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Special Report - Renewable Energy

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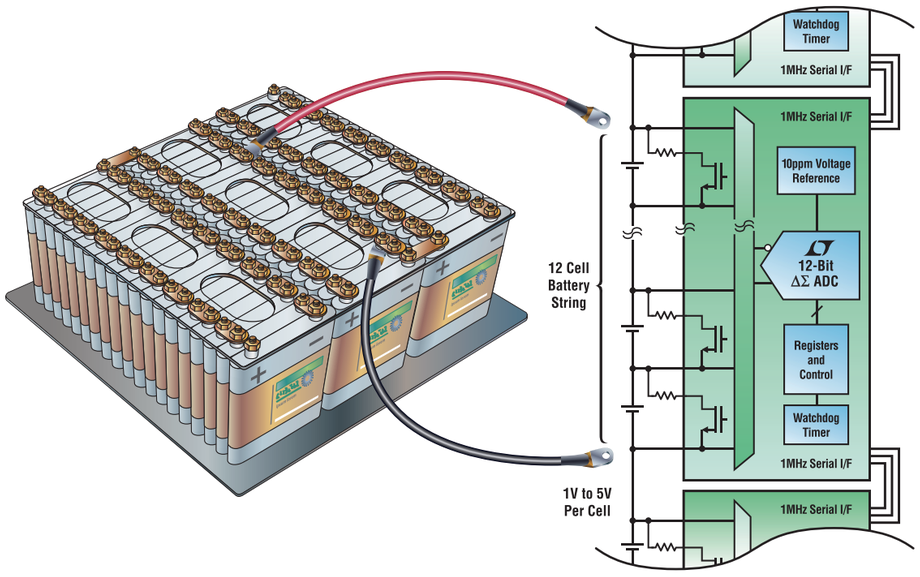

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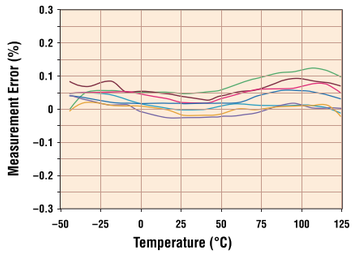

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Gloom is not an option

We find ourselves now right at the start of the forthcoming calendar year, although I'm still wondering what happened to the year – it went so fast. I'm not going to devote valuable space and bore everyone rigid in the process, with a detailed look back but would instead rather look forward. Even though we are facing, or indeed in, difficult times, we have a very solid industry overall, and power has never had such a pivotal role to play in the well-being of our engineers, our industry and our environment.

This issue is themed on renewable energy. For renewable energy I believe we can read renewable opportunities, businesses, as well as environmental well-being. Sounds a bit corny? Just consider the amount of good engineering and management that supports this potentially vast industry. The solar modules seen cladding the tops of buildings these days, are rapidly on the increase. So much so, that here in Germany it's an accepted part of the landscape. But just like with the proverbial 'tip of the iceberg' analogy, there is so much more going on below the visible part. A whole sector of our industry is devoted to producing higher efficiencies in power conversion, more intelligent management of solar arrays, connections to the grid and now, improvements in the panels themselves.

Turning towards the automotive sector, U.S. car sales in 2008 are set to drop by 17.7% compared to 2007, contributing to what is expected to be the worst year since 1980 for the global automotive industry, according to iSuppli Corp. A further worldwide decline representing a 6.5% decrease is projected for 2009. Western European sales will drop by a more severe 9.9%. Following 2009, auto sales in the United States and Europe are expected to begin a slow recovery. The situation is not expected to improve in the near future, with U.S. and Western European sales not expected to recover to 2007 levels for five or six years.

This is a grim picture indeed, even for our industry, but for sure there will be a revolution in the power technology used here. One of the harshest criticisms of the auto industry has been that it kept on doing what it was good at; producing the same old stuff without embracing the new ideas and technologies available. Let's hope things move forward here faster than predicted.

Aside from the economic reports of doom and gloom, the fact is we have an industry poised to achieve even greater things than ever before, and the need has never been so desperate.

National's boss, Brian Halla talks about the 'megatrends' in the industry reported in the 'On-the-Road' section of the magazine (also see my web exclusive extended electronica report by going to our home page and simply click on the electronica logo), representing his vision for the opportunities in front of us rather than the 'oh's and woes' in the current thinking of some other leaders. This is just the kind of inspiration and industry leadership we all need to fuel the optimistic enthusiasm for which our industry is renowned and to keep the spirit of innovation driving relentlessly forward.

I hope you enjoy this very full issue, to check out the exclusive online reporting and electronica 2008 Roundup, go to www.powersystemsdesign.com and simply click on the electronica logo. Also pay a visit to our fun-strip 'Dilbert' at the back of the magazine and as ever, keep your valuable feedback coming.

All the best!

Cliff Keys

Editor-in-Chief, PSDE
Cliff.Keys@powersystemsdesign.com

Tony Armstrong Appointed as Linear's Director of Product Marketing

Tony Armstrong has been appointed Director of Product Marketing for Power Products at Linear Technology. In this key position, Armstrong has responsibility for the management of all aspects of product marketing for integrated circuits as well as power µModule™ regulators. Armstrong also takes full charge of product pricing, advertising and marketing campaign development.

Armstrong brings a valuable 27 years of industry experience to his new role, including over eight years at Linear as Product Marketing Manager. Prior to joining Linear, he held key sales, marketing and management positions with major companies including Siliconix, Semtech, Fairchild and Intel. Armstrong holds a BS (Honors) in Applied Mathematics from the University of Manchester, England.

According to Don Paulus, Vice President and General Manager of Linear Technology Power Products, "Tony has demonstrated consistent vision, in-depth market knowledge and a broad understanding of the high performance analog business. I am extremely confident in Tony's ability to lead our product marketing efforts in order to grow the business going forward."

www.linear.com

CamSemi named 'Start-Up of the Year' 2008

CamSemi has announced that it has been named 'NMI Start-up of the Year' 2008 in the UK's National Microelectronics Institute (NMI) 12th Anniversary Awards. This prestigious award recognises one early-stage company per year who in the judges' view demonstrates the most exciting growth potential. The external panel of industry experts reviews each candidate company on the strengths of its technology, business model, management team and the market opportunity they are addressing.

CamSemi was awarded the honour at the NMI Awards Dinner held on Thursday 6 November in London. The photograph below shows from left to right: Derek Boyd, CEO of NMI; Rob Galuszka, Sales Director – Northern Europe from Cadence Design Systems, sponsors of the award category; and Ted Wiggans, VP Operations at CamSemi.

In accepting the award, Ted Wiggans commented on CamSemi's significant commercial progress this year at a time when energy efficiency has become a global priority: the company closed its C round funding in April to raise US $ 34 million; launched new controllers to enable low cost, more energy-efficient power supplies for cordless phones; and has shipped 10 million chips from its first product family. A number of further breakthrough performance products are also due for introduction over the next few months.

www.camsemi.com

Digi-Key Agreement with Tyco Expanded Worldwide

Digi-Key Corporation has announced that it has recently expanded its current franchise agreement with Tyco Electronics to a global authorization.Tyco Electronics is the world's largest supplier of passive electronic components, which includes connectors and interconnection systems, relays, switches, circuit protection devices, touch screens, sensors and wire and cable. These products are used primarily in the automotive, computer, consumer electronics, communication equipment, appliance, aerospace and defense, industrial machinery and instrumentation markets. "We are very pleased to expand to this global distribution agreement with Tyco Electronics. Tyco Electronics' reputation and history of bringing innovative products to the market is the perfect fit for the hundreds of thousands of design engineers we serve worldwide," said Mark Larson, Digi-Key president and COO. "Digi-Key's service advantage coupled with Tyco Electronics' technology advantage can do nothing but create a winning situation for a wide range of customers seeking to deliver new products to the market faster or improve the performance of existing products. This worldwide authorization will allow us to offer Tyco Electronics' leading edge products to our fastest growing markets in Europe and Asia."Digi-Key Corporation focuses on providing customers with superior service, which includes product selection and availability, on-time delivery, and responsiveness. Using streamlined processes and state-of-the-art technologies, Digi-Key serves a global customer base from its single 600,000 square foot facility in Thief River Falls, Minnesota, USA.

www.digikey.com

Diodes Incorporated Wins Environmental Award

Diodes Incorporated picks up the Elektra Environmental Award for 2008. Pictured left to right are: The Master of Ceremony Sky Sports Presenter Jeff Stelling, Colin Greene, European President, Diodes Incorporated, Martin Southam, Director of Marketing of the award sponsor TDK-Lambda and Richard Wilson, Editor in Chief of event organisers Electronics Weekly.

Diodes Inc. has won the Environmental Award at the annual Elektra Awards held in Munich on the eve of Electronica 2008. Now in their sixth year, the Elektra Awards are regarded as the most prestigious electronic product, technology and business awards in Europe and recognise the achievements of individuals and companies throughout the European Electronics industry.

Receiving the award on behalf of Diodes Incorporated, European President Colin Greene said, "We're thrilled to receive this award as it really does recognise the incredible efforts of our Green Team, a volunteer group of employees, representative of the entire organisation, with a real passion to see environmental objectives achieved."

"Diodes Incorporated believes that one of the most important ways to achieve environmental recovery and sustainability is through the continuous drive of its people to improve the business's environmental performance. Through workforce engagement and 'buy-in' to this vision, Diodes believes it is achieving 'world class' environmental performance."

Diodes' Elektra win follows hot on the heels of another award, the National Microelectronics Institute's Low Power "Green" Design Award for 2008. The award was made to Diodes for its ZXGD3101T8 MOSFET rectifier controller.

www.diodes.com

Fuji Electric and Semikron Team-Up

Dirk Heidenreich, CEO of Semikron International and Dr. Hisao Shigekane, President and Representative Director of Fuji Electric Drive Technology sign the agreement

Fuji Electric Device Technology and Semikron International have signed a supply and licence agreement at Semikron in Nuremberg. Fuji Electric will supply IGBT semiconductor chips to SEMIKRON; in return Semikron will supply Fuji Electric with freewheeling and rectifier diode chips, and module cases in spring contact technology. Power modules with spring contacts will be manufactured by Fuji Electric under licence.

Under this co-operation, the two companies are forging the basis for mutual supply of power semiconductor chips. With the new freewheeling diode and rectifier diode chips from SEMIKRON and the IGBT chips from Fuji Electric, both companies are expanding their product range to offer customers the optimum chip/module combination for a given application. By using the same spring contact technology Fuji Electric and SEMIKRON are able to increase the market penetration for industrial drives, power supplies and home appliances. This matches the second source policy of customers.

www.fujielectric.com and www.fujielectric.com/device/semi

www.semikron.com

Inauguration of Solar Roof at Goethe-Institut, Bangalore

The installed solar panels at the Goethe-Institut, Bangalore

IBC Solar, the photovoltaic system integrator, together with the German Energy Agency (dena) held a ceremonial inauguration of the photovoltaic installation on the roof of the Goethe-Institute/Max Mueller Bhavan in Bangalore, India.

Udo Möhrstedt, IBC Solar AG Chairman handed the system over to the head of the institute, Dr. Evelin Hust, in the presence of the Consul General of the Federal Republic of Germany, Mr. Stefan Graf. The project is part financed by the dena Solar Roofs Programme and realized by German IBC SOLAR with installation and maintenance support from Selco India.

The PV system at Goethe-Institute/Max Mueller Bhavan is connected to the house grid and feeds the electricity into its grid. It allows the institute to use the energy immediately and, in the case of a grid disconnection, the system switches instantly to backup mode in order to directly supply the institute.

During the inauguration event, a number of experts, including Professor Dr. Olav Hohmeyer, member of the U.N. Intergovernmental Panel on Climate Change, who was awarded the Nobel Peace Prize in 2007 along with Al Gore, outlined the advantages of photovoltaic energy production for India.

The demand for reliable energy is particularly high in India. Electricity cuts can be a regular occurrence and are a great challenge for firms. Solar energy is one solution to this problem.

www.ibc-solar.com

Optimized Control in Renewables

New digital DC/DC converter from Ericsson

Renewable energies have to convert, in one way or another, voltages to a level required by controllers and monitoring functions. Without considering the whole chain, the benefits of renewable energies could be ruined by sub-functions using lower efficiency dc/dc converters, not able to optimize their efficiency to different load conditions.

