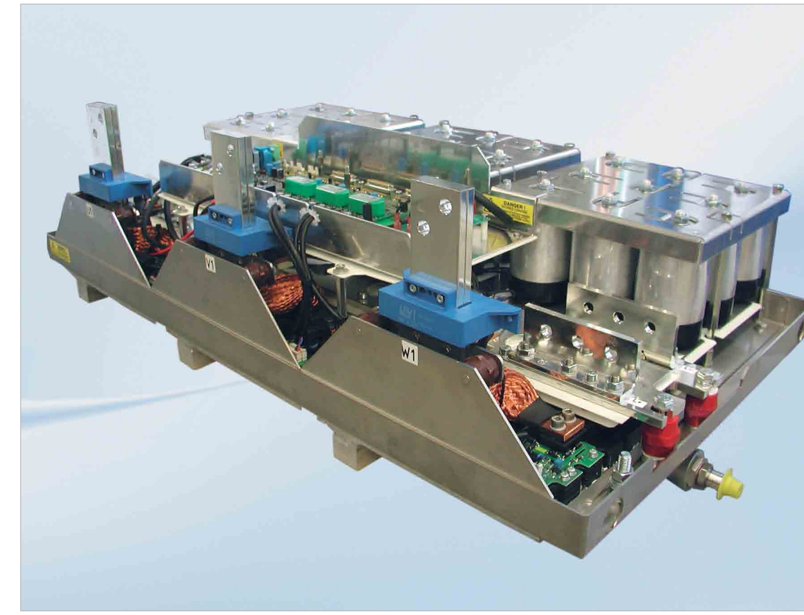

Figure 3: Stack assembly for a wind power application with 2MW throughput.

The electrical interface between generator and grid can be designed on module- or subsystem level. The power electronic subsystem, or Stack, can be considered an off-the-shelf component, available in power ranges up to megawatts. **Figure 3** gives an impression of a MODStack HD, designed for a throughput of 2MW. In this application, the most important thing to care for is robustness. The predicted lifetime is demanded to reach 20 to 25 years along with a warranted availability of 97%.

Energy transport

One of the major challenges coming with the extended use of regenerative energy is the geographic distance between the point of generation and the area where the energy is finally needed. Transferring energy from an off-shore windfarm in the North Sea to the industrial centers in the middle or even the south of Europe comes with two separated difficulties. Besides political aspects, the extension of the grid infrastructure is an obstacle to overcome.

Using AC-voltage to transfer energy over long distances is not a viable option. The losses that occur will make this a non-ecological approach. Starting from some hundred kilometers, High Voltage Direct Current (HVDC) transmission is to be favored. DC-transmission is most efficient in both, electrical losses and material in use as it can be done on a single-wire setup. HVDC is well established and, among others, connects England to the European continent via cable.

Core of these transfer systems are semiconductors in disc

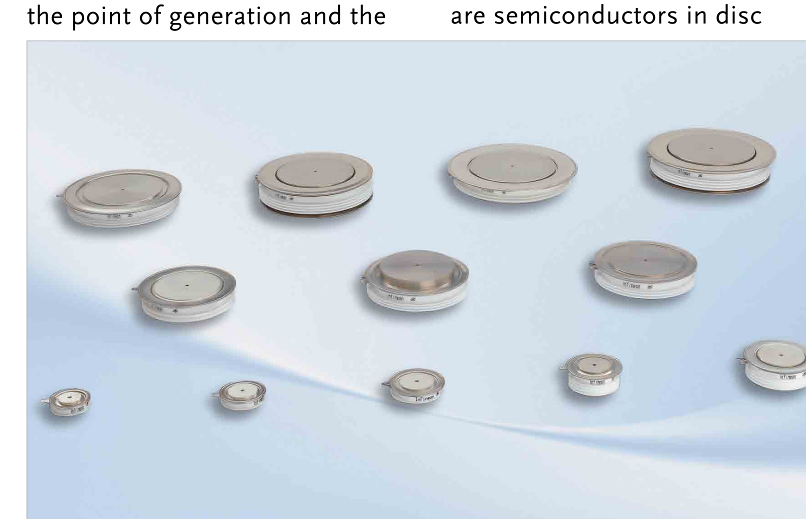

Figure 4: Disc-shaped thyristor and diode devices

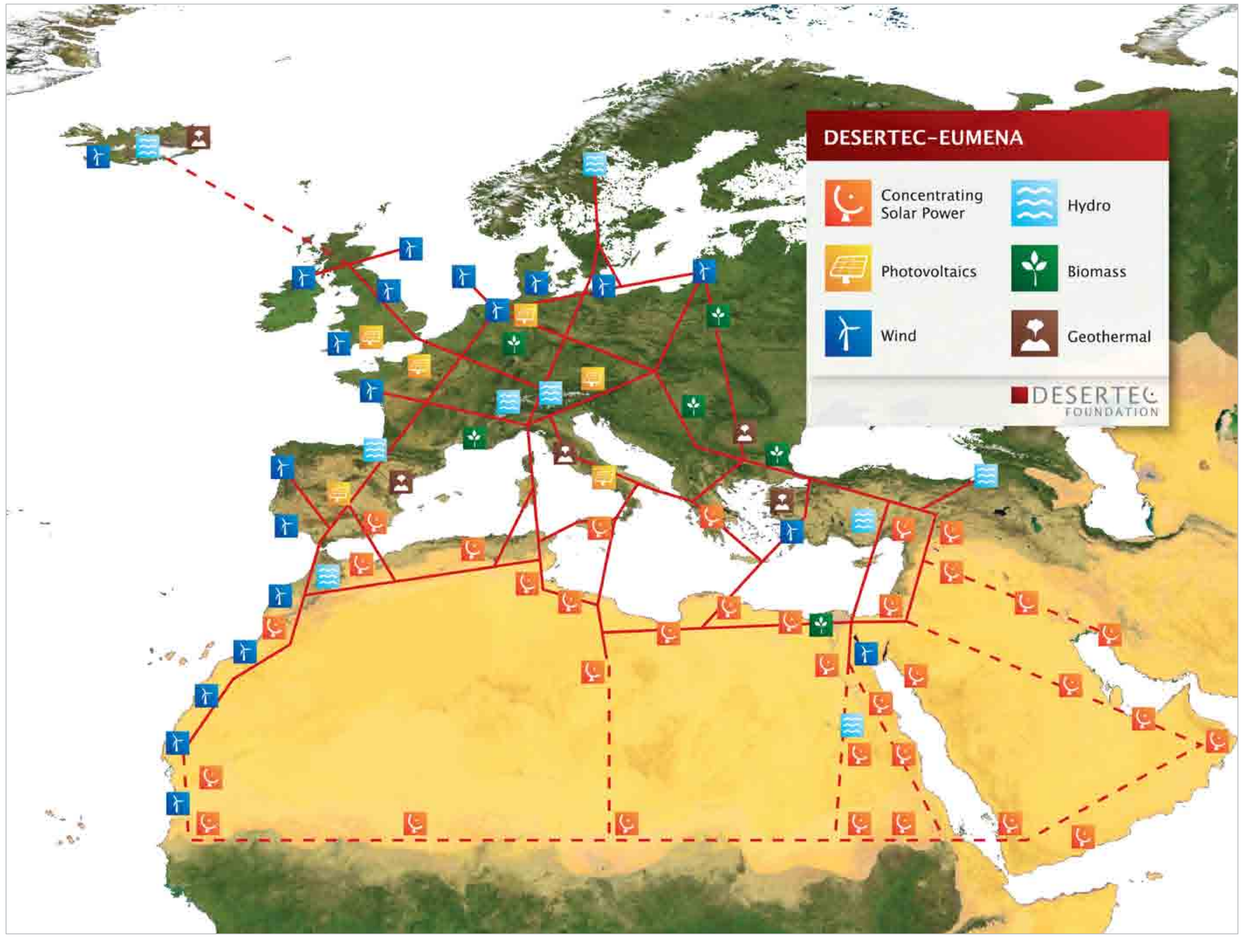

Figure 5: A transcontinental energy grid, Source: Desertec Foundation

designs. Thyristors and diodes are installed to transfer energy in a GW-range using bipolar DC-voltages of up to ±800kV. Today, the converter needed to create an AC-voltage from this DC-line is based on thyristors as well. **Figure 4** gives an overview on this kind of devices.

Currently, research is ongoing to use IGBT-based multilevel converters to replace the thyristors in the DC-AC converter. Here too, efficiency is the driving force. Expanding the interconnection beyond European borders would allow integrating the regions with the highest energy yield, North Africa and Middle East, into a transcontinental grid. The vision of the Desertec Project pictured in **figure 5** clearly shows, that thousands of kilometers would have to be crossed. In this vision, HVDC becomes the technology of choice for the necessary long-distance connections.

Conclusion

Power electronics both in module and disc design, is a mostly unrecognized part of the already existing supply network. New applications in Smart Grids demand innovative approaches to enhance efficiency and increase power density to build smaller power electronic devices. Especially mobile and electric vehicle applications demand low weight and volume and even in private houses, space is not necessarily available in excess. Furthermore, supply networks are expected to achieve a very long lifetime, especially if compared to classical consumer electronics. Robustness and longevity will be the most pressing needs to be fulfilled.

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Advanced T-type NPC- 3 level modules: A novel possibility with RB-IGBT's

A new device structure targets design engineers and program managers looking for the next big game changer

By: Nitesh Satheesh and Terry Takaku, Fuji Electric

A novel IGBT structure was developed with reverse-blocking capabilities comparable to the forward voltage rating of the IGBT. This new device, known as the RB-IGBT, was used to create a 3 level advanced neutral point clamping power converter that shows better loss characteristics than standard 3 level converters.

The results of loss comparisons performed have been presented along with an application where this new structure has helped improve performance. The presentation is targeted at design engineers and program managers looking for the next big game changer.

Energy is an issue that affects every person on the planet. With the advancement of the Human Race, Energy Dependence has increased and this has strained the Earth's natural resources. To make better use of the available resources, numerous efforts have been made to improve existing technology and change the way new products and made and used.

Fuji Electric has always been on the forefront of Energy innovation. Our operating philosophy is creation of responsible and sustainable societies through innovation in Energy Technology. In keeping with our long-standing history, innovating and bring to the world advanced solutions which serve the global effort toward a brighter and healthier tomorrow.

RB-IGBTs

Fuji Electric has pioneered this change in the field of Power Electronics, most recently with the introduction of RB-IGBT's (Reverse Blocking Insulated Gate Bipolar Transistor). The RB-IGBT was developed for use in Matrix Converters, but we have been expanding its target application areas, which now include Current Source Inverter for Motor Drives (EV/ HEV) and 3 level inverters for PV, Wind and UPS.

RB-IGBT's use in the Advanced T-type NPC (Neutral Point Clamping) 3 level modules give energy efficiency a whole new meaning. The intention of this article is to shed light onto this innovation and expand its use in the market.