The adaptive control and digital power management embedded within Ericsson's BMR453, offering the most advanced performances in terms of efficiency as well as control and monitoring through its PMBus.

In addition, BMR453 has a built-in auto-paralleling function, which can make possible for the intermediate bus to deliver twice power when needed, and to automatically switch to a single converter mode while the second turned into sleep mode. The implementation of similar functionalities to larger systems would let expect huge potential of energy saving, reducing CO_2 emissions, and total cost of ownership.

With 96% efficiency, the BMR453 offers up to 400W output power or up to 33A with ±2% accuracy. At that level of accuracy, the best module commercially available offers just 300W output power. So Ericsson's BMR453 offers a huge 33% more power in the same package size. Showing versatility, the BMR453 has an input voltage range of 36V to 75V, and its output voltage is variable from 8.5V to 13.5V.

Application areas for the BMR453 series are also found in systems that must use a telecom input voltage with battery backup or both -48V and -60V nominal input voltages. Its inherent load regulation also allows the BMR453 to be used as an IBC in systems where the intermediate bus voltage directly powers devices such as hard drives that cannot tolerate the wide variation in bus voltage provided by a normal IBC. The BMR453 series is available both with and without a baseplate. A communication pin header is used for connection to the PMBus.

Ericsson's BMR453 modules feature a PMBus interface for system connection, opening up a whole new world of control features. The digital control system provides users with access to control, configure and monitor the device itself. This is a huge step forward for customers as this level of control has never been available before, and these new capabilities allow for much more intelligent energy management that helps to reduce energy consumption.

For users that do not need to use the PMBus interface, an optional version is available without the communication pin header. The converters meet the insulation requirements of EN60950 and come complete with vital industry standard features.

A synchronization facility enables multiple modules to operate at exactly the same frequency to facilitate optimum filter design for quiet running – RF or conducted. A 'power good' pin operates between active low and active high and is a useful feature for event-based programming, for example sequenced start-ups.

For current sharing duties, BMR453 modules can be operated in parallel without the need for external balancing circuitry. Instead, dedicated pins are simply tied together and current sharing is automatic. A voltage track pin will follow an external device and again is used for event-based programming.

These extra features have all been added to what was the previous standard for a DC/DC converter, and together with its unprecedented power density, the combination makes the product truly unique.

An evaluation kit is available to help designers evaluate and program the modules. It comprises evaluation board, operating manual, CD containing Graphic User Interface (GUI) and cables. This is the first quarter brick DC/DC converter that can handle digital management and for the first time it is possible to actually 'see' inside the module when using a GUI, and track what is happening in the converter.

www.ericsson.com/powermodules

Smart Solar Energy Management Drives Solar Adoption

Today's solar inverters try to optimize the entire array from a central vantage point, which severely limits their effectiveness. National's SolarMagicTM technology is revolutionizing photovoltaic systems by distributing intelligence in solar arrays.

By Ralf J. Muenster, Director Renewable Energy Segment, National Semiconductor Corp.

Energy constraint is a global megatrend. With increased demand and limited conventional sources, renewable energy is an increasingly critical component of our world economy. Converting solar irradiation into electricity through the use of solar photovoltaic (PV) technology is the most promising and under-represented alternative energy technology on the market. Today, solar comprises less than 0.1 percent of the total energy production worldwide.

Continuing advances in PV technology make this form of renewable energy particularly well-positioned for future growth. With many new production capacities and new technologies entering the market, 2009 could become a banner year for solar. One promising new technology is a micro-optimizer technology, like National Semiconductor's SolarMagicTM technology, which makes solar energy management smarter.

Today, the typical solar photovoltaic installation consists of a number of carefully matched panels that are connected in a series of strings and put in parallel with other series strings. The DC current generated by this array subsequently feeds into an inverter on the side of the array.

Inside PV panels are strings of cells, and it is not uncommon to end up with hundreds of PV cells connected in series within these arrays. Similar to Christmas lights, if one cell in this link fails to produce current, the entire string drops out. This is exactly what happens when partial shading or soiling occurs on PV installations. As a remedy, modern panels have panel-integrated bypass diodes that will attempt to re-route the current around heavily impaired sections of the

strings. If active, these bypass diodes will reroute the current around big sections of string, not only losing the potential energy contribution of these cells, but worse, lowering the overall voltage of that string.

Coming back to the concept of maximum operating point for the cells, the inverter will now have to decide if it should optimize the voltage for the impaired string or maximize the energy harvest from the non-impaired strings. In most cases, the inverter will choose to optimize for the non-impaired strings, causing the energy harvest of the impaired string to drop to near zero.

The result is that a PV system affected by just 10 percent shade can cut its energy production in half. This phenomenon has to do with an extreme sensitivity of the solar architecture to mismatches in the PV system. Clearly, after more than 30 years, solar energy management is due for a major overhaul. We need smarter solar energy management to propel this promising form of renewable energy to its full potential.

Over the past few years, researchers in National Semiconductor's labs have been studying this problem. They realized that today's inverters still happen to be the least reliable component in PV systems, lasting only five to ten years. Panels, on the other hand, last about 25 years. Today's panels feature solely passive electronics because nobody had managed to integrate smart, reliable, active electronics. The main feature that needs to be distributed in PV systems is an optimization function, which can be highly integrated into a few sophisticated ICs. It turns out that National has created and delivered reliable ICs for very demanding applications for nearly 50 years.

The advent of micro-optimizer technology can make solar more efficient by monitoring and maximizing the energy harvest of each individual panel and maximizing the energy flow through the array. SolarMagic technology, which leverages National's expertise and competence in advanced algorithms combined with leading-edge mixed-signal and power management technology, allows solar installations to recoup up-to-50 percent of lost power due to shading and panel mismatches.

Distributing intelligence down to the panel level, it enables each panel to operate at its maximum power point regardless of what is happening in the string. This means PV arrays can now be installed even if there is partial shading, making way for green solar energy. Essentially, new micro-optimizer technology will truly enable solar to be more pervasive and efficient in real-world conditions.

www.national.com

Sellers' Market for Photovoltaic Raw Materials to Shift in Buyers' Favor in 2009

By Marijana Vukicevic, iSuppli Corp.

Pricing for polysilicon used to create Photovoltaic (PV) cells is expected to drop in 2009 and the following years due to fundamental imbalances in the solar supply chain, according to iSuppli Corp.

Global supply of polysilicon is expected to double in 2009, while demand will grow by only 34 percent. Although demand for polysilicon will still exceed supply in aggregate in 2009, the sharp increase in supply will cause polysilicon pricing to begin a precipitous plunge in 2009 after peaking this year.

Due to strong solar-driven demand that arose in 2005, suppliers of silicon and wafers have been able to dictate pricing and contract terms to customers during the past three years. This situation hit a crescendo in 2008, with spot market prices for polysilicon rising as high as $500 per kilogram, up from as low as $200 in 2007. The corresponding wafer price rose to $13 per piece and higher in 2008.

However, the average spot market price for polysilicon is expected to decline dramatically during the course of 2009, falling to as little as $200 per kilogram.

With new competitors entering the polysilicon market, supply will outstrip even aggregate demand starting in the beginning of 2010, causing prices to fall further. Spot market pricing is expected

to decline to as low as $100 per kilogram in 2010.

"The dramatic variance in the ramp-up rates of the polysilicon suppliers and their PV-cell customers will lead to major supply-chain imbalances," said Henning Wicht, PhD, senior director and principal analyst, photovoltaics, for iSuppli.

In 2007, more than 90 percent of polysilicon was supplied by only seven companies: Hemlock, Wacker, REC, Tokuyama, MEMC, Mitsubishi and Sumitomo. However, more than 60 other companies have announced plans to produce polysilicon by 2009, resulting in many supply and demand imbalances at the company-to-supplier level.

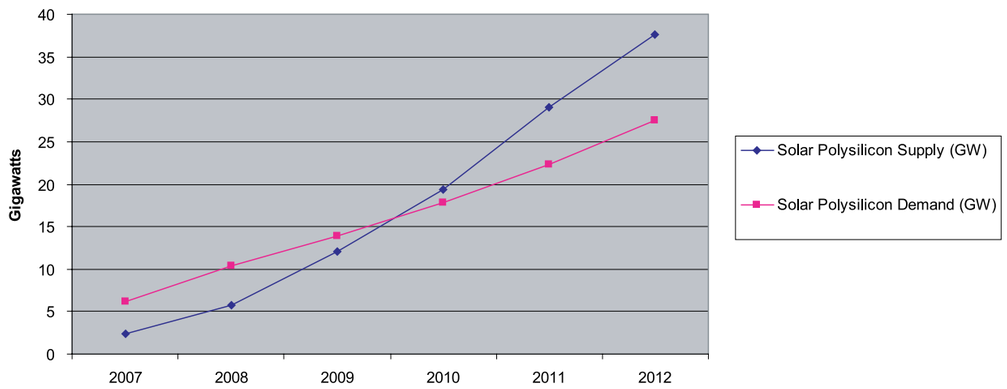
"The PV supply chain is immature and inflexible, which will result in significant supply chain instability and waste," Wicht said. "iSuppli estimates that more than 90 percent of the existing PV supply chain is characterized by fixed supply agreements that are incapable of adjusting to actual changes in end-demand.

Supply and demand will not be able to maintain balance at the various nodes in the supply chain for any length of time, resulting in substantial swings in inventory and pricing over the next two years, at which point polysilicon supply will exceed demand so much that all contracts and sales channels will need to be redefined."

Mounting supply-chain problems come at a time when the market is undergoing rapid growth. Wafer-based solar cell operational production capacity will increase from 6.2 Gigawatts (GW) in 2007 to 17.8 GW in 2010 and 27.5 GW in 2012, iSuppli predicts. However, polysilicon production will rise even faster, with production equivalent to 5.7 GW in 2008, to 19.4 GW in 2010 and to 37.6 GW in 2012.

The attached figure presents iSuppli's forecast of solar-grade polysilicon supply and demand.

The decline in pricing and expected oversupply of polysilicon will benefit PV wafer makers that buy the raw material. However, the pure solar wafer market



Source: iSuppli Corp. November 2008

will become a less attractive business in the future.

"The pure wafer business is a siren's call," Wicht observed. "The wafer business today is driven by profitability that results from the disposing of scarce supplies of polysilicon. In reality, producing a wafer is not technically beyond the capability of either the polysilicon suppliers or the cell producer. Eventually, then, both polysilicon and cell producers will try to drain all the profit out of this level of the supply chain."

The solar wafer segment will undergo consolidation sometime after 2012 after polysilicon prices collapse completely, iSuppli predicts.

www.isuppli.com

Power Supply Reliability

Always measure the switch current

In an article in June 2007, I wrote about the failure mechanisms of switching power supplies[1]. Almost always, at the heart of the failure, is the power FET. While it is not always the root cause of the failure, it rarely survives, and the failure can be quite dramatic.

Most designers are careful to look at the voltage waveforms on the FET, and this is mentioned as a source of failure of a power supply in[1]. However, many power supplies that I see have no record of current measurement, and this means that engineers often miss impending problems in their designs. The current is not always convenient or easy to measure, but you should always make the effort to look at it. This article gives some tips on making current measurements.

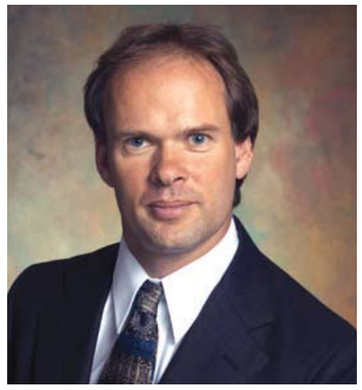
By Dr. Ray Ridley, Ridley Engineering

Current Sensing for an Offline Flyback Converter

Figure 1 shows a typical offline flyback converter with an integrated controller. On the primary side, an RCD snubber is used to clamp the voltage peak waveform on the power FET. Application notes often show this waveform under all different conditions, including overcurrent and shutdown mode.

The RCD snubber provides a very effective clamp, and even in cases where there is severe overcurrent in the switch, the effect will not be shown in the voltage across the FET. It is crucial to look at the current in the FET directly to make sure the power supply design is rugged under all conditions.

There is no direct current measurement point available in this schematic. Current sensing is done internally in the power supply controller. In order to measure the current, the circuit traces must be broken at either point A, B, or C. (Conventional lab techniques use a current probe at one of these points, but these are often too large and their inclusion in the circuit can affect the waveforms. In some cases, this can even cause failure of the power supply.)



If you don't have a suitably small current probe, you can insert sensing elements in the circuit to accurately measure the current. Figure 2 shows a current sense resistor at point A in the circuit, connected to the source of the FET. If your power supply design does not already have this resistor in the schematic, this is NOT a recommended approach. Integrated controllers can be adversely affected by the inclusion of a sense resistor since the grounding of the controller is changed.

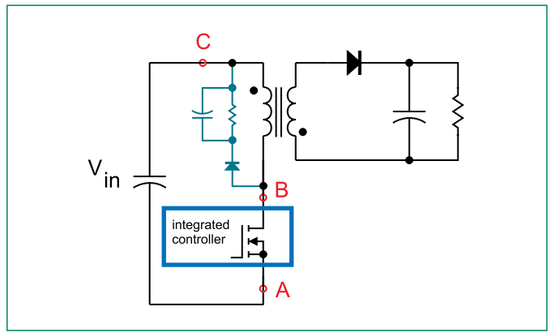


Figure 1: Flyback converter with integrated controller. No current measurement point is immediately available.

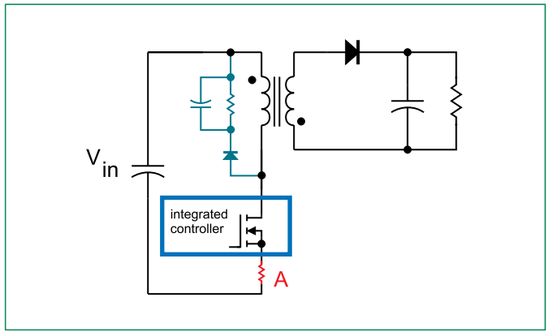


Figure 2: Flyback converter with current sense resistor.

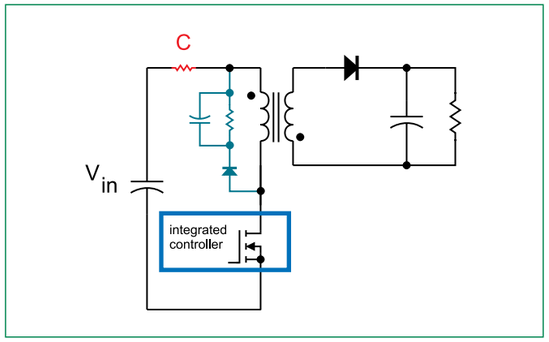


Figure 3: Flyback converter with a current sense resistor from the voltage rail.

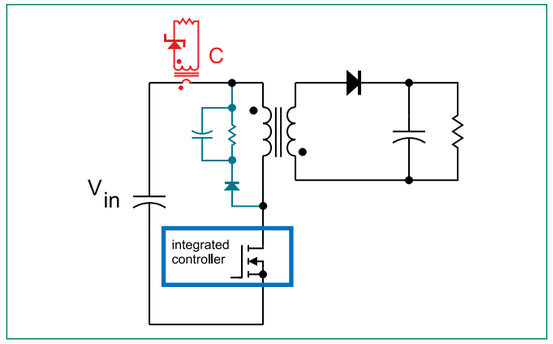


Figure 4: Flyback converter with a current transformer from the voltage rail.

For a discrete controller and FET design, the sense resistor can be used in the source, but bear in mind that the sensed current includes the gate drive current, and this can be substantial for large die FETs. With this setup, the scope ground clip is connected to the negative input rail, and this can present safety concerns for offline converters. It should be done with extreme care. I always recommend isolating the power supply with a line-frequency transformer, and establishing a ground point on the negative rail to make this measurement.

The drain of the FET, point B, is also not a recommended point for measurement. This node of the circuit has the largest voltage excursions, and this will affect the accuracy of current sense resistors, current transformers, and current probes.

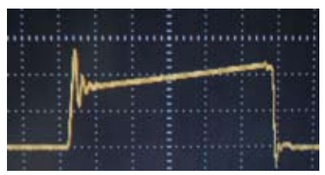


Figure 5: Current waveform for well-behaved converter.

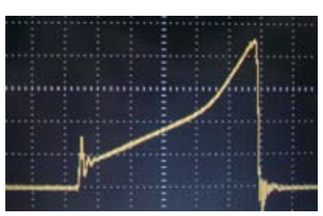


Figure 6: Current waveform with hard saturation with overload.

Figure 3 shows a current sense resistor connected to the positive rail of the power supply. This point does not have any high-frequency excursions, and if you isolate the power supply with a transformer, you can put the ground of the scope on the positive rail, and measure the inverted current signal across the resistor. This is a good and reliable method of measuring the drain current, but it has the disadvantage that the signal is very small, and you cannot simultaneously measure the voltage on the drain of the FET.

The current sense resistor method can work well, and certainly is noninvasive in the circuit with a small sized resistor. For low currents, this is a valid approach. Another way to measure the current is with a current-transformer network, as shown in Figure 4. This circuit can provide measurement of small or large currents, and will also provide a larger voltage signal. The current transformer can be a standard component, or a custom made transformer for reduced size. It is important to keep the loop of wire through the current transformer as small as possible since the inductance created will increase the voltage stress on the power FET.

If you are using a current sense transformer network like this, it is often a useful step to compare it to a resistor sense method to make sure your current sensing is working properly. Once the waveforms look good, the current transformer offers the advantage of providing a fully isolated signal, allowing you to look at the current waveform at the same time as establishing a ground on the negative rail of the input converter.

Unlike an active current probe, the current transformer does not have any delay in the sensing that must be compensated for when assessing quantities such as switching losses in the FET. This current sensing network is also the preferred circuit for sensing the signals to be used for feedback in higher power circuit, providing the required accuracy and speed.

Typical Converter Waveforms

The primary switch current for all converters look very similar if they are

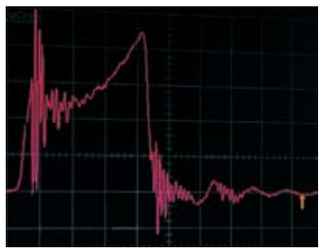


Figure 7: Current waveform with transformer saturation during startup.

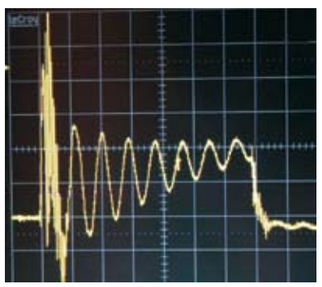


Figure 8: Current waveform with excessive ringing.

operating in conventional PWM mode. Figure 5 shows a typical current waveform for a well-behaved converter. There is an initial turn-on spike of current due to recovery of diodes, and stray capacitances. A subsequent ringing is quickly damped out, and the inductor current rise that follows is very linear.

The initial current spike presents problems when using the waveform for current-mode control, but filtering or leading-edge blanking can be used to solve this.

Figure 6 shows the same converter with an output inductor that is saturating abruptly. The slope of the current changes as the core saturates. Even though the power supply is in danger of failing with this condition, the impending problem cannot be seen by just looking at the drain-source voltage waveform on the power FET. The clamp voltage rises slightly, but you cannot see the change in inductance directly. It is essential to monitor the switch current under all conditions to avoid saturation.

Figure 7 shows another case of magnetics saturation. In this instance, the converter is not overloaded, but the saturation is occurring during startup of the converter. The leading edge blanking period is too long, and the switch current is uncontrolled during startup. This is a relatively common event in converter designs, and it must be avoided to prevent increased failure rates. For high power converters, it is advisable to have a secondary current limit which is active even during the control blanking period in order to prevent severe overcurrent that can lead to failure.

Figure 8 shows a converter where the initial current ringing is never properly damped or controlled. The voltage waveforms in the circuit do not reveal this ringing. The ringing in the FET waveform presents serious problems in implementing current-mode control, and prevents accurate current limiting for the circuit.

Other current waveform anomalies exist in PWM converters, especially bridge or push-pull topologies. It is essential to monitor all the currents to ensure there is no impending imbalance in drives. This can be a very sudden event in full-bridge, half-bridge, or push-pull designs, and the consequences can severely degrade performance, or lead to failure.

Summary

It is not always easy to cut into a circuit to measure the power switch currents, but this is an essential design step to ensure that your converter is rugged under all conditions. Experiment with current-transformer sensing circuits, and you will quickly find this is a very useful approach for monitoring multiple currents in a circuit while maintaining isolation. You should always be careful that current sensing loops are kept as small as possible so as not to introduce increased leakage inductance that change circuit waveforms.

References

1. "Why do Power supplies Fail", Raymond B. Ridley, Power Systems Design Europe article, July/August 2007, available online at http://www.powersystemsdesign.com/design_tips_ja07.pdf

Four-Day

Power Supply Design Workshop

Bordeaux, France at the Mercure Hotel • March 30 - April 2, 2009

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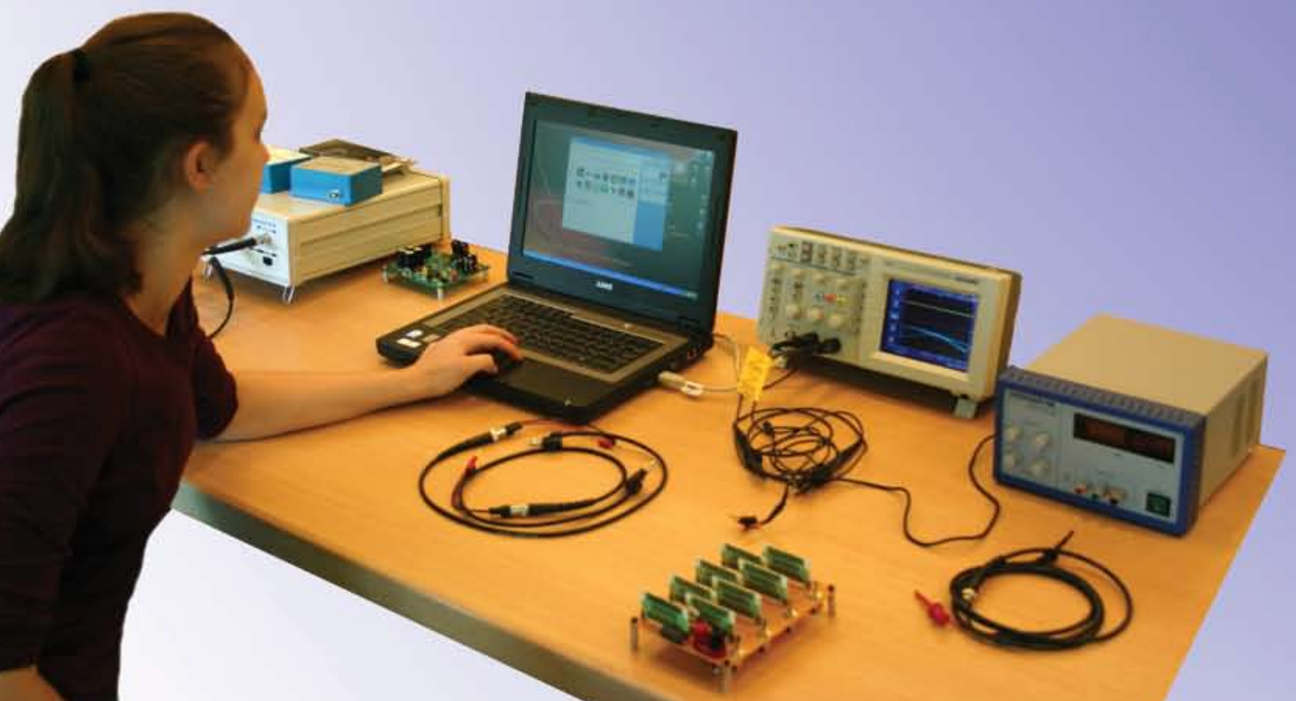
The Workshop focuses on theoretical and practical concepts with hands-on experience. Learn to design, build and measure switching power supplies in our state-of-the-art travelling laboratory.

Study theory and design concepts each morning, and build circuits and magnetics in the afternoon. Learn how to use POWER 4-5-6, the world's most comprehensive design software and receive your own personalized copy for attending the workshop.

Tuition is €2500 and includes training, lab notes, POWER 4-5-6 software and lunch. Reservations are now being accepted. Only 24 seats are available at each workshop.