Device Structure

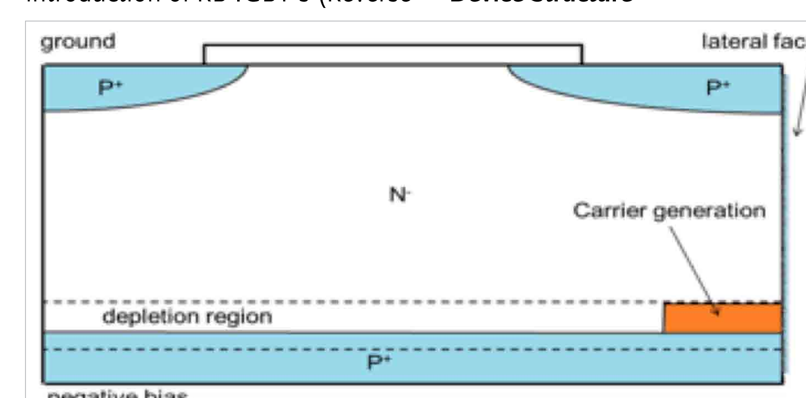


Figure 1: Cross section – Conventional IGBT

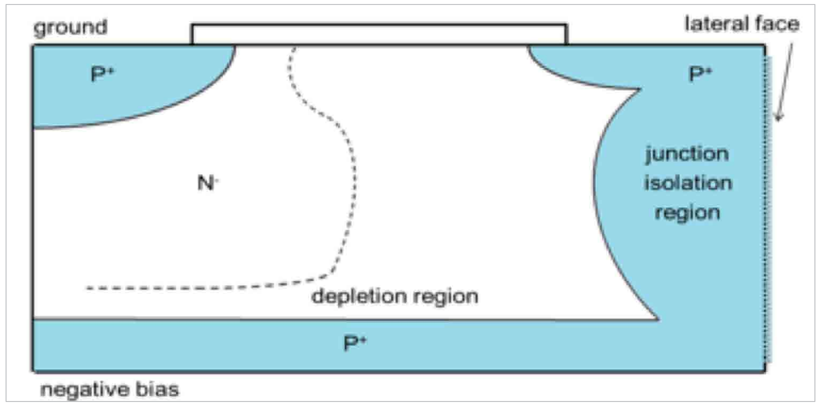


Figure 2: Cross Section – RB – IGBT

A conventional IGBT has forward and reverse blocking capability. So theoretically, we can use the IGBT to block reverse voltages equivalent to the IGBT forward voltage rating. However, practically, this is not true. Under reverse bias, there is a leakage current, the dependence of this current on reverse voltage is exponential.
The primary difference in structure between the Fuji RB-IGBT & a conventional IGBT is that the former has deep junction isolation structure that limits carrier generation thereby providing the needed (higher) reverse blocking capability. **Figure 1** below shows the cross section of the conventional IGBT and **Figure 2** that of the Fuji RB-IGBT.

There are other ways to achieve reverse blocking – Halo Implants (Selective implantation), passivized sidewall, post treatment of diced IGBT dies to heal the crystal lattice, etc. All the mentioned methods however are not commercially viable and Fuji research found the implanted junction isolation region to be the technology of choice.

The first question to be answered is why there is carrier generation at the lateral face junction and how the junction isolation helps. At the Collector-Drift PN junction, the collector region is more heavily doped, so under reverse bias, the depletion region extends further into the drift region that the collector region.

In a conventional IGBT, this extension extends only part way into the drift region. This combined with the fact that mechanical dicing of the IGBT die damages the crystal lattice, creating carrier generation hot spots. The generated carriers with enough energy enter the drift region and contribute to the leakage current. As the reverse bias increases, the carrier energy increases thereby increasing leakage current.

In the Fuji RB-IGBT, the introduction of the junction isolation region, isolates the crystal lattice defects from the drift region. The E-field also changes significantly and the concave curvature of the junction isolation region helps achieve the required Reverse breakdown voltage.

Performance
The forward characteristics of the RB-IGBT are very similar to that of a standard IGBT. Therefore switching speed and trade-off curve of V_{on} are similar. **Figure 3** shows the reverse characteristics of a conventional IGBT as compared to a RB-IGBT.

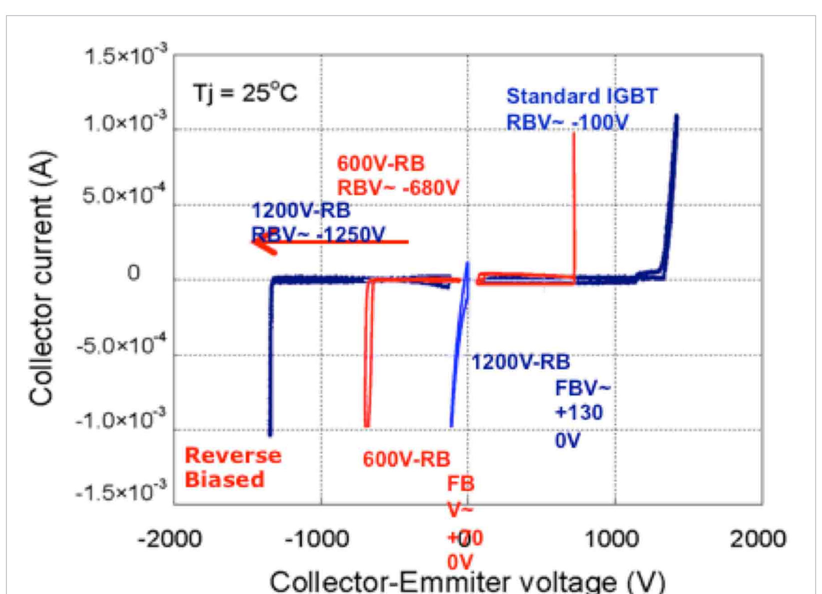


Figure 3: The advantage of using RB-IGBT's – The reverse blocking capability.

Figure 4 shows the $V_{ce(sat)}$ v/s E_{off} tradeoff relationship for the IGBT+FWD & RB-IGBT. There is a significant improvement in $V_{ce(sat)}$ at the same E_{off} levels.

Figure 5 above shows the implementation of an AC-Switch. 5(a) is the AC switch implementation using a conventional IGBT, this requires 4 dies (2 IGBT + 2 FWD). 5(b) is the RB-IGBT implementation, which requires only 2 dies (2 RB-IGBT's).

Multilevel inverters
Multilevel Inverters have been in discussion from the early 1980's. Their end goal is to reduce inverter harmonics and thereby reduce use of magnetic components. An added advantage is reduced losses, with the introduction of NPC, TNPC & ATNPC (Advanced T-type Neutral Point Clamp) topologies.

A direct application of the Fuji RB-IGBT is the Advanced T-type Neutral Point Clamped module. The T-type modules in existence/ those offered by our competitors use the conventional AC-Switch shown in 5(a). More components means more losses and more chances of failure. A loss comparison is presented in the next section that details the performance of the 2-level inverter, 3 level NPC inverter, Advanced NPC 3 level inverter and the Advanced T-type 3 level inverter. **Figure 6** shows the different inverter topology phase legs that are used for comparison.

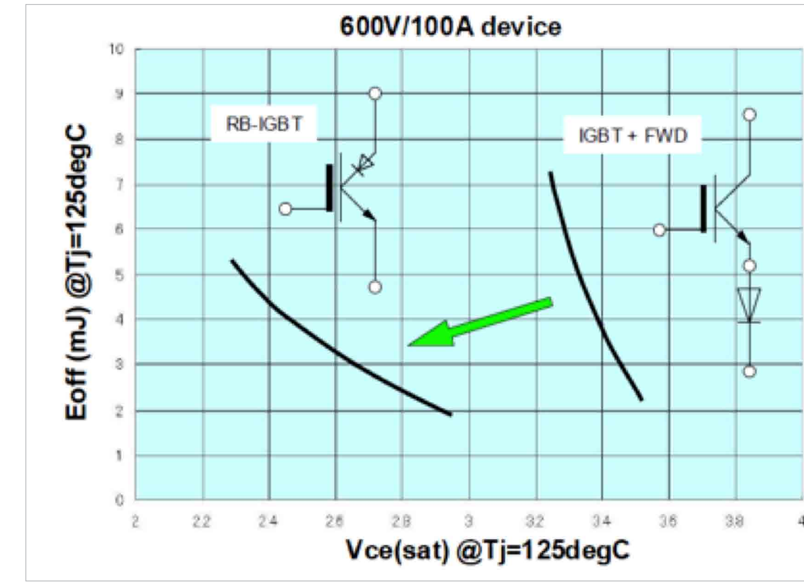


Figure 4: Trade-off relationship of RB-IGBT and IGBT + diode.

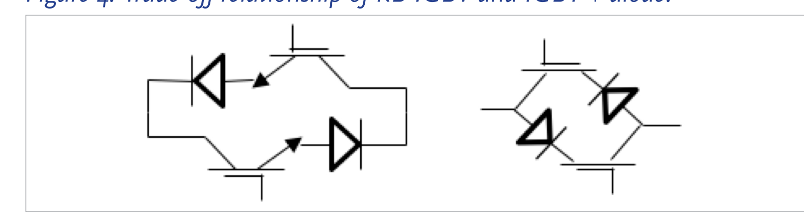


Figure 5: (a) Conventional AC-switch (b) AC-switch with RB-IGBT

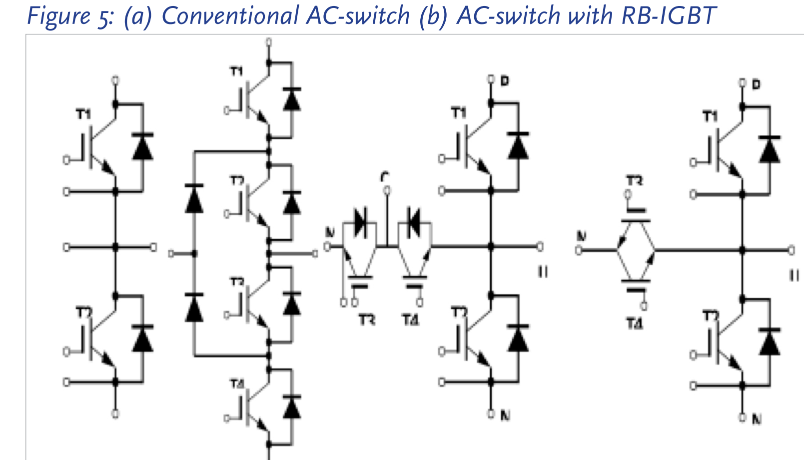
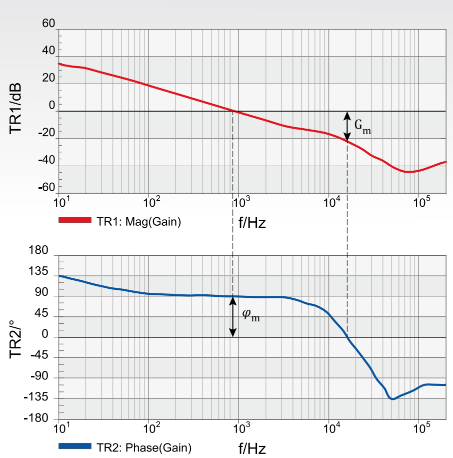


Figure 6: Inverter Topologies

The loss comparison (see **Figure 7**) is made at the following conditions:
Fsw = 10 kHz; Vout = 400 VAC; Iout = 145 A; PF = 1; DC Link Voltage = 660V.
The 2-level inverter has the highest loss among the 4 topologies, thereby having the lowest efficiency. The AT-NPC on the other hand has the least loss and therefore the highest



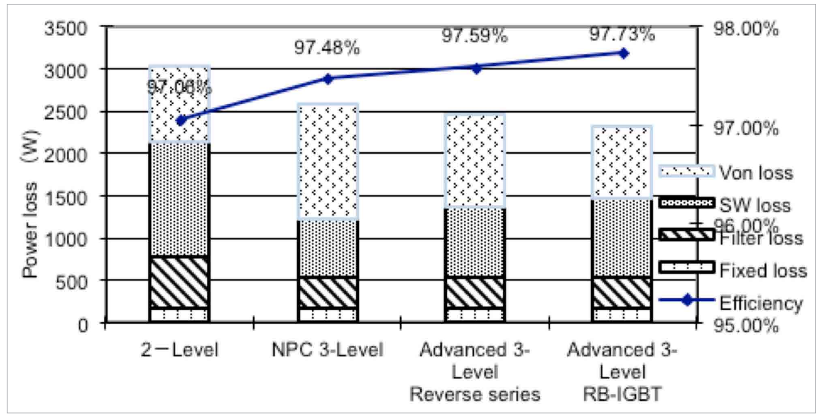


Figure 7: Loss comparison of different inverter topologies

Figure 8: Before and after

efficiency. With the NPC 3-level and ANPC 3-level modules, there is a higher Von loss compared to the 2-level inverters due to the increased number of IGBT's. With the AT-NPC, there is a trade-off between switching loss and Von loss.