Download a registration form at www.ridleyengineering.com



Agenda

Monday

Morning Lecture 8:30 - 12:00	Afternoon Laboratory 13:00 - 17:00
Power Stage Topologies	Design of Flyback Inductor/Transformer
Inductor Design	Construction, Winding, Gapping Transformer
Saturation	Impedance and Leakage Measurement
Core Loss	In-Circuit Testing
Proximity Loss	Snubber Design
Practical Design Procedures	Full Power Testing
	Efficiency Measurements

Tuesday

Morning Lecture 8:30 - 12:00	Afternoon Laboratory 13:00 - 17:00
Transformer Design	Design of Forward Inductor
Saturation	Design of Forward Transformer
Leakage Inductance	Construction, Winding, Gapping Forward Mag.
Planar Magnetics	Impedance and Leakage Measurement
Proximity Loss	In-Circuit Testing
Multiple Output Cross-Regulation	Snubber Design
Winding Capacitance	Full Power Testing and Efficiency Measurements
Practical Design Procedures	
Gate Drive and Current-Sense Transformers	

Wednesday

Morning Lecture 8:30 - 12:00	Afternoon Laboratory 13:00 - 17:00
Simulation of Power Supplies	Measurement of Forward Control Characteristics
Small-Signal Analysis for Voltage-Mode Control	Output Impedance Measurement
PWM Switch Model	Control Loop Compensation
CCM and DCM Operation	Loop Gain Measurement
Right-Half-Plane Zeros	Stability Optimization
Loop Gain Criteria	Step-Load Response Measurement
Compensation Design	

Thursday

Morning Lecture 8:00 - 11:00	Afternoon Laboratory 12:00 - 15:30
Current-Mode Control	Measurement of Flyback with Current-Mode
Current-Mode Circuit Implementation	Compensating Ramp Addition
Current-Mode Problems	Control Loop Compensation
Current-Mode Advantages	Loop Gain Measurement
Small-signal Analysis of Current-Mode Control	Stability Optimization
Subharmonic Oscillation	Second-Stage Filter Design
Current-Mode Feedback Design	

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On the Road

Reported by Cliff Keys, Editor-in-Chief, PSDE

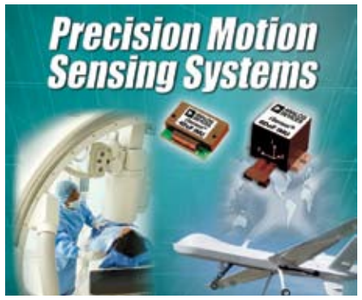
Analog Devices

As ever, ADI brings something very special to the party. At electronica, the company unveiled many new products and I have selected the following as the pick of the best.

Inertial Sensors Motion Sensing

Industrial and Medical Instrumentation

ADI expanded its award-winning iSensor™ intelligent sensor product family with two new inertial sensors that make it simple and affordable to implement sophisticated motion and navigation control in a broader range of applications, including medical instrumentation. The ADIS16405 six-degrees-of-freedom (6DoF) inertial measurement unit (IMU) combines high-performance, simplicity, and a tri-axis magnetometer sensor for improved heading accuracy. The ADIS16300 four-degrees-of-freedom (4DoF) IMU is offered at an industry breakthrough price that is up to 10 times less than other products in its class.



Designed using ADI's iMEMS® Motion Signal Processing Technology™, the ADIS16405 complete inertial sensing system integrates a three-axis gyroscope, magnetometer, and accelerometer. The embedded magnetometer provides accurate heading to complement the product's superior response and short-term stability.

The ADIS16405 features 0.05 degree rate-sensor orthogonal-alignment-accuracy, which improves overall system accuracy and simplifies end-system design. The magnetometer sensors are calibrated and aligned to the inertial sensor axis. The extensive calibration and dynamic compensation results in an angular random walk of below 2.0 degrees/√hr and temperature stability of 40 ppm/°C. All sensors are accessible over a standard SPI interface, which also allows control of internal digital filtering.

The ADIS16300 and ADIS16405 are compatible with other iSensor multi-axis inertial sensors which include the ADIS16365, ADIS16364, ADIS16355, ADIS16354, and ADIS16350.

New Power Efficient Continuous-Time Sigma-Delta ADC Family

Analog Devices has unveiled the industry's lowest noise, widest bandwidth family of continuous-time sigma-delta (CTSD) analog-to-digital converters (ADCs) today. The 16-bit, AD9261 and AD9262 CTSD converter, and the AD9267 CTSD modulator couple low noise and high dynamic range with a bandwidth of up to 10 MHz.

The new ADC family achieves its unique combination of speed, accuracy and bandwidth by incorporating a breakthrough CTSD converter technology that is ideal for wireless infrastructure, medical and other high-performance equipment demanding uncompromised data resolution and wide bandwidth.

The new converters complement Analog Devices' data converter portfolio providing an exceptional combination of wide bandwidth and low noise. The highly integrated CTSD architecture eliminates multiple discrete components at the system level, while simultaneously improving performance and simplifying product development.

Raised Performance Threshold

The 16-bit single and dual AD926x ADC family achieves industry leading performance with an unprecedented combination of 86-dB dynamic range for an input signal bandwidth of up to 10MHz. The highly integrated AD9261 and AD9262 feature an on-chip PLL clock multiplier, decimation filters, and sample rate converters and provide flexible output data rates between 30 MSPS (mega-samples-per-second) and 160 MSPS.

The AD9267, which features only the high performance 640-MSPS modulator core and PLL clock multiplier, presents the high speed data directly to the output.

This provides designers the flexibility to offload signal processing functions to an FPGA or other processor.

Low Power Consumption

The 150-mW per channel to 350-mW per channel power consumption of the new CTSD converters is matched to a range of communications and industrial applications, including emerging radio architectures, such as direct down conversion, where the dual AD9262 and AD9267 can be used to support multiple wireless carriers and standards simultaneously. The AD926x CTSD ADC family is sampling now and will be available in volume production in April 2009. Complementary ADI parts in the signal chain include the AD9520 clock generation and distribution integrated circuit and the high performance ADL5382 I-Q demodulator.

www.analog.com

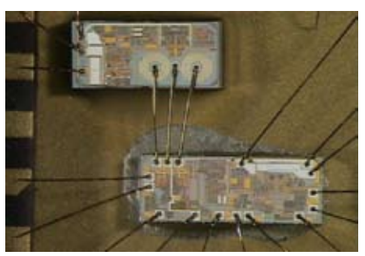
Infineon Technologies

At its press conference at the electronica trade fair, Infineon demonstrated its alignment with its key customer segments and gave a powerful overview of the company's commitment to this alignment. Here follows a report on the products presented.

Intelligent Lamp Ballast Controller for Fluorescent Lamps

Infineon launched its next-generation lamp ballast controller that features intelligent digital/mixed signal power control. The new ICB2FL01G lamp ballast controller integrates Power Factor Correction (PFC), lamp controller and high-voltage half-bridge driver functions into a single, compact, surface-mounted package. Employing digital/mixed signal power control technologies, the product integrates all of the lamp start, run and protection features required by current and future fluorescent lamp ballasts. Reliable and robust high-voltage isolation is achieved using Infineon's proprietary Coreless Transformer Technology (CLT). CLT is by nature an intrinsically robust high-voltage isolation media and offers excellent immunity from positive as well as negative transients.

Typical applications for the ICB2FL01G product are electronic ballasts for compact fluorescent lamps, linear fluorescent T5 and T8 lamps, dimmable fluorescent lamps and emergency lighting.



Infineon's proprietary Coreless Transformer Technology (CLT).

Lamp ballast controller ICB2FL01G demo-board.

Digital / mixed signal power control enables stable, dependable ballast designs to be implemented with the minimum of external components and at minimum system cost. Depending on the application, more than 20 components, including capacitors, diodes and resistors can be saved. Furthermore, the use of this technology allows parameters to be set utilizing only resistors, which avoids the issues with trimming and aging associated with the use of capacitors in existing solutions. With few additional external components the ICB2FL01G supports multi-lamp designs controlling up to four lamps as well as multi-power ballast designs handling different power lamps. A key new feature of the second generation ballast controller is the provision of special built-in test modes that allow ballast manufacturers to dramatically shorten production test times, halving the time for key tests such as End-of-Life detection and preheat operation modes.

Further key features of Infineon's ICB-2FL01G lamp ballast controller include a wide programmable preheat time spanning from 0ms to 2500ms, which allows lamp ballast designers to support a wide range of lamps, as well as highly accurate timing and frequency control over a wide temperature range of -25°C to +125°C.

More and more emphasis is being placed not only on the efficient production of light, but also on its effective use. With this in mind, the ICB2FL01G has been designed to be highly compatible with dimmable lamp ballasts, offering outstanding efficiency (up to 90 percent) and THD (Total Harmonic Distortion) performance over a wide load range. Intelligent lamp fault detection and restart control enable compliance with Emergency Lighting requirements according to the European DIN VDE 0108 standard.

Availability and pricing

The ICB2FL01G lamp ballast controller is sampling now. It comes in a standard lead-free DSO package with 19 pins. Volume production is scheduled for January 2009.

A fully featured demo board is available and the product is supported by comprehensive application documentation.

Additional information on Infineon's new lamp ballast controller is available at:

www.infineon.com/lighting

Smallest ESD Protection Diode for RF Antennas

Infineon Technologies launched the world's smallest transient voltage suppression (TVS) diode for the protection of antennas in latest electronic equipment. Applications include GPS, mobile TV, FM radio, and vehicles' Remote Keyless Entry (RKE) and Tire Pressure Monitoring Systems (TPMS). The new TVS antenna protection diode, the ESD0P2RF-02LS, is only 0.62mm x 0.32mm in size and a mere 0.31mm in height. It is designed to protect the latest electronic communication and consumer devices against electrostatic discharges (ESD) and can reliably absorb electrostatic discharges as high as 20kV. High linearity up to 6GHz together with market's lowest capacitance of 0.2pF for a TVS diode and low clamping voltages in a bi-directional configuration are the perfect fit for sensitive RF antenna applications. Infineon is a technology leader in diodes and already launched the world's smallest TVS diode for the protection of high-speed data lines in December 2007.

The TVS antenna protection diode ESD0P2RF-02LS is designed in a tiny leadless TSSLP package that measures only 0.62mm x 0.32mm (equivalent to the 0201inch package with 0.024inch x 0.012 inch in size). The miniature package, which is about 70 percent smaller than today's products with similar features, not only allows significant space saving on high density PCBs and great flexibility but also it is specifically designed for the integration into complete modules and

World's smallest transient voltage suppression (TVS) diode.

frontend systems or even directly into original component packages of filters and ICs (e.g. System in Package, SiP). Especially valued for implementation in mobile phones and other thin portable devices, its ultra-low package height down to 0.31 mm can meet the most stringent height requirements.

Ultra-low capacitance characteristics

With only 0.2 pF parasitic capacitance, the diode ESD0P2RFL-02LS offers optimum signal integrity at a maximum of protection against ESD without degrading effects. That means that Infineon's diode masters an extremely fast response time of less than 0.5 ns to effectively shunt the electrostatic discharge current away from the protected circuit to a low and safe level, a characteristic that is of great value in very susceptible circuits in RF-antenna applications. The ESD0P2RF-02LS diode offers a multi-strike ESD absorption capability up to 20kV contact discharge, exceeding by far the industry standard IEC61000-4-2 level 4 of 8kV.

The new antenna protection diode ESD0P2RF-02LS is designed for applications with signals swinging above and below ground with a maximum working voltage of up to ±5.3V. Because of its bidirectional characteristics with symmetrical clamping voltage, orientation of the device in the PCB is not an issue. Battery-powered mobile applications will greatly benefit from this new subminiature TVS diode as it drains extremely low leakage currents down to 1nA (at 5.3V) and therefore helps to extend battery duration. The ESD0P2RF-02LS is qualified according to the most stringent standards like the Automotive AECQ101 standard.

Availability

The ESD0P2RF-02LS diode is scheduled to enter mass production by end of 2008 just as the ESD0P2RF-02LRH diode in the larger TSLP-2 package (1.0mm x 0.6mm x 0.31mm) for applications with less limitation on space demand. Both TSSLP-2 and TSLP-2 packages are fully compliant with RoHs and halogen-free directives.

Additional information on Infineon's TVS diode product portfolio is available at:

www.infineon.com/tvsdiodes

www.infineon.com

International Rectifier

I was invited to attend International Rectifier's unveiling of this new and certainly ground-breaking technology. The company, led by President and Chief Executive Officer, Oleg Khaykin, is leading the way in attaining a supercharged figure of merit (FOM) for the new devices from this technology.

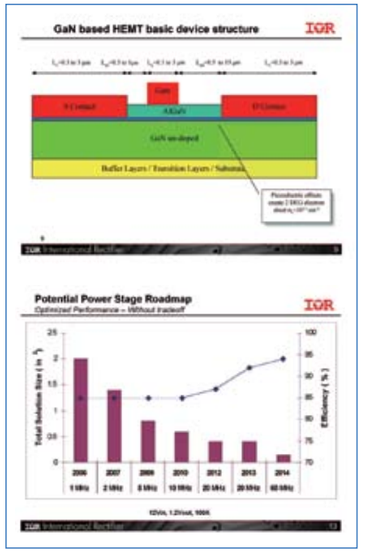
Revolutionary New GaN-based Power Device Technology Platform

Proprietary GaN-on-silicon epitaxy and power device technology heralds new era for power conversion

International Rectifier announced the successful development of a revolutionary gallium nitride (GaN)-based power device technology platform that can provide customers with improvements in key application-specific figures of merit (FOM) of up to a factor of ten compared to state-of-the-art silicon-based technology platforms to dramatically increase performance and cut energy consumption in end applications in a variety of market segments such as computing and communications, automotive and appliances.

The pioneering GaN-based power device technology platform is the result of five years of research and development by IR based on the company's proprietary GaN-on-silicon epitaxial technology.

IR's GaN-based power device technology platform enables revolutionary advancements in power conversion solutions. The portfolio of system solution products and related intellectual property (IP) extends far beyond leading-edge



Oleg Khaykin, IR's President and Chief Executive Officer, unveils the new GaN wafer. (Note the handcuffs on the briefcase!).

discrete power devices by effectively deploying the company's 60-year heritage in power conversion expertise in a wide variety of applications including AC-DC power conversion, DC-DC power conversion, motor drives, lighting, high density audio and automotive systems.

The high throughput, 150mm GaN-on-Si epitaxy, together with subsequent device fabrication processes which are fully compatible with IR's cost effective silicon manufacturing facilities, offers customers a world-class, commercially viable manufacturing platform for GaN-based power devices.

"This leading-edge GaN-based technology platform and IP portfolio extends IR's leadership in power semiconductor devices and heralds a new era for power conversion, in line with our core mission to help our customers save energy," said IR's President and Chief Executive Officer, Oleg Khaykin.

"We fully anticipate the potential impact of this new device technology platform on the power conversion market to be at least as large as the introduction of the power HEXFET® by IR some 30 years ago," he added.

Prototypes of several new GaN-based product platforms were made available to leading OEM customers at the Electronica tradeshow which took place in Munich, November 2008.

Khaykin continued: "We believe that early adopters will be those market segments and applications that will take full advantage of the revolutionary capability of transforming the value realization of the key features of power density, power conversion efficiency and cost".

International Rectifier is already a world leader in power management technology. Its analog- and mixed-signal ICs, advanced circuit devices, integrated power systems, and components enable high-performance computing and reduce energy waste from motors, the world's single largest consumer of electricity. Leading manufacturers of computers, energy-efficient appliances, lighting, automobiles, satellites, aircraft, and defense systems rely on IR's power-management benchmarks to power their next generation products.

www.irf.com

Intersil

I met with Dave Bell, Intersil's President and CEO. I asked him directly what was new from Intersil for the power community. Dave gave me the answer. He then walked me through the company's industry beating new power module, the ISL8201M. The company is rapidly expanding its areas of activity and is well on track in achieving this through internal restructuring to integrate its acquisitions. The company is cash rich, aggressive and hungry for expansion. A refreshingly powerful combination.

Industry Beating Power Conversion Module

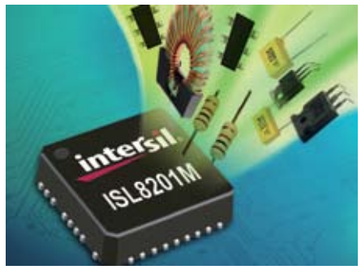
Intersil, universally known and respected by designers in the arena of design and manufacture of high-performance analogue semiconductors, announced at electronica, the development of the ISL8201M, a highly integrated Power Conversion Module that saves space and cost.

This new DC/DC module has 4.5V to 20V input voltage range, 0.6V to 5V output range and 10A current capability in a 15mm x 15mm x 3.5mm QFN package. Designers and manufacturers have been attracted to the device for its high power density, high accuracy and high efficiency across a wide load range, plus it can be easily probed with pins easily accessible and not 'buried' under the package. Inspection becomes 'real world' in not having to rely on X-ray tech-

niques to examine hidden connections under the package.

The ISL8201M, a high efficiency, low noise, highly integrated DC/DC power solution in a thermally enhanced QFN package, includes in the package the PWM controller, MOSFET drivers, power MOSFETs and inductor along with an optimized compensation circuit.

It simplifies power supply design as only input and output capacitors and a resistor are needed to implement a complete power solution. This small form factor saves considerable board space



Dave Bell, Intersil's President and CEO.

while the high integration reduces procurement and placement costs in various applications such as telecommunication, data communication, electronic data processing, wireless network systems, medical & instrumentation and distributed bus architecture based point of load applications. Also, an onboard input filter supports an ultra-low noise operation thus reducing EMI which can give a fast track to market.

The ISL8201M achieves up to 93% efficiency and excellent thermal performance due to the QFN package that is designed to offer an optimum heat transfer through the PCB. A large copper plate under the package allows the ISL8201M to achieve a power density of approximately 200W/in^3, roughly four times that of conventional open-frame modules thereby eliminating the need for heat sinks. Other features include internal soft-start, auto-recovery overcurrent protection, ENABLE pin option and pre-biased output start-up capability.

The ISL8201M is housed into a tiny 15mm x 15mm x 3.5mm QFN package and is available imminently for sampling.

www.intersil.com

National Semiconductor

Brian L. Halla, Chairman of the Board and Chief Executive Officer addresses the press at electronica.

The only way is up!

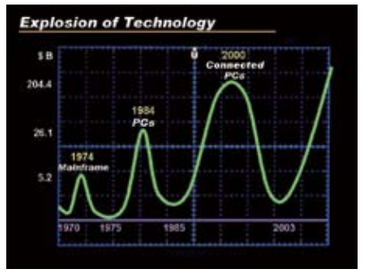
National's chief, Brian Halla, presented to the assembled press at the electronica trade fair in Munich, Germany. Capitalizing on National's strength in energy-efficient, high-performance analog technology, Brian has sharpened the company's strategic focus to serve major market segments including personal mobile devices, communications infrastructure, medical, automotive and industrial applications as well as alternative energy. National's leading-edge standard linear products include power management circuits, display drivers, audio and operational amplifiers, interface products and data conversion solutions –products that enhance robust sound, enable vibrant graphics, maximize battery life and power as well as provide better portability.

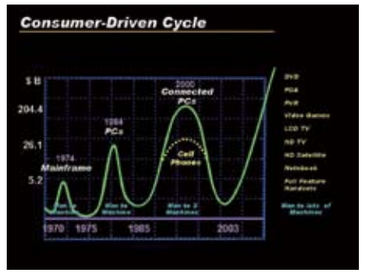
He is extremely active in our industry; on the board of Cisco Systems, Inc., the Semiconductor Industry Association

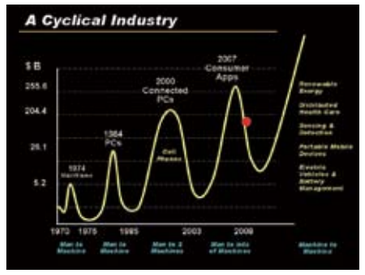
(SIA), the IEEE Noyce Award Committee and the Silicon Valley Leadership Group. He also serves on the University of California at Berkeley's Engineering and the University of Nebraska Engineering College Advisory boards. Brian tells us 'just like it is' –not a marketing pitch, but a realistic and therefore more credible picture of where the industry is and importantly, where it's going.

He called for a 'Semiconductor Sea change' arguing that governments do not care about our industry. Research funding just doesn't happen fast enough, if at all. Our industry's R&D dollars/euros/pounds now target "Quality-of-Life" Megatrends. Analog continues to play an increasingly vital role as the enabler. Furthermore, Moore's law doesn't work here. Without low power technology, we would, in Halla's own words need 'fans powered by Boeing'. Eloquently put!

Low-power solutions will enable future solutions for all the new megatrends in Energy, Healthcare, Safety and Personal productivity such as Personal Mobile Devices.







Brian took us through the 'Cycles of Semiconductor Demand' peaking in 1974 with the mainframe computer and subsequent explosive growth of the DRAM market. Some of us are long enough in the business to remember this!

Then along came the personal computer which peaked around 1984, followed in 2000 with the proliferation of the internet and so-called 'connected PCs'.

Looking at the second chart, we can see that the consumer driven cycle is impacted by the cell phone, PDAs, video games, LCD TVs, digital cameras and consumer electronics, probably the biggest our industry has ever seen. But it doesn't stop there.

So what comes next? Almost as a sidebar, Brian explained how he gave one of his scientists at National the challenge to use all the resources at his disposal to predict what was coming, based on what the boom/bust cycles had brought in the past. Naturally, as a scientist he used advanced mathematics, simulation, the chaos theory and other 'beyond my imagination' theorems. The chart below shows this prediction curve, the red spot shows the uncomfortable position we're in at the moment, but apparently, with good news on its way.

PowerWise®

National's PowerWise product portfolio consists of more than 300 products in 25 product categories that are classified top performers in efficiency. It is, in simple terms, an umbrella brand that gives a special badge for energy efficient products from National throughout their product range including, Power Management, Data Conversion, Operational Amplifiers, Interface and Audio.

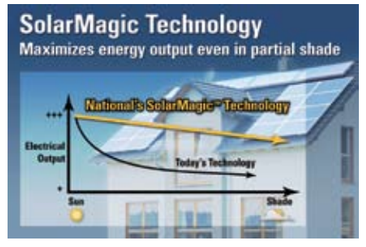
PowerWise utilizes Adaptive Voltage Scaling (AVS) and combines external power management with internal intellectual property to dramatically lower power consumption in digital CMOS logic by actively monitoring conditions & internal properties of the digital system to select the optimum operating voltage. The system can save up to 64% over traditional fixed voltage systems.

Unlike a mere brand though, PowerWise products are rigorously checked against the company's published metrics to help designers evaluate & compare analog components & subsystems across a broad range of manufacturers.

According to Brian, the future of PowerWise technologies lies in Analog-to-Information (A-to-I) where entire processing chains move to the analog domain delivering tremendous savings in power due to 'near instantaneous' processing of analog signals directly into useful signals.

An example of this is National's Far-Field Noise Suppression (FFNS) where noise, traditionally the bane of mobile calls in public environments, is cancelled using phase comparison at the microphone, giving a clearer voice quality using 10% of the power that would be used by a DSP solution.

The top PowerWise Markets include Renewable energy, Distributed health



care (portability), Sensing & detection (security, health & surveillance), Personal Mobile Devices, Electric vehicles / battery management…the list is endless in these power sensitive times.

SolarMagic™

The Solar market in particular is booming and Germany leads the way here. SolarMagic is National's answer to the practical problems encountered in the implementation of solar arrays.

Ideally, the panel would be in full sun the whole day delivering full output to the load. In practice, trees, leaves debris and 'gratuitous deposits' from birds can cause shading and virtually shut down the system. Other known problems include solar panel mismatch, panel aging, and panel failures. SolarMagic technology is able to help overcome these types of problems by optimizing the energy output of each individual panel in an array.

SolarMagic basically isolates the shaded panel and so maximizes the output of the other unshaded and productive panels. Field trial results have been encouraging with SolarMagic technology delivering 12% more energy over the entire day.