Applications

Figure 8 shows the implementation of a conventional IGBT in a classic 2 level configuration in a 500 kVA UPS v/s the application of RB-IGBT in the Advanced T-type configuration for the same application. There is a significant performance improvement with an efficiency increase of 2% from 95.1% to 97.1%. There is also an added benefit of a 33% volume reduction, weight reduction of 36%, due to the reduction in filter components & magnetics. Target application areas include matrix converters, current source inverters for motor drives (EV&HEV), and level Inverters for PV, Wind and UPS.

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Understanding ErP II compliance for external PSUs

The second stage of legislation intended to reduce power consumption for electronic equipment has come into force.

By: Craig Eaton, Ideal Power

There have been numerous changes to the EU's directives and regulations concerning the efficiency of electronic devices in recent years, particularly concerning standby power. The Eco Design directive, 2009/125/EC, is the all-embracing directive intended to improve the energy efficiency of all energy related products (ErP). It's a revision of the directive formerly known as the energy using products (EuP) directive, 2005/32/EC. The goal of this directive is to reduce the energy consumed by ErP by 20%, by 2020; high efficiency external power supplies can help achieve this.

As part of the ErP directive, EC 278/2009 is the regulation that specifically concerns an external power supply connected to electrical or electronic equipment in a household or office. This regulation restricts an external power supply's maximum no-load power consumption, that is, its power consumption when the power supply is connected to the mains but the output is not connected to any primary load. The regulation also restricts the average active efficiency of the power supply, which is intended to ensure the efficiency of the supplies while they're in use. A power supply's average active efficiency is calculated by measuring its efficiency when it's at 25%, 50%, 75% and 100% of full load and averaging the four numbers.

New limits for both these criteria were introduced with Stage II of the ErP directive came into effect for anything placed on the market after 27 April 2011. The maximum no-load power consumption was previously 0.5W, but has been reduced to 0.3W for AC-DC power supplies with rated power below 51W. Above 51W output power, the limit is 0.5W.

A summary of the requirements for Stage II for minimum average active efficiency is shown in **table 1**. Different criteria apply for 'low voltage external power supplies', defined as those with a rated DC output below 6V and above 550 mA.

Does your system comply?

If you're designing a piece of electronic equipment that uses an external power supply, it would be wise to consider whether that external power supply is compliant to ErP Stage II. Aside from the technical requirements, the manufacturer of the external power supply must have a conformity system in place to compile a declaration of conformity (DoC). To do this, they must keep technical documentation, including test results showing the product

	AC-AC and AC-DC external power supplies, except low voltage external power supplies	Low voltage external power supplies
$P_O \leq 1.0$ W	$0.480 \cdot P_O + 0.140$	$0.497 \cdot P_O + 0.067$
$1.0 \text{ W} < P_O \leq 51.0$ W	$0.063 \cdot \ln(P_O) + 0.622$	$0.075 \cdot \ln(P_O) + 0.561$
$P_O > 51.0$ W	0.870	0.860

Table 1: The minimum average active power for Stage II of the EC 278/2009 regulation as they relate to external power supplies. Po is the rated output power of the power supply

Figure 1: The no-load efficiency of Ideal Power's 25HK-AB series has been increased to meet ErP II regulations

meets the average active efficiency and no-load power consumption requirements, which must be available for ten years after the product was manufactured. They must also mark the product with the CE mark to show that it complies to all the relevant European standards. If the manufacturer is outside the EU, this responsibility falls to whoever imports the product.

Compliant Products

Part of the reason for introducing the requirements in stages is to allow manufacturers time to redesign their products to meet the new constraints. Ideal Power has done exactly that for all external power supplies, including the 25HK-AB, 25HK-AJ and 25HK-U series, shown in **figure 1**. Several changes were made in order to meet ErP Stage II.

Firstly, the pulse width modulation (PWM) controller that controls the switching frequency of the components inside the power supply has been upgraded to one with a frequency foldback feature. This feature helps to maximise the power supply's efficiency at low-load, for example, when the equipment being powered is in standby mode. As the load drops, the PWM controller reduces the switching frequency, which helps reduce switching losses in the power components and therefore increase efficiency.

The PWM controller also has a pulse-skipping mode, which is a way of reducing the switching frequency even further, for maximum efficiency when the load is very low.

Secondly, the cross-sectional area of the output cable has been increased, and for some members of the product range, the output cable length was decreased as well. This helps to reduce the resistance of the cables, meaning less energy is wasted, contributing to the overall efficiency.
The output power for this series is 6-30W with a variety of output voltages and currents to choose from. The units can be supplied in either desktop or plugtop configuration, to suit the application's requirements. An 8-way DC connector set is supplied with the –CP versions.

Getting help

In summary, external power supplies must comply with the more stringent Stage II of the ErP directive, under regulation EC 278/2009, in order to qualify for a CE mark. When buying external power supplies, they should come with a statement of compliance for CE marking.

If you're confused about these requirements, or about EC 1275/2008 (which relates to the power consumed by electrical or electronic household or office equipment) or EC 617/2013 (which specifically relates to computers and computer servers), Ideal Power can help clarify the situation.

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Medical power supplies and capacitor choices

Performance demands land heavily on the power supply designer

By: Danielle Sklepik, BEAR Power Supplies

Operating rooms and clinical settings are crowded with instruments that pack in more functions and features every year, such as surgical tools with lights, lasers and video microscopes. The pressure for them to be smaller, lighter and easy to move around continues to grow. Since the AC-DC converter is often the largest component in an instrument, this pressure lands heavily on the power supply designer.

The drive to minimize the size of the power supply conflicts with the imperative for reliability. This leads to some interesting challenges in specification development, component selection and board layout.

Many medical equipment OEMs market and sell their products worldwide. Rather than create different versions for different regions, they require the AC/DC converters to accept a universal input voltage, that is, 90-264VAC. This AC input is rectified to a DC voltage of 127-373V using the formula

$$V = V_{rms}\sqrt{2}$$

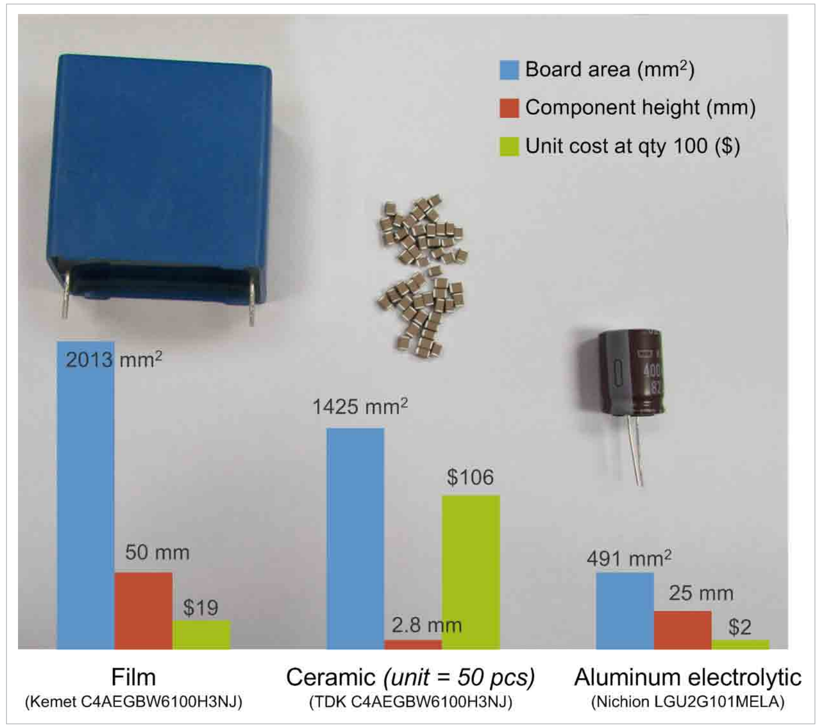


Figure 1: Component height, board space and cost for 100 μF of capacitance with common capacitor types, rated for more than 373 V.

which means the rectifier circuit requires capacitors that are rated for more than 373V. A full-wave rectifier circuit will typically need 100μF to 400μF of capacitance, which makes aluminum electrolytic capacitors the only real choice due to cost and size (see **Figure 1**).

Specifically:

A 100μF aluminum electrolytic capacitor rated for 400V is available in a 25mm dia. x 25mm tall through-hole package, costing $2 to $5. Ceramic capacitors rated for 450V are available, but the maximum capacitance is 2.2μF. You would need to use 50 of them to get 100μF, for a cost of $50 to $100. A 100μF film capacitor rated for 400V costs about $20 and measures a whopping 56 x 33 x 49 mm.

Compensating for the drawbacks of aluminum electrolytics

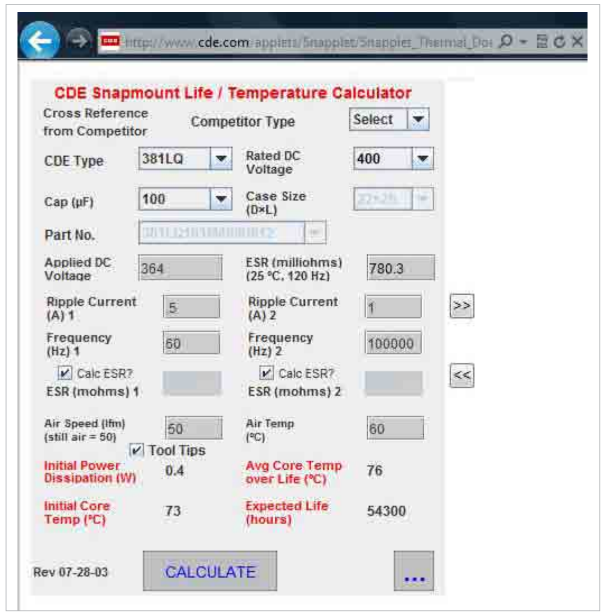


Figure 2: An online calculator shows the effect of ripple current and temperature on capacitor expected life.

The requirement to use aluminum electrolytic capacitors means that the capacitors will be the life-limiting component of a medical power supply. These capacitors contain a liquid electrolyte that dries up over time, even sitting on the shelf. Wear-out is the most common failure mode, with gradual conversion to an open circuit as the device becomes increasingly resistive.

There are a several things a power supply designer can do to compensate for this and create a reliable, long-life and compact power supply. The most obvious is to choose a capacitor with the longest rated lifetime. "Long life grade" capacitors come with lifetime ratings as high as 12K hours, but those rated for 400V give you only a few nanoFarads in very large packages, so we usually have to settle for 2K to 4K hours.

Next, you can choose a capacitor that has a higher temperature rating and a higher ripple current rating than you think you will need. A component rated for 85 °C may seem sufficient for the hospital environment, where the worst-case specification is typically 0°C to 60°C, but a capacitor rated for 105°C will have a longer life at the same temperature. It will also be larger, and more expensive.

Likewise, a capacitor with a 2A ripple current rating will last longer than one with a 1A rating, even if you expect less than 1A ripple current.

With these choices, you can significantly increase the expected life of a capacitor. Using one online calculator (see **Figure 2**) shows that a selected capacitor rated for 2K hour life at 105 °C and 1 A ripple current will have an actual expected life of more than 54K hours when used at the lower 60 °C and 0.5 A ripple current.