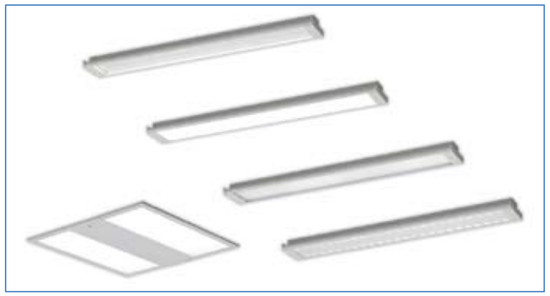
Brian expanded on the broad range of offerings from National and concluded that with the opportunities open to our industry, even in these tough times, it is a 'Fabulous time for technology' with low-power electronics (PowerWise), enabling green, portable, and brand new quality-of-life applications. Continued semiconductor R&D investments will now drive this focus which for our industry – even given the current troubled times- will mean a renewed vitalization of our technology.

www.national.com

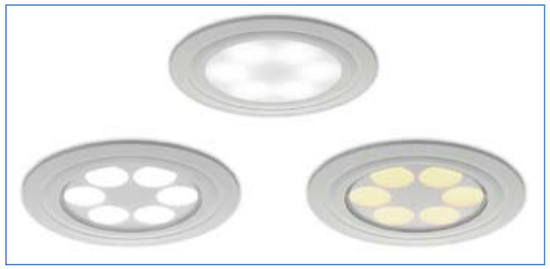
Sharp Microelectronics

Sharp introduced lighting for factories, offices and commercial spaces. The company's next generation of lighting fixtures deliver high environmental performance combined with high energy efficiency and long product life.

Dedicated to Energy Saving LED Lighting



Oblong and Square type LED lighting fixture.



Sharp LED down lights use only one fifth of the electricity of standard incandescent bulbs of equal brightness.

Besides introducing the Zenigata LED modules as illuminant component for lamp designers and system integrators, Sharp Corporation has developed new series of LED lightings as finished products. The "oblong" type LED lighting features a brightness equivalent to standard fluorescent lamp fixtures that are currently the main lighting in factories, offices and commercial spaces. The "downlight" type LED lighting systems deliver a brightness equivalent to a standard 150-watt incandescent light lamp. Sharp introduced a total of 11 models, including four oblong, one square, and six downlight models.

The "oblong" lights being introduced feature an elongated form factor resembling conventional fluorescent light fixtures equipped with twin 40-W straight-tube fluorescent lamps. Due to a luminaire efficacy of 74 lumens/watt, currently the highest in the industry for LED lighting, the "oblong" Sharp LED lighting delivers a light intensity of up to 4,000 lux directly underneath the fixture at a distance of one meter. This is equivalent to the brightness of twin 40-W straight-tube fluorescent lamps, consuming about 25% more power than the new LED lightings from Sharp. The outstanding light efficiency is also supported by the sophisticated lamp design: Sharp developed a proprietary optical design technology that reduces light absorption and boosts the percentage of light utilized by treating surfaces to have high reflectivity. This technology provides efficient surface-emitting illumination minimizing variations in color and light intensity overcoming drawbacks of LED-based lighting in the past. Coming in different color temperatures (4800K, 4900K, 5000K and 5600K) and also being available as "square" type model the LED lightings are ideal for conference rooms and reception areas, providing an even, uniform illumination thanks to diffused surface-emitting light technology.

Further, the "downlight" line-up includes a model with light output of up to 1,400 lumens which is equivalent to a conventional 150-watt incandescent bulb, the highest brightness in the industry for LED Lightings. With a power consumption of maximum 27.5 Watt the Sharp LED down lights use only one fifth of the electricity of standard incandescent bulb of equal brightness. The series features lamps in three different color temperatures of 5200K, 5000K and 2800K. Besides the 150W equivalent lamps there are also 100W equivalent models available. These downlight types are suggested for use in commercial spaces such as shopping centers and department stores, as well as hotel lobbies and entrance foyers of business offices.

LED lights, which have low energy consumption compared to incandescent lamps and fluorescent tubes, also feature an outstanding environmental performance including being mercury-free and a long product life of 40,000 h which is about 10 years of operation at an on-time of 10 hours a day. Besides the resource saving effects this is reducing maintenance costs particular on factory floors and office buildings, whereas illuminating systems occasionally need be installed in hard to reach places. As large scale case all plants located within the new manufacturing complex now under construction in Sakai City, Osaka Prefecture will adopt LED lightings manufactured by Sharp as the main lighting. This will represent the world's largest collection of LED Lightings installed in buildings of this scope. Using this achievement as a springboard, Sharp will be working in the future to further expand its LED lighting business into factories, offices and commercial spaces around the globe.

www.sharpsme.com

Texas Instruments

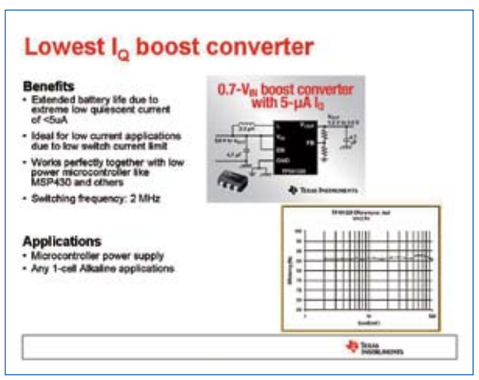
I met with Steve Anderson, Senior Vice President and worldwide manager of TI's Power Management business unit and Uwe Mengelkamp who is responsible for definition, development, engineering and sales of DC/DC Converter products worldwide.
Steve outlined the company's new structure and gave me the clear message that the company is streamlined, well positioned, fit and ready to drive forward relentlessly in this highly competitive growing market. TI have taken top ranking in the power market share assessment according to Databeans and are releasing products in this sector at the rate of over 200 per year.
Uwe ran me through the latest from TI, a report on which follows.

0.7-V Input Boost Converter Supports 5μA Operating Current

TI has introduced a 2-MHz DC/DC boost converter that operates at 5μA of quiescent current, while maintaining a high efficiency at light load conditions. The integrated circuit supports an input voltage of 0.7V to 5.5V and an output voltage range of 1.8V to 5.5V, extending battery life in low-power microcontroller-based designs, such as single AA or coin-cell alkaline applications.

The new TPS61220 boost converter, which comes in a small SC-70 package, provides full battery capacity utilization of a portable system, because of its ability to start up with a 0.7-V input voltage into a connected load. Based on a hysteretic, off-time control method, the device uses synchronous rectification to maintain more than 85 percent power efficiency at the lowest possible operating current. This allows microcontroller-based applications, such as those that use TI's new CC430 microcontroller and low-power RF on a chip, to extend battery life by maintaining efficient standby operation.

The TPS61220 provides output current up to 50mA at a 5-V output, and discharge the system's lithium-ion battery down to 2.5V. The device's output voltage can be programmed by an external resistor divider, or is fixed internally on the chip. In addition, the converter can be disabled to minimize battery drain.



Smallest boost converter solution in an SC-70 package

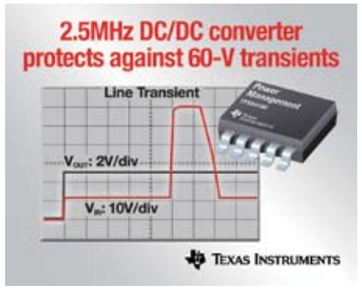
The TPS61220, which comes in a 6-pin, SC-70 package, can achieve a total DC/DC converter solution size of 6.4 x 9mm with a height of only 1mm. The small size and high performance allow designers to implement the device in any portable, microcontroller-based application powered by A, AA or AAA batteries.

Leading power management IC portfolio for MSP430 microcontrollers

TI power management products support a wide range of microcontroller-based designs, including those MSP430-based applications that require ultra-low input voltage, low quiescent current boost conversion or a low-power step-down configuration. In addition to the TPS61220, the TPS61200 boost converter can support input voltage levels as low as 0.3V and lower, opening the door to energy harvesting designs. TI's TPS780xx is the industry's first 500-nA, dual-output low-dropout regulators (LDOs) available in a 2mm x 2mm SON package.

60V SWIFTTM DC/DC Converter Eco-modeTM Technology Maximizes Light-Load Efficiency

Expanding on the company's popular integrated SWIFT™ family of DC/DC converters, TI introduced a new 60-V input, 1.5-A output step-down switcher with integrated FET that achieves significant energy savings in light-load efficiency. The wide-input converter helps save up to 25 percent of board space compared to competitive wide-input voltage solutions and eases design in industrial and automotive applications.



The TPS54160 non-synchronous buck converter operates from a 3.5-V to 60-V input voltage range providing designers flexibility in applications with input transient protection up to 65-V. By leveraging TI's innovative Eco-mode™ light-load switching technique, the converter is able to achieve a low 116-uA operating current and 1.3-uA shutdown current, resulting in longer system run-times and a more efficient power system design.

In addition, the converter's high switching frequency range of 300 kHz to 2.5MHz reduces the size of the output inductors to save board space. The TPS54160's frequency fold-back and thermal shutdown features allow the converter to protect itself during an overload condition.

The TPS54160 also has an integrated track pin that simplifies various sequencing schemes and a clock pin that reduces noise by synchronizing its switching frequency to an external clock. TI's SWIFT DC/DC converters serve a broad range of applications, such as telecom, computing, industrial and consumer point of load applications with input voltage ranges as wide as 60V and output currents as high as 14A.

www.ti.com

Vishay Intertechnology

Vishay Intertechnology, Inc., one of the world's largest manufacturers of discrete semiconductors and passive electronic components, completed the third quarter of 2008 with net revenues of 739 million US dollars. The overview from the company's press conference at electronica follows.

Well Equipped for a Troubled Market

Commenting on the current business climate, Dr. Gerald Paul, CEO of Vishay, stated, "Overall, the last quarter for Vishay and the entire industry has been difficult. Sales and profits have remained lower than expected. The low order intake in October points to a further economic slowdown. Nevertheless, we achieved 0.18US dollars net earnings per share, and 55 million US dollars from continuing business activities, and generated a free cash flow of 89 million US dollars.

In the meantime, the automotive industry in Europe has also suffered from the economic slowdown, as have mobile telephones, computers and consumer goods, which remain below expectations. Conversely, industrial automation is relatively stable, as is military/aerospace. However, orders from global distributors are decreasing rapidly. Should the recession become deeper and longer, Vishay will take all necessary measures to maintain its free cash flow. This also applies to worst-case scenarios."

Dr. Gerald Paul, CEO.

Dr. Felix Zandman, Executive Chairman of the Board and Chief Technical and Business Development Officer.

Diversification in terms of its products, geography, markets – beneficial in times of crisis

From the start, Vishay has been a financially strong and innovative company, and has established itself as a technical and business market leader. Despite sales losses, the last quarter's results confirm the Company's conservative financial policy, which allows it to remain free of debt. Diversification is an important factor in this, as Dr. Paul stresses: "Our geographical distribution is an asset for our international business. Proximity to our customers and location loyalty, both in the USA and Germany, play a major role. Thus, jobs are shifted if necessary, but processes remain at the same location." During economically difficult times, market diversification helps carry the Company and stands for Company security. Vishay also stresses that no single OEM customer accounts for more than 5 percent of its turnover.

Acquisition strategy of profitable specialty products

Despite the current downturn, Vishay has pursued a continuous acquisition strategy, as Dr. Felix Zandman, Executive Chairman of the Board and Chief Technical and Business Development Officer of Vishay said: "We will continue our acquisitions and drive organic growth by focused R&D activities."

Capital investment in the current financial year is at a high level, with some 150 to 160 million US dollars. This is an important milestone in the completion of Vishay's specialty products offering, which finds itself momentarily in a difficult profitable situation. For example, the acquisition of KEMET Corporation's wet tantalum capacitor line in September marked a further step in the extension of Vishay's specialty capacitor product portfolio, which is used in military, aerospace and medical applications.

Dr. Gerald Paul continues: "Any takeover offers new synergies and opportunities for growth. It supports our basic principle of being a "one-stop-shop," because we offer developers the widest choice of discrete semiconductors and passive components. By creating new products, we can address new markets and drive our vertical growth."

All acquisitions underscore Vishay's stable position as a safe and local supplier of high-quality products, regardless of economically turbulent times. Vishay's share of new products introduced to the market continues to increase and its R&D program is on target. The Company is still committed to the development of its production sites in Germany. In recent years, Vishay has invested large sums in the development and optimization of its German capacity (e.g., conversion of wafer production in Itzehoe for the manufacture of standard 200-mm MOSFETs).

Vishay's Research and Development Expertise Trendsetting in Industrial Electronics/Energy Saving and Automotive Projects

In 2006, income from products less than 5 years old was, on average, 26.4% (semiconductors: 35.6% and passive components: 15.3%). By 2010, these figures are set to increase to 36% (semiconductors: 46% and passive components: 22.3%) which, if expressed in figures, represents a rise from $681 million to $1.08 billion.