Here, a 100µF / 400 V capacitor rated for 2K hours at 105°C and 1A ripple current is shown to have an actual expected life of >54K hours when used at a lower temperature (60°C) and ripple current (0.5 A), with applied voltage of 364 V DC.

Other ways to maximize MTBF

Another approach to maximizing power supply MTBF is to over-spec the power requirement. It was once common to specify a 100W supply when 50W was needed for the application, in the effort to increase the usable life of the converter as the capacitors aged and the power dropped below the 100W specification. Among the drawbacks of this approach is that converters of 75W or more require power factor correction, increasing the board size and cost.

Today's components have improved and this technique is no longer needed. It's better to specify a 50 W supply for a 50 W application, as long as you make sure to consider the tolerances of all components, not only when they are new but also at the end of the power supply's intended lifetime.

For example, stacking up the tolerances of all components including the capacitors, transformer, and ICs, you may conclude that designing for an initial low-end input of 86 VAC would be acceptable for a universal input spec of 90-256VAC. However, considering the tolerances of all the components at the target MTBF of the power supply gives a different result. At BEAR Power Supplies, after considering the tolerance stack-up and adding a safety margin, we typically design to something closer to 80VAC for the low-end input of medical AC/DC converters at their end of life. This is typically 5000 to 7500 hours, which may be four hours a day for five years for instruments such as surgical tools, or 12 hours a day for two years for products like infusion pumps.

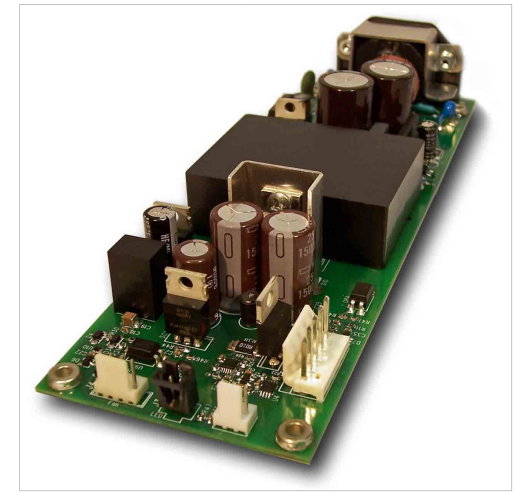


Figure 3: Custom 75 W dual-output AC/DC medical power supply has a CF-rated output with capacitance of less than 15 pF.

Fitting capacitors into limited space

Fitting the capacitors into the smallest board space is the next challenge. Choosing taller, smaller-diameter packages is usually best. However, we often have a 30 mm height constraint on the complete assembly, so we are limited to the 25 mm tall aluminum electrolytics and need to use several of them to get enough capacitance.

Leakage current and capacitance

Next you need to consider the constraints on the leakage current for patient safety. This is the current that flows from the primary to the secondary of the power supply unit. IEC standard 60601-1 revision 3 specifies the maximum leakage current for medical power supplies, depending on the type of medical use. A CF-rated device is one which may come into internal contact with a patient, such as a surgical tool. A BF-rated device is one which may come into contact with a patient's skin. Because the skin provides some protection against a leakage current, the limit is higher. The leakage current will be determined by the capacitance between the primary and secondary, and translates to a maximum capacitance of 92 pF for universal input CF-rated supplies.

If the device will be used in an operating room, you may need to meet even lower capacitance specs to withstand the application of a defibrillator. When the high voltage of the defibrillator is applied across the heart, any instrument that may potentially remain in contact with the patient must not provide a path to ground through the power supply, which would render the defibrillator ineffective and cause serious injury at the point of contact with the instrument. We have designed power supplies with capacitance between input and output lower than 30 pF for this purpose.

When calculating the capacitance, you must include the inherent capacitance between the primary and secondary windings. With traditional winding techniques, this is typically 100 - 200pF for converters between 50W and 250W, which is higher than the CF limit, so you need to use creative winding techniques.

Capacitors and EMI

Another common design technique is to add a Y1 capacitor, typically around 2.2 nF, between the primary and secondary to reduce EMI. While this is a simple solution for EMI, it will result in too much leakage current to meet the IEC 60601-1 requirement. You will have to carefully consider the board layout and look for other ways to mitigate all sources of EMI. Experienced power supply designers have developed a number of innovative isolation techniques and create custom medical power supplies of more than 600 W with leakage current less than 5 µA (see **Figure 3**).

Capacitor choice is a key aspect of medical power supply design. With experience and careful consideration, you can maximize MTBF, minimize board size, and meet patient safety requirements. The CF-rated output can be switched off, leaving a separate BF-rated output active to power electronics used in the vicinity of a patient. (BEAR Power Supplies)

www.bearpwr.com

Low power design – how low is enough?

Designers continue to demand more power in their products to support increased functionality

By: Tony Armstrong, Linear Technology

The portable power application space is both broad and diverse. Products range from wireless sensor nodes (WSNs) that consume average power measured in microwatts to cart-based medical or data acquisition systems with multi-hundred Watt-hour battery packs. However, despite this variety, a few trends emerge – designers continue to demand more power in their products to support increased functionality and look to charge the battery from any available power source.

Consider modern handheld devices – both consumer-oriented devices and industrial devices may include a cellular phone modem, a Wi-Fi module, a Bluetooth module, a large, back-lit display ... the list continues. The power architecture of many handheld devices mirrors that of a cell phone. Typically, a 3.7V Li-Ion battery is used as the primary power source due to its high gravimetric (Wh/kg) and volumetric (Wh/m3) energy density. In the past, many high powered devices used a 7.4V Li-ion battery to reduce current requirements, but the availability of inexpensive 5V power management ICs has pushed more and more handhelds to the lower voltage architecture.

The tablet computer illustrates this point well – a typical tablet computer incorporates significant functionality along with a very large (for a portable device) screen. When powered from a 3.7V battery, the capacity must be measured in thousands of milliamp-hours, for example 2200mAh. In order to charge such a battery in hours, thousands of milliamps of charge current are required.

However, this high charge current does not prevent consumers from also wanting to charge their high-powered devices from a USB port if a high current wall adapter is not available. To satisfy these requirements, a battery charger must be able to charge at a high current (>2A) when a wall adapter is available, but still efficiently make use of the 2.5W to 4.5W available from USB.

Furthermore, the product needs to protect sensitive downstream low voltage components from potentially damage-causing overvoltage events and seamlessly direct high currents to the load from a USB input, a wall adapter or the battery while minimizing power loss. This represents an excellent opportunity for battery IC manufactures to develop an IC to safely manage the battery-charging algorithm and monitor critical system parameters.

At the other end of the power spectrum are the nanopower conversion requirements of energy harvesting systems such as those commonly found in WSNs that necessitate the use of power conversion ICs, which deal in very low levels of power and current. These can be 10s of microwatts and nanoamps of current, respectively.

An energy-harvesting WSN

There is plenty of ambient energy in the world around us and the conventional approach for energy harvesting has been through solar panels and wind generators. However, new harvesting tools allow us to produce electrical energy from a wide variety of ambient sources. Furthermore, it is not the energy conversion efficiency of the circuits that is important, but more the amount of "average harvested" energy that is available to power it.

For instance, thermoelectric generators convert heat to electricity, Piezo elements convert mechanical vibration, photovoltaics convert sunlight (or any photon source) and galvanics converter energy from moisture. This makes it possible to power remote sensors, or to charge a storage device such as a capacitor or thin film battery, so that a microprocessor or transmitter can be powered from a remote location without a local power source.

In general terms, the necessary IC performance characteristics needed for inclusion and use in the alternative energy market include the following:

- Low standby quiescent currents – typically less than 6μA and as low as 450nA
- Low start-up voltages – as low as 20mV
- High input voltage capability – up to 34V continuous and 40V transients
- Ability to handle AC inputs
- Multiple output capability and autonomous system power management
- Auto-polarity operation
- Maximum Power Point Control (MPPC) for solar inputs
- The ability to harvest energy from as little as 1°C temperature delta
- Compact solution footprints with minimal external components

WSNs are basically a self-contained system consisting of some kind of transducer to convert the ambient energy source into an electrical signal, usually followed by a DC/DC converter and manager to supply the downstream electronics with the right voltage level and current. The downstream electronics consist of a micro-controller, a sensor and a transceiver.

When trying to implement WSNs, a good question to consider is: How much power do I need to operate it? Conceptually this would seem fairly straight forward; however, in reality it is a little more difficult due to a number of factors. For instance, how frequently does a reading need to be taken? Or, more importantly, how large will the data packet be and how far does it need to be transmitted? This is due to the transceiver consuming approximately 50% of the energy used by the system for a single sensor reading. Several factors affect the power consumption characteristics of an energy harvesting system of WSN.

Of course, the energy provided by the energy-harvesting source depends on how long the source is in operation. Therefore, the primary metric for comparison of scavenged sources is power density, not energy density. Energy harvesting is generally subject to low, variable and unpredictable levels of available power so a hybrid structure that interfaces to the harvester and a secondary power reservoir is often used. The harvester, because of its unlimited energy supply and deficiency in power, is the energy source of the system. The secondary power reservoir, either a battery or a capacitor, yields higher output power but stores less energy, supplying power when required but otherwise regularly receiving charge from the harvester.

Thus, in situations when there is no ambient energy from which to harvest power, the secondary power reservoir must be used to power the WSN. Of course, from a system designer's perspective, this adds a further degree of complexity since they must now take into consideration how much energy must be stored in the secondary reservoir to compensate for the lack of an ambient energy source. Just how much they will require will depend on several factors.

These will include:

1. The length of time the ambient energy source is absent
2. The duty cycle of the WSN (that is the frequency with which a data reading and transmission has to be made)
3. The size and type of a secondary reservoir (capacitor, supercapacitor or battery)
4. Is enough ambient energy available to act as both the primary energy source and have sufficient energy left over to charge up a secondary reservoir when it is not available for some specified period?

Ambient energy sources include light, heat differentials, vibrating beams, transmitted RF signals, or

ENERGY SOURCE	TYPICAL ENERGY LEVEL PRODUCED	TYPICAL APPLICATION
Small solar panels	100s of mW/cm^2 (Direct Sunlight)	Handheld electronic devices
Small solar panels	100s of µW/cm^2 (Indirect Sunlight)	Handheld electronic devices
Seebeck devices (which convert heat energy into electrical energy)	10s of µW/cm^2 (Body heat)	Remote wireless sensors
Seebeck devices continued	10s of mW/cm^2 (Furnace exhaust stack)	Remote wireless actuators
Piezoelectric devices (which produce energy by either compression or deflection of the device)	100s of µW/cm^2	Handheld electronic devices or remote wireless actuators
RF energy from an antenna	100s of pW/cm^2	Remote wireless sensors

Table 1: Energy Sources & the Amount of Energy They Can Produce

just about any other source that can produce an electrical charge through a transducer. **Table 1** illustrates the amount of energy that can be produced from different energy sources.

A Nanopower IC Solution

It is clear that WSNs have very low levels of energy available. This, in turn, means that the components used in the system must be able to deal with these low power levels. While this has already been attained with the transceivers and microcontrollers, on the power conversion side of the equation, there has been a void. However, Linear Technology introduced its LTC3388-1/-3 to specifically address this requirement.

The LTC3388-1/-3 is a 20V input capable synchronous buck converter than can deliver up to 50mA of continuous output current from a 3mm x 3mm (or MSOP10-E) package (see **Figure 1**). It operates from an input voltage range of 2.7V to 20V, making it ideal for a wide range of energy harvesting and battery-powered applications including "keep-alive" and industrial control power.

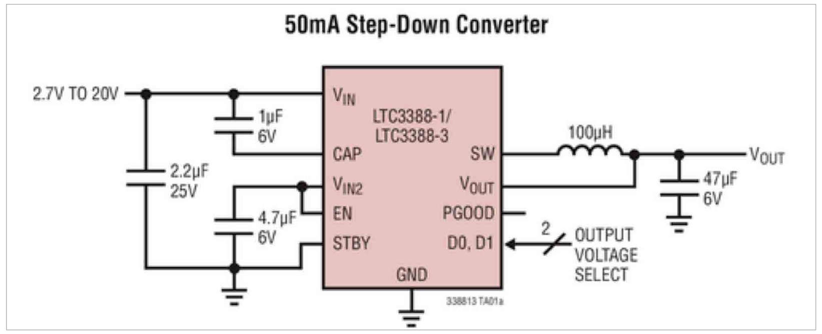


Figure 1: LTC3388-1/-3 typical application schematic

The LTC3388-1/-3 utilizes hysteretic synchronous rectification to optimize efficiency over a wide range of load currents. It can offer over 90% efficiency for loads ranging from 15 µTFA to 50mA and only requires 400nA of quiescent current, enabling it to provide extended battery life. The combination of its 3mm x 3mm DFN package (or MSOP-10) and only five external components offers a very simple and compact solution footprint for a wide array of low power applications.

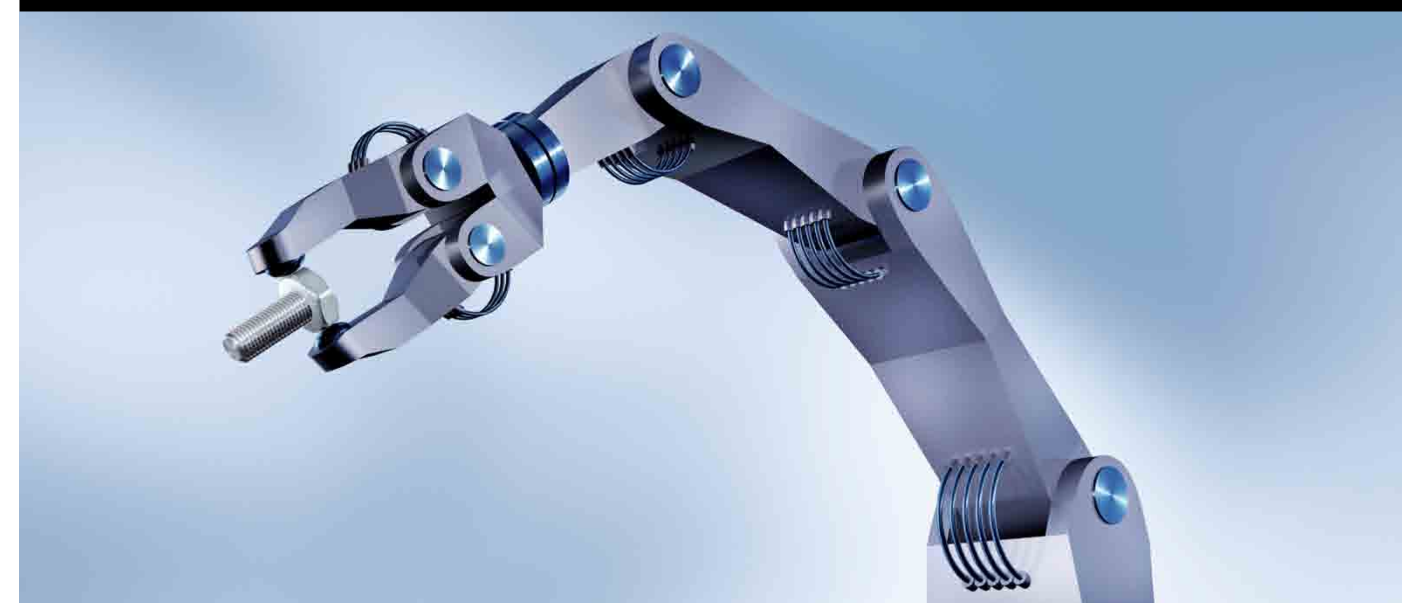
The LT3388-1/-3 incorporates an accurate undervoltage lock-out (ULVO) feature to disable the converter when the input voltage drops below 2.3V, reducing quiescent current to only 400nA. Once in regulation (at no load), the LTC3388-1/-3 enters a sleep mode to minimize quiescent current to only 720nA. The buck converter then turns on and off as needed to maintain output regulation. An additional standby mode disables switching while the output is in regulation for short duration loads, such as wireless modems, which require low ripple. This high efficiency, low quiescent current design is ideal for applications, such as energy harvesting, which require long charging cycles accompanied by short burst loads for powering sensors and wireless modems.

www.linear.com

Special Report: Motors & Motion Control

PSD EUROPE

Empowering Global Innovation



INSIDE:

Conveyor belts rely on limit switches for process monitoring & control

The two main industrial classes of conveyors are general and bulk material handling

By: Richard Staiert, Honeywell Sensing and Control

An industrial conveyor belt usually consists of two or more pulleys, with a continuous loop of material (belt) that rotates about them. One or both of the pulleys are powered, moving the belt and the material on the belt forward. There are two main industrial classes of belt conveyors: general material handling (moving boxes along inside a factory) and bulk material handling (transporting industrial/agricultural materials).

Limit switches are utilized to both provide conveyor system monitoring and control as well as safety in case of a problem. A limit switch is a precision snap-action switch that has been encased to protect it from external forces, such as hazardous chemicals, extreme temperatures, water, oil and dirt and is most commonly used to detect presence or absence in areas where physical contact is allowed. In the conveyor belt application as shown in **Figure 1**, a variety of Limit Switches can be used.

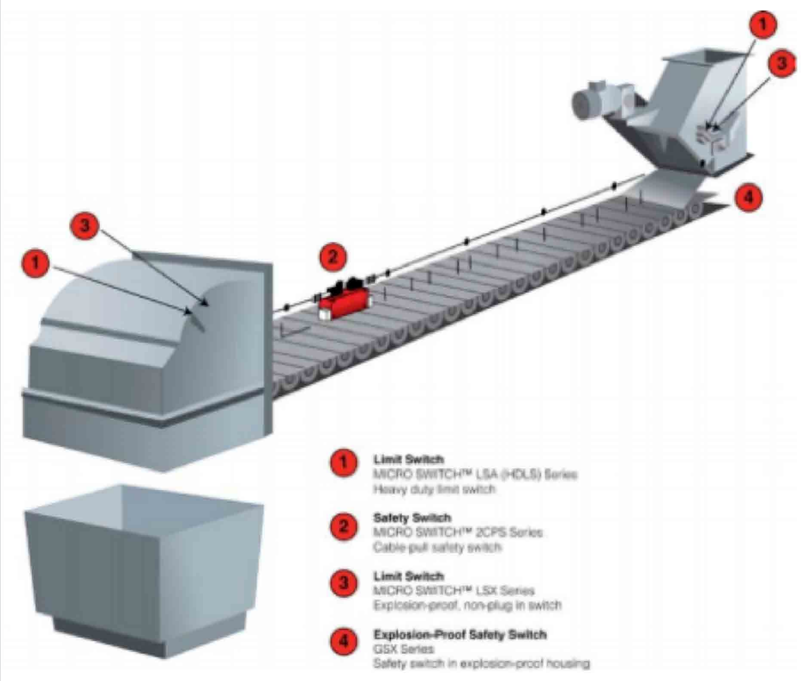


Figure 1: A variety of limit switches can be used in a conveyor application

Number 1 - Often used on conveyors designed for use in harsh indoor and outdoor environments, heavy-duty limit switches can be used to reliably indicate position to the system's controls. In this configuration, the limit switch could be used to count the items that are flowing through it. It could also be used to ensure that the materials are corrected positioned and will sound an alarm or stop the belt if there is a problem.

Number 2 - Safety Switches - Cable-pull limit switch are emergency stop switches often control access around the conveyor perimeter or provide emergency-stop cable-pulls along the conveyor. These kinds of limit switches provide a highly reliable, highly visible, safe to-use rope-pull device to protect operators working near conveying systems.

Figure 2: Limit switches are available in a wide range of formats, sizes and types including wireless.

Number 3 - Hazardous Location Switches are very similar to Switch 1 but are housed in completely sealed enclosures to prevent a spark or electrical discharge from setting off an explosion. They are often utilized for door or diverter position detection in outdoor, aboveground, potentially explosive environments, such as grain handling and oil/gas applications.

Number 4 - Safety and Hazardous Location Switches have also been designed with an explosion-proof housing. Often used in outdoor, above-ground, potentially explosive environments, such as grain handling conveyors, or oil and gas applications, these kinds of switches can quickly and reliably stop system operation when the switch is triggered by the operator (see **Figure 2**).

Limit switches can also be used in variety of other ways on conveyor belts. For example, a limit switch alongside the belt, could ensure that the conveyor belt is working correctly, that packages and materials are correctly positioned on the conveyor belt. The limit switch signal connects to a controller, which will stop down the belt if there is a problem.

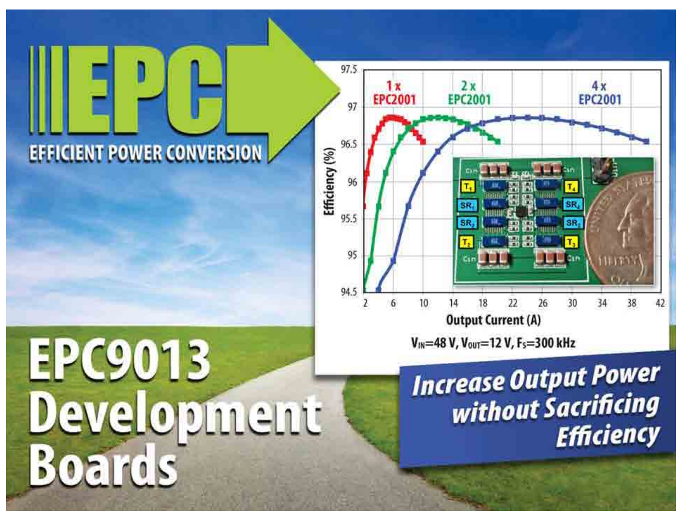
To prevent jamming the belt's discharge, limit switches could measure the number or height of the products on the conveyor belt. If too much product is going down the belt, it can shut down the system before damage or spillage occurs.

www.sensing.honeywell.com

Product roundup – Motors and Motion Control

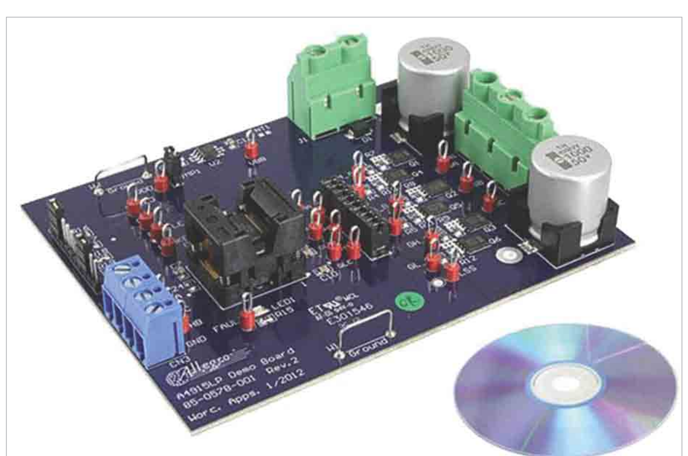
Here is a collection of the latest in motor and motion control solutions, addressing the latest demands for functionality and energy efficiency.

Edited by Alix Paultre, PSD



The EPC9013 development board is 2" x 2" with eight EPC2001 eGaN FETs in conjunction with the Texas Instruments LM5113 gate driver. The development board can be operated as a Buck, Boost, or bidirectional, as well as a half bridge for motor drives and isolated converter applications. Its parallel configuration is recommended for high current applications. The printed circuit board (PCB) layout is designed for optimal switching performance. There are various probe points to facilitate simple waveform measurement and easily evaluate the eGaN FETs.