Vishay's R&D investment, which leads to involvement in many leading applications and projects, is a key factor in the company's image and growth.

Industrial Electronics/Energy Saving

With an average growth of 15.7% per annum (from 2003 to 2008), Vishay ESTA has a unique position in industrial automation. Vishay ESTA is the only company worldwide to offer a complete range of power capacitors, thereby occupying 15% of the European power capacitor market. In Europe, the market grows annually by approximately 5% and in energy content over 25%. In addition, the market also demands smaller and specific, optimally adapted capacitors and capacitor designs. This is where Vishay ESTA scores with its customized development and production of capacitors. The capacitors, manufactured in the Czech Republic, are designed to meet increasing demands for longer life, reliability, electrical characteristics (high acceptable current loads of up to 800 A for each unit, small self-inductance <40nH), lower losses and smaller weight. Development and testing, as well as MTBF tests, all take place at the Landshut, Germany headquarters.

Projects leading the way: Energy transportation, power quality (current and network quality), traffic control

High-voltage direct current (HVDC) transfers are required for the transportation of electricity from large water- and coal-fired power stations to far removed large cities, resulting in high demand for DC and AC high-voltage capacitors. Vishay ESTA has developed and supplied the DC voltage filter capacitors for the HVDC between the Chinese provinces of Yunnan and Guangdong and has built the associated capacitor banks. A first in this project was the high transmission power capacity of 5,000MW, with a voltage of ±800kV and a line length of 1400km, while the previous limit was set at a transmission voltage of 600kV. The project, under the leadership of Siemens, will be completed by 2010 and another project is currently underway in India. A further new application is for offshore wind parks, where energy is fed to the mainland across cables. These also require large quantities of power capacitors. The latest project is the EON offshore project in northern Germany.

Vishay ESTA's cooperation with CERN (the European organization for particle physics) is of particular interest in the progress of science. Vishay ESTA supplied CERN with 8 units of 18-kV condenser filter banks for the SPS (super proton synchrotron) in the quest for the Higgs particle. These components have an installed power of 247 Mvar and consist of 420 capacitors, with a total order value of approximately 400,000 Euro. The capacitor filter banks are used for both reactive power compensation and power grid voltage stabilization for the SPS particle accelerator.

ESTA power capacitors can also be found worldwide in the metro trains of many large cities (including Shanghai, Hong Kong, Taipei, Delhi, Bombay). ESTA capacitors were selected for a recent project in China aimed at the construction of freight locomotives - with an output of 9600 KW (13000 HP), these are the 1500 most powerful locomotives in the world.

Automotive

The automotive industry, which has the highest demands in technology, quality and reliability, is clearly leading the way. Vishay's expertise in the automotive market is confirmed by its turnover of between 16 and 20% of total revenues. Vishay optimizes the power loss of all the components required in a converter (buck or boost) including the storage choke, the MOSFET switch and power Schottky diode (rectification) as well as the power capacitor.

The new storage choke IHLP®-1616, with its patented IHLP® technology (Inductor High Current Low Profile), allows for very high saturation current levels in comparatively small dimensions. Vishay can also adjust certain coil parameters, including the relative permeability μ_{re}, the winding geometry and the DC resistance (DCR).

The newest TrenchFET® MOSFETs from Vishay Siliconix (qualified to AEC-Q101) allow junction temperatures of up to +175°C and are the first components of this type in small housings that are suitable for automotive applications. Due to their higher cell densities, they have an advantage over planar technology, and offer very low switching losses at high frequencies (>100kHz). The first automotive Trenchsky™ (Trench Schottky) Rectifiers also show significantly lower power losses in comparison to standard Schottky diodes. The newest available product is the 200-V/30-A double-high-voltage TMBS® Trench Schottky rectifier, which is an economical alternative to synchronous rectifier solutions.

Trendsetting projects: START-STOP function, brake by wire, sensor technology

A concrete project for achieving power savings is the new START-STOP function: It switches off the combustion engine on short stops in order to reduce fuel consumption and CO_2 emissions. Without the required powerful DC/DC converters that overcome the battery voltage interruption phase, this procedure would cause serious problems to the on-board voltage supply and thus to the operation of devices which are required, even if the engine is switched off, or on restarting. Today, the START-STOP function already generates a saving of up to 8 percent of the fuel consumption. In combination with braking energy recovery this can even be up to 12%. Highly efficient inverters/regulators will be needed, as well as an additional battery sensor (high Power Metal Strip® shunt, 100 μOhms, 36 W) for the monitoring of both charging and load currents.

Trendsetting vehicles (hybrid, electric, fuel cell) require new technologies (e.g., SiC) and high-voltage components. The fuel savings and emission reductions required for today and the future can be attained with various technologies, but all of these rely on electronics (hardware) in connection with associated software. The electrical controllers and sensors in the vehicle are of particular importance and car manufacturers increasingly require that they exhibit electromagnetic immunity to external interference. The power filter components (I-, PI-, LC-filter) must also be designed to keep line voltage drop to a minimum (battery clamp or ignition clamp). Vishay leads the way with its new series of filter chokes (IHTH) that feature a very low DC resistance of 0.5mΩ at 2.2 μH and a rated current of 50A.

Losses in control electronics are a cause for higher fuel consumption and thus higher CO_2 production. The number of discrete components in an electronic control unit (ECU) is usually, depending upon application, from 50 to 2500 devices. Each device, through which a current flows, produces energy dissipation. Vishay has specifically developed components with high component density and low energy dissipation — for example, resistor networks and arrays in diverse technologies (thick and thin film) or combinations of R/C components. As these arrays save copper circuits, they reduce line losses and thus the building area of a controller, which contributes, again, to the weight reduction of a modern automobile.

www.vishay.com

Energy-Efficiency: Walking the Talk

I talked with Andrea Mirenda, VP of Marketing, Fairchild Semiconductor, about the way that some companies are now struggling to get themselves in better shape for the future 'leaner and greener' way they must now do business. Fairchild, with a proven track record in this arena, was a good place to put my question. Here is what she told me.

Today's industry buzz words are green and energy-efficiency. It is encouraging to see our industry step up to the challenge of innovation and focus on contributions that address the significant environmental issues we are facing. Although there are many aspects of participation, it is important that we welcome all to this bandwagon to share best practices and challenge one another to invent the next power-saving product. It is important that this topic is not solely a marketing campaign; it needs to be ingrained in a business' consciousness and an integral aspect of a company's corporate responsibility.

Semiconductor suppliers are the key drivers of innovation in the world of electronics, but they also are instrumental in developing energy-efficient technology and "greening" their IT, manufacturing and employee practices to make them more environmentally friendly.

Companies need to become both entrepreneurs in developing innovative technology, and ecopreneurs in creating energy-efficient technologies; limiting the use of materials that are environmentally unfriendly; and generating internal business practices that conserve resources.

Minimizing environmental impact has many facets. A fundamental opportunity for improvement is developing and incorporating technological advancements to reduce energy waste in popular applications. Addressing energy consumption vs. energy requirements in sleep mode, standby mode and active mode provides a perspective to the problem that helps define the solution. Another opportunity for improvement is manufacturing practices. Recycling, conserving water and energy and migrating to environmentally friendly materials are critical activities for sustainable and economic production. Supply chain improvements such as reducing transportation requirements will conserve energy and have the added benefit of shorter cycle times. Finally, every employee's willingness to assume the mantle of recycling/reuse, conservation and elimination of waste has the promise of profound positive impact on efficient use of resources in both the work place and at home.

Technological advancements in IC design and advanced packaging are instrumental in reducing wasted energy. In motor applications, we are witnessing the shift from single-phase AC motors to variable speed motors, resulting in a 40 percent energy savings. Power supplies waste a tremendous amount of energy in standby mode. By developing power supplies that increase efficiency and reduce standby power, this will have a far reaching impact on consumers who have power supplies for their household electronics and on residential electricity consumption. Lighting applications consume 22 percent of the electrical energy generated worldwide. Transitioning from a standard incandescent bulb to a compact fluorescent lamp (CFL), LFL, HID, or LED, can recoup as much as 75 percent energy savings. Package options that reduce size and weight but match the performance requirements also contribute to the options available for energy savings.

To have a significant impact, environmental awareness must extend to the corporate and individual employee level. It needs to be ingrained in our DNA to focus on energy-reduction and ways to conserve resources. IT departments need to initiate server consolidation practices that can result in tremendous energy-savings. This includes reducing the number of servers, choosing energy-efficient servers and servers that have a smaller footprint. Semiconductor suppliers need to monitor and record the rates of water and energy usage and solid and hazardous waste generation. We must encourage individual employees to be aware of their pivotal role in conserving resources. This can be as simple as printing only what you need or car pooling to work with someone in your neighborhood. All of us have the opportunity to be environmental stewards.

Designers and system architects in semiconductor companies cannot just simply create energy-efficient products, but must also actively contribute on behalf of their company to the ways that their environmental stewardship can make a difference in the broader sense.

www.fairchildsemi.com

APEC 2009, Washington DC, February 15-19th

Where real engineering happens

The yearly IEEE Applied Power Electronics Conference APEC 2009 (www.apec-conf.org) will be here soon and with it, the gathering of the best and brightest in power electronics which takes place this time around in Washington, DC February 15-19 2009. This, the 24th consecutive year for the conference, will highlight applications from portable power in low power battery applications to UPS, Inverter, Motor Drives, vehicle electronics and everything in-between.

Increasingly, the efficiency of power electronics for the generation, conversion delivery and utilization of energy in practical applications is of paramount economic and environmental importance. We are fortunate that the APEC conference is again designed for engineers by engineers. The APEC board is consistent in its efforts to ensure all technical content is peer-reviewed and all new material, representing state-of-the-art, practical and technical content of the highest quality.

APEC's exhibitors represent the top global suppliers to power electronics designers involved in test and measurement, components, services, software and systems. APEC has become a 'pacing' event annually – in other words, organizations time their product releases and new technology announcements to align with the APEC conference dates. Importantly, the press, financial and industry analysts will be there as well as a vast range of prospects and customers.

The conference will be 'greener' this year. The APEC board is instituting sustainable practices in collaboration with its conference partners to greatly reduce this waste and reduce environmental impact.

Appropriately, as the conference is in Washington, DC, the intention of the APEC conference is to promote awareness of opportunities available in power electronics to make a global impact on important issues facing our world:

Kevin Parmenter, General Chair APEC 2009 -IEEE Applied Power Electronics Conference and Exposition

Promoting standards and incentives for technologies which reduce losses, increase efficiency and effectiveness in power electronics applications.

It is clear that the rising cost of energy has dramatically increased awareness of the new role of power electronics as the single most important enabling technology for the future well being of the environment. We are fortunate that we are in the right business and discipline with the right technologies at the right time. Power electronics is an essential part of optimizing diverse applications such as lighting, motor control, power conversion, battery chargers, induction heating and myriad other applications.

Several 'mega trends' are driving increased intelligence in systems including the impact of internet- connected systems which incorporate not only power electronics but networked intelligent power electronics able to communicate and manage on a huge scale. For example, home appliances which can communicate to a smart grid to the utility for demand planning via a network enabled power meter at the home. Green and Sustainable practices being mandated for energy conservation and reduction of emissions as a business mandate, is another industry trend.

Smart power electronics are becoming pervasive in medical electronics applications from diagnostics to home healthcare and tele-health applications. Consumers are demanding safer, healthier products and enhancement in quality of life, increased convenience and quality experiences. These products need built in maintenance, repair and diagnostics – fault monitoring via the network. The markets range from industrial, consumer, residential, commercial, government, for energy generation energy storage and energy management in all kinds of systems including transportation, communications/ computing systems.

The critical systems which will make a difference in all these areas, both now and in the future, are dependent on power electronics as an enabler.

APEC is the best technical conference in the industry with professional development –education courses taught by top experts in the industry, plus the time to network, compare experience, ideas and opportunities with other professionals in the industry.

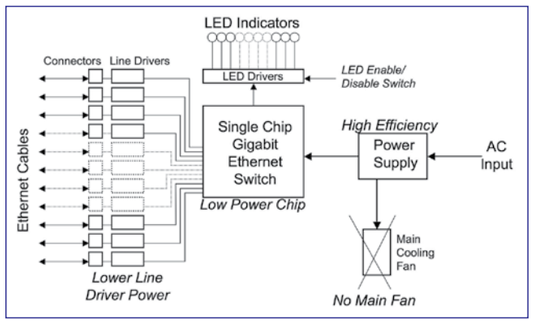
The place to be February 15-19 is in Washington, DC, at the beautiful Marriott Wardman Park Hotel.

www.apec-conf.org

Power Sensitivity in Design Makes Networking Green

I talked with Melvyn Wray, Senior Vice President of Product Marketing EMEA, of Allied Telesis who make Gigabit Ethernet switches for the worldwide networking industry. This is a vast power consuming industry and one gaining high visibility now in the quest to maximize efficiency and reduce losses.