Image: EPC EPC9013 development board
www.powersystemsdesign.com/epcs-high-current-development-board-features-multiple-half-bridges-in-parallel



Addressing the A4915 3-phase MOSFET controller IC, an Allegro evaluation kit consists of a printed-circuit board with everything required to spin and control a brushless DC (BLDC) motor with just a voltage supply and the motor itself. The A4915 incorporates on-chip Hall commutation and a novel speed control input that takes an analog voltage and generates a pulse-width-modulated (PWM) output with a variable duty cycle to efficiently control a BLDC motor with little or no microprocessing power, resulting in a 75% reduction in PCB space compared with alternative solutions on the market.

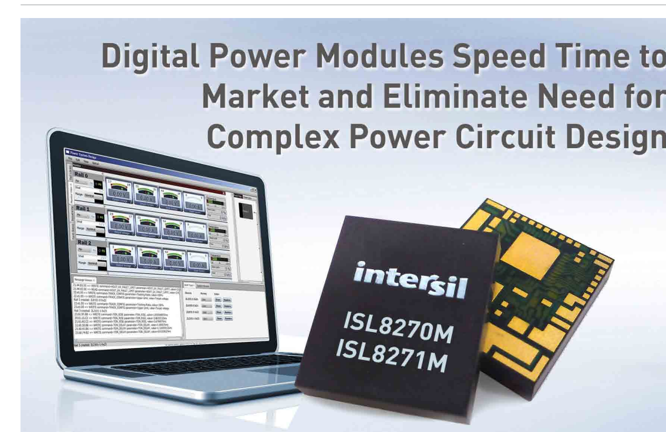
Image: Allegro A4915 3-phase MOSFET controller IC
www.powersystemsdesign.com/allegro-releases-eval-kit-for-their-3-phase-brushless-dc-motor-driver-ic

Microchip's family of dsPIC33 Digital Signal Controllers (DSCs is an expansion of Microchip's dsPIC DSC portfolio that adds higher levels of integration for motor-control applications. The DSCs enable efficient dual motor control with 12 motor-control PWM channels (6 pairs), dual 12-bit ADCs, multiple 32-bit quadrature encoder interfaces, and two CAN modules. With this level of integration, the dsPIC33EP512GM710 family can independently control two motors with a single microcontroller (MCU) for optimized system costs.

Image: Microchip dsPIC33 Digital Signal Controller
www.powersystemsdesign.com/microchips-dspic-digital-signal-controllers-enable-dual-motor-control-and-can-communication-with-advanced-sensor-interfaces

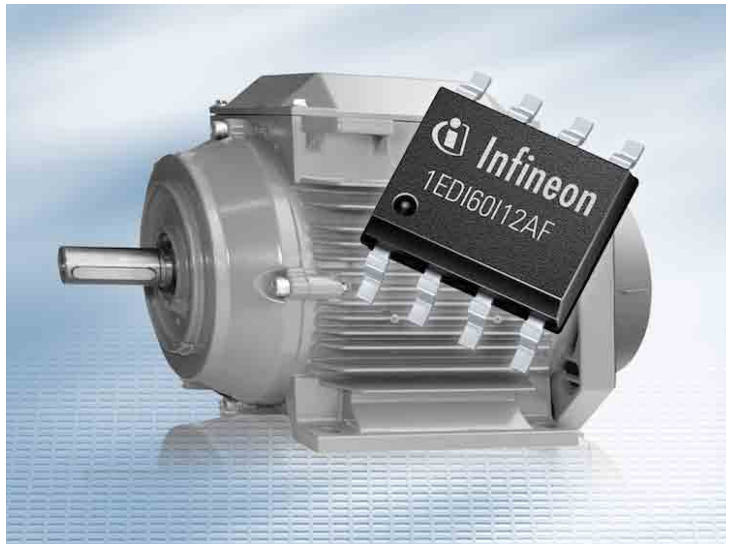
AVX's family of FLB Series medium power film capacitors are packaged in a cylindrical aluminum can with terminals that enable direct, three-phase, internal wire connection. FLB Series capacitors are comprised of metallized polypropylene dielectric imbued with a soft polyurethane resin, and feature a dual safety system consisting of an overpressure disconnector and self-healing technology, as well as exhibit high ripple current and extremely high dielectric strength in operating temperatures spanning -40°C to +80°C. Ideal applications include power factor correction and output AC filtering in power converters, UPS systems, solar and wind inverters, and motor drives.

Image: AVX FLB Series medium power film capacitor
www.powersystemsdesign.com/avx-unveils-three-phase-power-film-capacitors-at-apec-2014



Intersil's ISL8270M/71M family of digital power modules can dramatically reduce design complexity and accelerate time to market. Designed for 25/33 Amp applications, the ISL8270M/71M product family is based on Intersil's fourth generation digital power controller and leverages patented technologies to enable customers to quickly design high-performance, highly efficient and low profile power management systems.

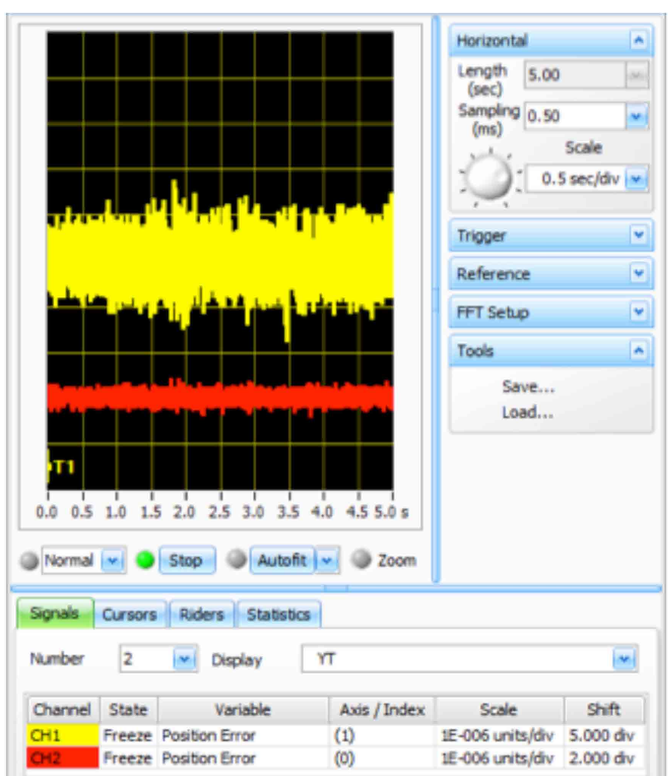
Image: Intersil ISL8270M/71M family of digital power modules
www.powersystemsdesign.com/intersils-digital-power-modules-simplify-speed-circuit-design



Infineon Technologies' 1EDI EiceDRIVER Compact single-channel gate driver serves applications with isolation voltages of up to 1200 volts. The galvanically-isolated driver components are based on the Coreless Transformer Technology developed by Infineon, which enables output currents of up to 6 amperes on separate output pins. The basic system includes UVLO (under voltage lockout) for IGBTs and MOFETs as well as an active shutdown in the event that the driver is not connected to the power supply. The 1EDI drivers are supplied in a compact DSO-8 housing and can be used at ambient temperatures of up to 125°C.

Image: Infineon Technologies' 1EDI EiceDRIVER Compact single-channel gate driver

www.powersystemsdesign.com/infineons-compact-single-channel-gate-driver-serves-applications-with-isolation-voltages-of-up-to-1200-volts



ACS Motion Control's NanoPWM switching PWM servo drives deliver sub-nanometer position jitter performance and nanometer following errors when moving at low velocities, providing better performance than linear servo drives. The NanoPWMTM servo drives are ideal for applications such as 450mm & 300mm semiconductor wafer inspection systems as well as the latest high resolution OLED flat panel display handling & inspection machinery.

The NanoPWMTM drives are available as part of ACS' MC4U Control Modules complete solutions that includes also an EtherCAT Motion Controller and power supply. The NanoPWM drive operates from 100V and delivers up to 15/30A (Cont./Peak) of current.

www.powersystemsdesign.com/switching-pwm-servo-drives-can-replace-linear-servo-drives

Image: ACS NanoPWM switching PWM servo drive display

Custom power plant system guarantees steady electrical supply to life-saving equipment

Within 10 years, the plant will provide backup power to 16 of the 18 Rush buildings

By: Kevin McKinney, MTU Onsite Energy

MTU Onsite Energy's state-of-the-art generators power the Tower of Rush University Medical Center's new 14-story hospital (see **Figure 1**), the cornerstone of the Rush Transformation, an ongoing effort to build new facilities, renovate existing buildings and adopt new technology. The Tower houses acute and critical care patients and will be powered by a custom-designed MTU Onsite Energy power plant (see **Figure 2**). Within 10 years, the plant will provide backup power to 16 of the 18 Rush buildings.

Figure 1: The Rush University Medical Center Tower

"We need a backup power source to ensure that the operating rooms, life-support systems, monitoring equipment and anything else that keeps patients alive and safe will operate if utility power is lost," said Mike Craig, electrical and electronics manager at the Rush University Medical Center.

Rush collaborated with MTU Onsite Energy distributor, Inland Power Group, and engineering firm, Environmental Systems Design, to design a custom central energy plant power system that met both Illinois code and EPA Tier 2 emissions requirements.

The Rush transformation

Over the years, Rush University Medical Center has expanded many times to meet the needs of a steadily growing patient population. Along with each new floor or building came one or more new generators to supply the necessary backup power. Finally, in the mid-1990s, small expansion steps gave way to a master plan for a major renovation of the Rush campus. The master plan called for the construction of the Tower, Rush's new 14-story hospital, as well as a number of

Figure 2: The MTU Onsite Energy generator sets meet EPA Tier 2 emissions requirements

other medical treatment facilities, an office building and a parking garage.

First, though, Rush would build a central energy plant to house the major equipment that would supply backup power to all of the new facilities within 10 seconds of a utility outage to meet code requirements. This would be no easy task. In some cases, power from the plant would have to reach life-saving safety equipment in buildings up to four blocks away. Today, however, the plant is delivering critical power in time wherever it's needed, thanks in part to state-of-the-art generators, controllers and transfer switches from MTU Onsite Energy.

Figure 3: The medical center's emergency power system includes six 2,000 kW generator sets from MTU Onsite Energy

Backup system put in place

Much of the backup power equipment in the central energy plant was supplied by MTU Onsite Energy distributor, Inland Power Group. Key Inland-supplied components of the standby power system include six 2,000-kilowatt (kW) generator sets that operate at 12 kilovolts (kV). Each of these three-phase units is equipped with a DGC-2020 digital controller that relays start and stop commands from the switchgear to the generator (see **Figure 3**). Inland also supplied the paralleling and transfer switchgear, all housed in the central plant.

Outside the central plant, automatic transfer switches from MTU Onsite Energy help to distribute backup power to loads within in the buildings on the campus. Rush's electric power is provided by Commonwealth Edison Co. (Com Ed). Illinois code requires at least two utility feeds into each hospital building, according to Craig. Some buildings on the campus have as many as five Com Ed feeds.

Rush chooses equipment, supplier

Following a competitive bid, MTU Onsite Energy was selected to supply emergency standby power to the Rush campus. At the time of the bid, there were no MTU Onsite Energy generators on campus, however Craig and his colleagues selected the leading producer of diesel-powered generator sets. "When we looked at cost and reliability of the generator sets, and at the companies themselves, MTU won out," Craig said.

One reason for the decision was ever-changing EPA emissions requirements. The generators specified by one company under consideration couldn't meet the more stringent emissions requirements of an anticipated EPA ruling. "We wanted to make sure that once a new rule was put in place, the gensets would be compliant," Craig said. The MTU Onsite Energy units chosen for the job meet EPA Tier 2 emissions requirements, according to Scott Sell, an Inland product support manager. In addition, Craig and his colleagues were swayed by their comfort level with the equipment suppliers. "Knowing Inland and what we were going to get in terms of support, gave us a good feeling to go down that road," Craig said.

Designing with distribution in mind

Craig worked on the design of the standby power system with Environmental Systems Design Inc. In the process, one of his main goals was to come up with a fully redundant system. "One thing I've learned in my career is that the biggest issue is always distribution," he said. "You can put as much power in as you want, but without the proper distribution there's going to be a problem."

To prevent major power-distribution problems, the Rush system has separate A and B feeds going into each building. "If someone is digging in a parking lot and knocks out my A side, I still have power on my B side," Craig noted.

Each of the two sides of the system includes three generator sets and its own paralleling switchgear. Both sides feed 16, 12 kV substations scattered throughout the campus, which in turn supply power to the buildings via two separate feeds. This ensures that the equipment in each building will be powered by at least one of the two sides of the system.

However, the buses for the two separate sides are also connected, Craig noted. Instead of two buses with three generators feeding each one, this allows the creation of a single bus with six generators. "If one of the generators goes down, I'm not down to two on one side. I have five standby generators feeding the bus to supply what I need," Craig explained.

According to Craig, tying the two buses together improves the stability of the power and frequency going out to the 16 substations on campus. It also helps Rush meet code requirements for rapid and reliable startup of critical equipment following a utility power failure.

Steps for system upkeep

Due to its importance, the emergency standby power system must be exercised regularly. Rush personnel run the generators for about an hour each week to meet Chicago and Illinois code requirements.

In addition, Inland does a system test of all six generators on a yearly basis, using a load-bank instead of the actual building loads to make sure the units are in good working order and capable of operating at full power. While the generators are running, technicians check them for any problems. While performing maintenance on the generators, service technicians use the DGC-2020 controllers. Among other things, the controllers start and stop the generators, reset parameters, and provide data readouts to the technicians. The controllers give service personnel detailed information about generator operation.

Meeting the needs of a changing campus

Inland personnel handled the startup and commissioning. As the first of the new buildings to be constructed as part of Rush's multi-year renovation project, the plant also supplies steam and chilled water to other campus facilities.

In addition to providing backup power for its own operations, the new plant will soon be serving seven other buildings, with a total load of approximately 4.5-megawatts. These buildings include the new 376-bed East Tower hospital, which opened in January 2012. The old hospital building will be used for a different purpose once all of its functions are transferred to the new facility.

Over time, the old hospital building and most of the others on campus will be added to the list of facilities served by the central energy plant. As the transition unfolds, new automatic transfer switches will be added to the backup power system and most of the old standby generators scattered across the Rush campus will be decommissioned.

Capable of a maximum power output of 12 MW, the central energy plant can greatly expand its reach as it's presently equipped. In addition, there's room in the plant for four more generators of the same size as its current units, giving it a total future capacity of 20 MW. "When we've had minor utility outages, it has worked flawlessly," said Craig. "It does exactly what it's supposed to do, and we get exactly what we need."

www.mtuonsiteenergy.com

SPECIAL REPORT : MOTORS & MOTION CONTROL

Making it snow

The sophisticated artificial snow technology at St. Moritz uses Movicon to ensure optimal snow production and energy efficiency

By: Progea

Modern ski resorts are the heart of the tourist trade in mountain holiday locations. Tourists spending their holidays in the mountains constitute a major part of hotel tourism economy in winter along with other activities such as dining, handicrafts, transportation, and access to the ever-increasing fast and capacious ski lifts.

Figure 1: The snow generators are complex machines that need the right technology and know-how to operate properly

This usually depends on whether there is enough snow, with the entire economy of the big hotel resorts relying on snow on the ski slopes. Furthermore, the snow must be a certain consistency and quality to ensure that skiers and snowboarders enjoy their winter holiday experience. It is for this reason that the local ski resort community in St. Moritz has placed its trust in modern technology to produce artificial snow to ensure that the ski slopes remain open and in operation.

The snow making system needs to be well engineered, not only to guarantee both quality and snow productivity, but primarily to optimize energy and water consumption in way that is also environment friendly. To accomplish this, the best automation technology available both in terms of hardware (considering below zero temperatures and temperature changes) and in terms of supervision and control management software were obtained.

Artificial snow process

Artificial snow is produced with a process that replicates the natural snow process based on water. The water is pumped through nebulizers defined "snow cannons", positioned in those points where snow is needed. The water is pumped and nebulized when entering the machine to form very small droplets of water, which are frozen instantly upon contact with the air below zero temperatures (usually below -6 °C, -7 °C) to then become tiny ice crystals.

Practically, the snow cannon imitates the natural snow process in fast motion. In addition, it is essential that the temperature and humidity conditions are ideal. For instance, the transformation of water to snow is more effective when there is low humidity. By obtaining this condition the structure of the frozen particles become more compact and spherical and therefore greater in density than natural snow (see **Figure 1**).

The St. Moritz – Engadin Project

The "St. Moritz Engadin Mountains" consortium needed to modernize and unify all the ski resort snow generator management systems on

Figure 2: The complex network architecture of the entire ski resort using optic fiber

both their North and West ski slopes. The West ski slope has a snow making system installed in the 90's by DEMA (now DEMACLENKO), which provides a series of 250 underground wells for storing the artificial snow with 6 connected pumping stations, which supply water at 1800 to 2900 meters above sea level. The total power generating capacity installed is 7 MWatt. The system used on the North slope was also installed in the 90's by a company called SUFAG. It has 200 wells and 3 pumping stations with a power generating capacity of 4 MWatt. The unification project focused on optimizing system management by creating one unique monitoring and control system to improve operability efficiency and optimize and reduce energy and water consumption (see **Figure 2**).

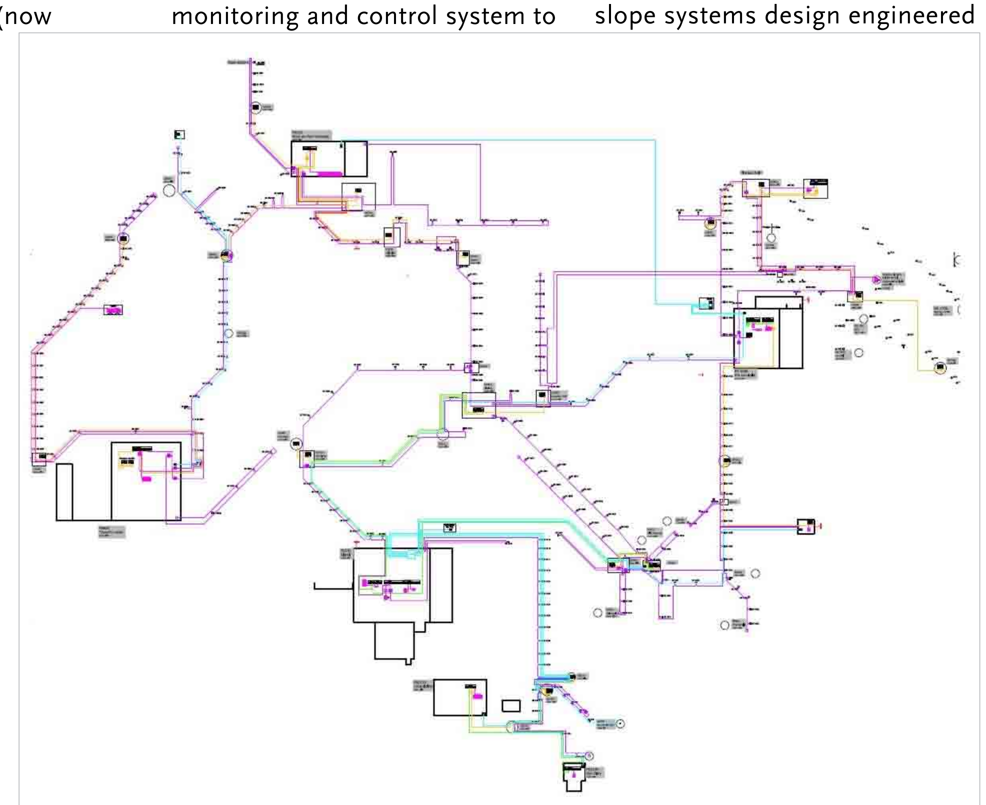


Figure 3: One of the ski lift stations used to reach the top of the St. Moritz – Celerina ski resort pistes

The project engineering and deployment was commissioned to FREY AG, a company from Stans, Switzerland, who sought collaboration with ELA Srl, a company from Laion (Bolzano), for their expertise and experience in projects such as this one. After carefully assessing various technology system architectures the Movicon 11.3 SCADA platform was chosen along with field Saia PLCs. The Movicon Scada platform was specifically chosen for its project modularity that enabled the union of the two ski slope systems design engineered by two different companies. The North ski slope project was assigned to FREY AG, while the West ski slope project was assigned to ELA Srl.

Based on the Movicon project modularity, the projects were designed with Parent-Child architecture. The Parent project therefore disposes the resources of the various Child projects which remain independent and exist on their own. This enabled the Movicon project designed by FREY AG for the North slope and the Movicon project designed by ELA Srl for the West slope to unite in one 'Parent' project as one unique project while at the same time maintaining the two development teams and projects separate and independent.

The architecture includes an unmanned server station located in the valley of Moritz-Signal. This station is connected in network, using optical fiber, to the client stations and various PLCs located throughout the ski slopes. The two remaining supervision stations are allocated at the mountain terminal stations and are operated by personnel from the Croviglia, Celerina, Trutz ski lift terminal stations and the main Signal Station (see **Figure 3**).

The Saia PLCs are connected in net to the central supervision station where there are 13 main control stations connected in Ethernet using optic fiber with a series of substations connected

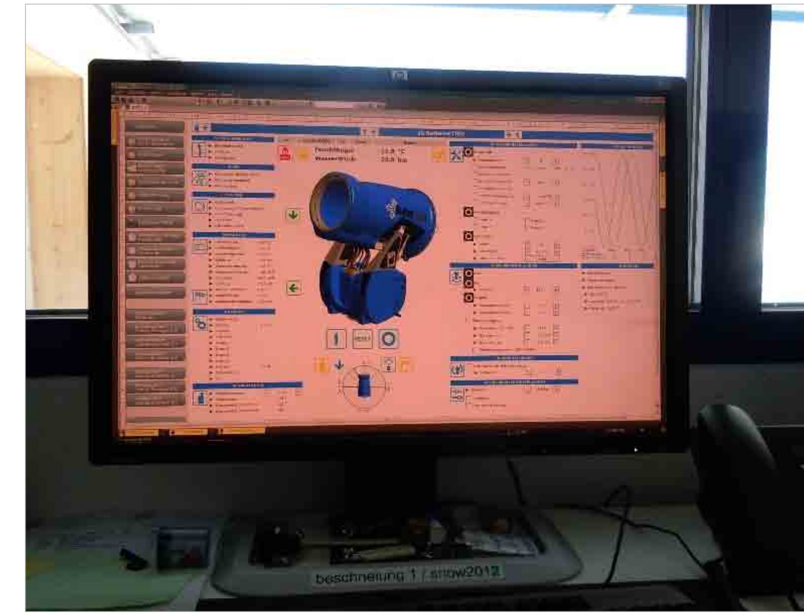


Figure 4: One of the Movicon supervision system control station terminals at St. Moritz – Engadin

in a RS485 sub network using the Gateway Master technology betweem the Saia PLCs. The Movicon supervision uses its native 'Multiport' I/O driver for Saia which is capable of connecting to any Saia device with all available protocol including S-Bus.

System Requirements

St. Moritz new ski slope supervision system's main task was to distribute control stations through one system with centralized and standardized management based on modern and popular user interface criteria. This was to be implemented with the purpose of re-modernizing the St. Moritz and Celerina control stations. This would allow management staff to access any one of the functionalities within the system from any one of the control stations using the same interface. Furthermore, the continuously manned Corviglia control station, would assume the central role in managing the whole system (see **Figure 4**).

In addition to this, the supervision system had to ensure that the user authentication management remained centralized to allow new system users access to the system from any control station terminal using the web as well. All these requirements were taken into full consideration when evaluating which Scada platform to adopt as well as the capacity to be managed by the two different developer teams: FREY AG and ELA Srl.

The choice of using the Movicon technology was successful, satisfying the

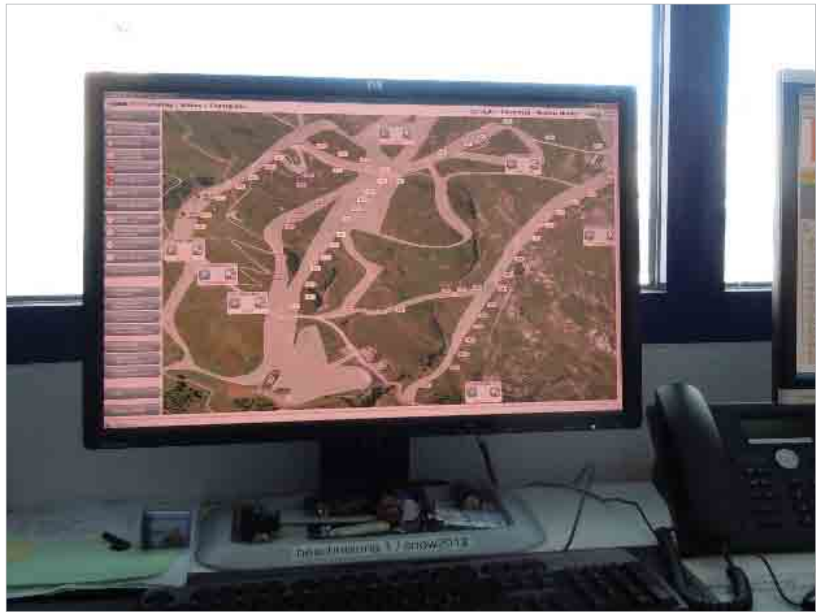


Figure 5: Maps of the whole skiing resort complex are managed on screen so 150 generators can be easily localized and configured

fundamental requirements due to its expandability and design engineering modularity. It must also be recognized that the project had to be predisposed for integrating with the ropeway system management. In addition the design engineers were given little time to complete the project. This was due to the fact that the short summer period at high altitude meant that they had to work fast to design, install and get the system up and running before the winter season set in.

This did not hinder the engineers who were able to complete work in time and with success to the great satisfaction of the clients and co-operation of the different company developer teams, the potentiality of the Movicon platform and the Progea technical support services.

The new supervision system now enables the client to start producing artificial snow from as early as October. This means that they can completely cover the slopes with artificial snow in time for the Christmas holiday season before the freezing temperatures of December set in.

Main system functionalities

The Movicon supervision system manages a total of 4,500 variables, organized in data structures to enable smooth system parameterization, making data easier to manage in the PLC and organize in the supervisor. The various modular projects can be accessed from the various area workstation terminals spread throughout the North and West ski slopes.

Pumping Stations

The Movicon supervision system enables the complete management of the pumping stations using parameterized screen page interfaces to quicken repetitive function programming and drastically reduce risk of errors. All the pumps of each station are completely controlled individually using manual and automatic commands. The functional parameter definitions are recorded in appropriated databases to ensure traceability and data protection. Purposely defined algorithms enable energy consumption optimization that can be analyzed statistically in detailed reports.

Snow generators

Artificial snow is produced completely in automatic using the snow generator management system defined also as snow cannons. Maps of the whole skiing resort complex are managed on screen on the supervisor side so that the existing 150 generators can be easily localized and configured (see **Figure 5**). These generators can also be dismantled by hand and repositioned where required. The supervisor uses a parameterization system that enables configurations to be read from the field. It also allows each generator to be displayed with its status on screen maps. The area map layout on screen shows the location and status of each generator so that they can be individually analyzed in detail. The parameterized page contains all the information about the machine processes (startup, alarms, shutdown, production, etc.) and retrieved measure values (air temperature, corona discharge, water, humidity, water pressure, wind speed and direction, etc.).

An interesting feature to note is that any one of the generators can be physically positioned and reconnected in any part of the ski resort complex without needing any program modification. By using just the one command, the supervisor updates the configuration to point to the specified addresses even when physically present in different PLCs. This is made possible by the "Hot" driver's capacity to automatically reconfigure.

Historical logging and Analysing

Each individual snow generator records all the process information on a relational database based on SQL Server, using the native Movicon data logger tools. For example, the measure values include air temperature and wet bulb, air humidity and efficiency. All consumptions are historically logged, such as duration of time in service divided by temperature ranges, water consumption and energy consumption. This enables partial or total consumptions to be consulted by filtering them by period and other filter selection types.

Reports and Trends using the powerful Movicon analytic tools are also used for presenting recorded data in various graphical charts according to selected period. The pumping stations are also managed in the same way by recording process data, value behavior such as water level, input and output pressure and flow values and more.

Alarm Managment

The supervision system collects and centralizes alarm data from modular projects (child) so that it can be distributed to the various workstations for viewing diagnostics both as realtime events and recorded events. The system manages a total of 3,800 alarms divided by area and severity. By using the Movicon diagnostic system and functions, staff can easily manage the snow generation under all circumstances in response to the information displayed by the system on screen. The efficient alarm management enables maintenance and service staff to intervene with preventive or corrective procedures immediately and obtain complete control of the whole system from any position throughout the entire ski resort complex. In addition, Movicon manages notification of events with SMS, Email or Voice mail to enable quick intervention by on-call duty staff in certain situations when the different areas are left unmanned.

User and Password Management

The supervisory system handles all modular (child) and parent project users in a centralized management. Movicon enables the various projects, whether modular or client-server architecture, a continuous synchronized user profile management. It can also be used for those users inserted by clients during runtime mode. The system defines seven user levels (1024 can be defined with Movicon) and an administration level to allow access to certain system commands according to user responsibility status.

Web Client and Terminal Server

The supervisory system offers the use of a management within its architecture to handle different client stations using the Windows Terminal Server function when the client station is connected in LAN with the ski resort complex's local network. Even though momentarily not in use, Movicon is predisposed with a Movicon Web Client feature which enables staff to access the system through the web by iPhone, iPad or mobile device with any browser.

We would like to thank Mr Helmut Lardschneider and Alfi Piazza from Ela Srl

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You can't progress by restricting forward motion

By: Alix Paultre, Editorial Director, PSD

One of the things I love about serving this industry is that we are in the process of making things better for everybody by making the world a more efficient and empowered place. Migrating from technologies as wasteful in materials as they were in power benefits everyone. Materials get lighter and more multipurpose, hardware shrinks and converges, energy storage gets denser, and the software behind it all gets more functional and user-friendly.

A good example of this progress can be found in even the most casual comparison between a modern LED-driven LCDTV and a CRT display of similar size. Not only is there a significant difference in the materials required, there is also a significant difference in how the two devices generate an image and the resulting power required in both manufacture and operation. At the societal scale, silicon sank the film industry so thoroughly and rapidly most people don't even think about the multi-billion-dollar global market that existed less than a generation ago.

Every application space where solid-state technology enters eventually becomes dominated by solutions based on that technology. The replacement speed versus legacy technology is in proportion to the commercialization and utility of said solutions. Every developing technology goes through an early-adopter phase where the products are expensive, but this rapidly changes as the consumer base spreads and the production scale increases. The free market chooses what solutions survive, giving the new tech its chance to demonstrate itself to the consumers and expand its footprint by providing a better product or service.

That's how it works, you work hard and build a product, and if it's a good one, you get to sell it in the capitalist free market and let the people choose what they want to buy. The best products win, and society benefits as we all move forward a tick or two on the great wheel of progress.

At least that's how it's supposed to work. Unfortunately there are hypocrites in high places, places where politicians profess to support the free market yet actively restrict it by blocking next-generation energy legislation, or preventing electric vehicles to be sold directly to consumers in their state (while lobbying for the EV factories to be built there, oddly), or actively speaking against spending money on technology development in the USA while we watch the alternate-energy and electric-vehicle markets become dominated by others?

Not only does that stifle development, but it also shortchanges the electronics industry. The jobs in solar panel, LED light bulb, and electric car manufacture and maintenance are technical jobs that pay more than minimum-wage service work. Clean energy is not only a tech-laden industry; it helps the environment by reducing the use of fossil fuels to only the application spaces that truly need it. But for that to happen we must be honest with ourselves and let the free market truly decide, not try to game it.

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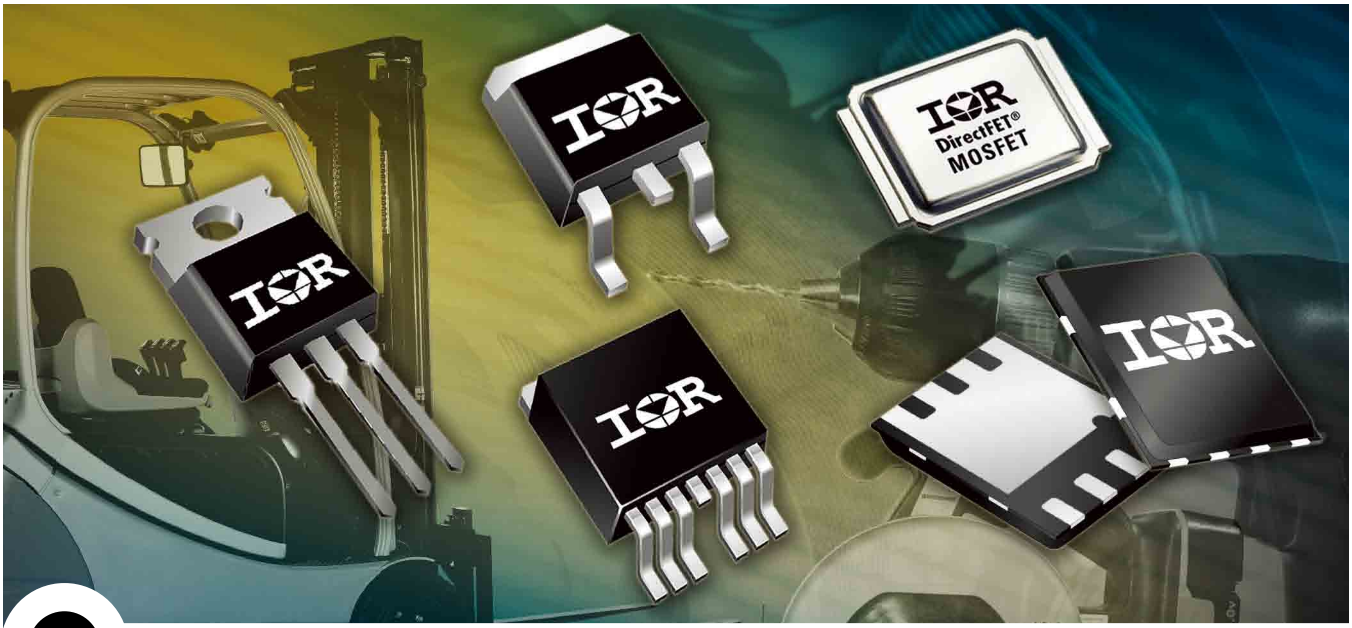
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