In keeping with the company's commitment to environmentally friendly processes and products, the AT-9000/28 is the first of its new green range of products designed to reduce power consumption, minimize hazardous waste and even reduce environmental noise pollution.



Allied Telesis AT-9000 Block Diagram.

The AT-9000/28 is a 28 port Gigabit managed switch with 24 port 10/100/1000Mbps fixed configuration and 4 additional 100/1000Mbps SFP ports in combination with 10/100/1000T ports.

As one of a series of high performance Gigabit Ethernet switches from Allied Telesis, the AT-9000/28 provides high performance Layer 2 switching at an affordable fixed configuration platform. The switch brings enterprise features to a more affordable level while supporting the changing needs of the SMB market space to improve the delivery of converged data. Support for jumbo Ethernet frames enables higher throughput of time sensitive data.

The company opted for an advanced chipset with the latest Broadcom Silicon, BCM56214. This represents 10th Generation Switch on a Chip silicon with very high density. Lower power = 7.6W. At the time of design, this was the lowest power chipset on the market and chosen for this new 'green' product development.

A highly efficient internal power adapter was chosen to provide minimal power loss, but without escalating the costs making the switch non-viable in the marketplace. Power efficiency is 83% representing best in class performance measured from AC in to DC out.

With the high performance, low power design there was no longer the need for the 'traditional' main cooling fan (only a very small CPU fan for the main Broadcom chipset).

The traditionally utilized fans consume significant power, and also greatly increase noise. The issue is compounded when whole banks of these switches are installed, both in terms of heat and noise pollution. We have all heard the reports of huge air conditioning plants being run to keep the networking and processing equipment running in datacenters.

Use of the latest PHY technology allows length of cables to be determined (VCT technology), and to only inject the required amount of power needed to power the cable. Obviously cables have resistance and impedance which both consume power. On shorter cable runs the switch consumes significantly less power ~9% on tests the company has carried out on their products.

When RJ45 not connected, or the remote device is powered off, the switch can go into an overnight mode, where the PHY is basically put into a sleep mode. Every millisecond or so, it is brought back to life to check if there is some equipment connected, if not it is put back to sleep. Again, if on time is 10% and sleep time is 90%, then significant power savings are made.

Allied's simple yet effective ECO-Switch - turns of unwanted LEDs. A typical switch has at least 2 LEDS per port, so in the case of the AT-9000/28, turning off the LEDs saves 0.6W, and a couple of degrees of temperature inside the unit.

This method of 'chipping away' at the power consumption by the use of high quality silicon together with the creativity that makes good design engineering worthwhile, is certainly the way forward to reducing the future power overhead of our vital networking systems.

www.alliedtelesis.com

Speed and Precision in Gate Drives

High-power gate driver controls MOSFET switches up to 500kHz

Modern power semiconductors allow switching schemes that would have been unthinkable even ten years ago. Conventional MOSFETs, COOLMOS™ devices and prospective compound semiconductor switches are constantly pushing the limits of power density and switching frequency. Only a dedicated gate driver allows the full potential of today's most advanced power switches to be exploited.

By Sascha Pawel and Jan Thalheim, CT-Concept Technologie AG, Switzerland

It is common wisdom that prediction is difficult, especially about the future. At the moment, however, it seems as if a multitude of long-cherished dreams are on the point of coming true for designers of power conversion systems. There is great public interest in renewable energy, the concepts of zero emission vehicles and hybrid cars are finally gaining momentum and a whole wave of small improvements to the ecologic footprint of our lifestyle constantly feeds people's awareness of formerly elusive issues such as sustainability and efficiency. All this leverages the role of power electronics, since electricity is the most valuable and flexible form of energy. With that in mind, efficiency is probably the single most important criterion for judging the quality of future energy systems, because no user will accept wasting precious and expensive energy.

MOS Power Switches

MOS switches hold a decisive low-voltage advantage over bipolar devices such as GTOs or IGBTs: their voltage drop under load is determined solely by their turn-on resistance R_{DS_on}. In contrast, IGBTs require a minimum forward voltage drop of several hundred millivolts in order to forward-bias the internal diode. This voltage offset sets an efficiency limit under light load conditions, when only a small current is flowing through the power switch. Whenever the mission profile of the power application includes light-load operation, MOS devices are often the best choice. This opens up a broad range of target systems such as converters for solar panels, auxiliary drives in industry and traction, mains-operated chargers and many more.

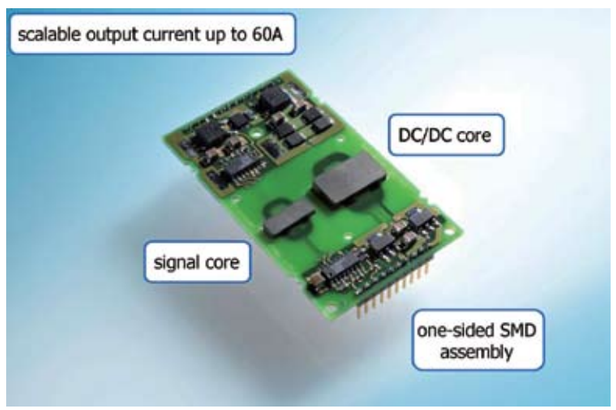


Figure1: Gate driver core 1SC2060P with planar transformers (dimensions 74mm x 44mm x 6.5mm).

High-frequency systems are another typical application area for MOS-gated transistors. The switching losses of bipolar devices increase sharply with operating frequency, because the electron-hole plasma has to be removed and built up in every switching cycle. MOSFETs do not exhibit this high-frequency limitation and can be operated up to several hundred kilohertz and beyond. The main benefits of elevated switching frequency are: smaller systems that occupy less compartment volume, higher power density, a smooth output current waveform, and satisfying functional requirements such as the penetration depth and power coupling in inductive heating systems.

Of course there is a fundamental drawback to MOS switches as well - their blocking capability is limited by the comparatively low breakdown field strength of silicon. Typical voltage ratings for conventional power MOSFETs are in the range of 20V to 300V. Charge compensation devices, such as COOLMOS™, can break this barrier with blocking voltages of up to 600V and even 900V.

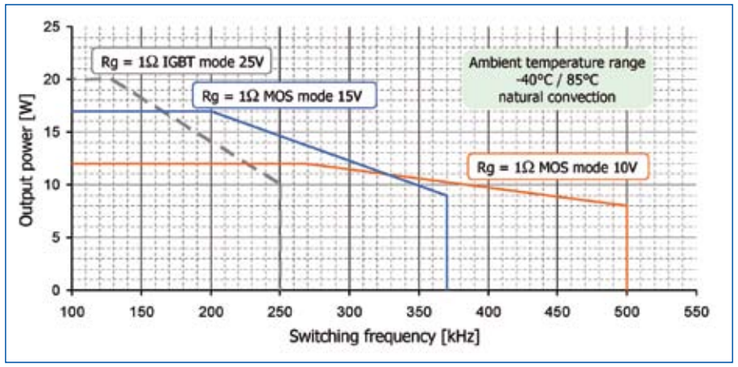


Figure2: Output power vs. switching frequency.

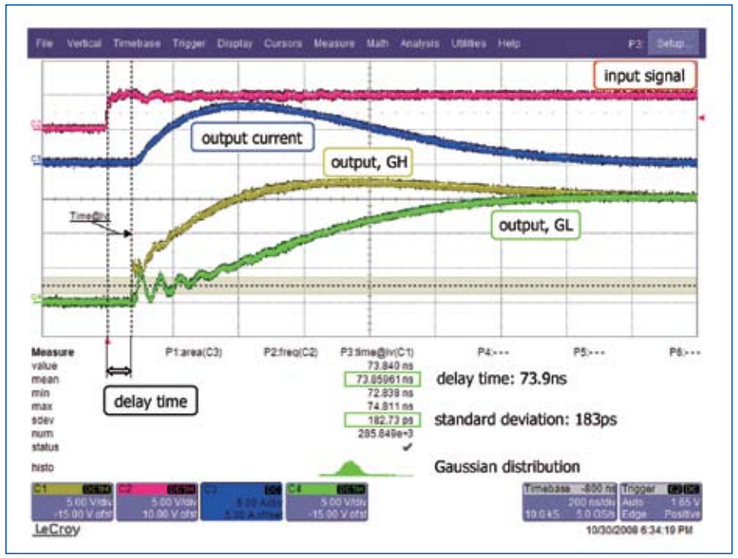


Figure3: Measurement of driver delay and delay time jitter.

High-Frequency Gate Driver

No matter which device type is used in a given application, the main current and thus the power flux is determined by the charging and discharging process of the device's gate capacitance. The required drive power is supplied by a high-performance gate driver such as the 1SC2060P shown in Fig. 1. A dedicated MOSFET mode is implemented in the 1SC2060P. It allows the optimum output voltage swing Vdd across the power switch to be chosen freely. Any value between 10V and 20V can be utilized, whereas the separate IGBT mode incorporates switching up to 25V (–10V / +15V). The driver shown in Fig. 1 is based on CONCEPT's recently introduced SCALE-2 ASIC chipset. Full custom integration of almost all gate driver functions into ICs leads to an enormous 80% reduction in component count compared to conventional solutions.

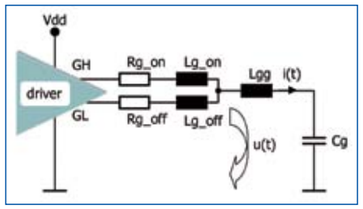


Figure4: Circuit representation of a typical gate loop (simplified).

Figure 2 shows the output power versus the switching frequency of the gate driver. The gate resistance is 1.0W for both the turn-on and turn-off resistors. The maximum switching frequency is limited by the self-heating of the driver under natural convection cooling. In MOS mode, the driver allows extremely fast switching of up to 500kHz for an output voltage swing of 10V and 370kHz for one of 15V. The output curve in IGBT mode is shown for comparison. Dedicated thermal balancing trades a part of the 20W in IGBT mode off against a higher switching frequency in MOS mode.

Gate Control

Fast switching in the hundreds of kilohertz range not only requires high drive power and maximum frequency but also tight control over crucial parameters such as the driver's delay time and the associated jitter. A fast driver with a short delay introduces significantly less phase lag into the power system's control loop. Less phase lag is of great importance for maintaining the stability of the control loop, thus allowing the benefits of fast switching to be fully exploited. Fig. 3 shows the measurement of driver delay and delay time jitter. The graph reveals ultra-fast switching at a typical 74ns delay and enormous reproducibility with a standard deviation of less than 185ps. The total delay variation is virtually negligible with a maximum of ±1ns over 285,000 acquisitions. This combination of power and precision makes the 1SC2060P the first choice for highly optimized systems, where tight control over timing margins is mandatory.

At very high frequency switching, the influence of parasitic circuit elements has to be considered to obtain optimum performance in the gate drive loop. Figure 4 illustrates a simplified gate loop consisting of a driver module, the turn-on and turn-off gate resistors, parasitic inductances of the gate resistors, the parasitic inductance of the power switch gate and an effective load capacitor. This configuration is a well-known standard RLC resonance circuit. For both the turn-on and turn-off transition, the elements can be concentrated into an effective gate resistance Rg, the load capacitance Cg and the sum of all effective parasitic inductances Lg. The gate drive current i(t) is then governed by the differential equation (1).

$$Lg \cdot \frac{d^2 i(t)}{dt^2} + Rg \cdot \frac{di(t)}{dt} + \frac{i}{Cg} = \quad (1)$$

Solving for i(t) yields the time-dependent drive current. Even in the simplest case with constant parameters Lg, Rg, and Cg, the solution shows two distinct characteristics depending on the ratio of the damping resistance Rg to Lg and Cg. If Rg is too low, the current waveform will take the form of a damped harmonic oscillation. This case is undesirable in a gate control loop because it leads to a gradual loss of controllability and because of serious EMC problems. If Rg is very high, slow settling towards the final value will occur without any oscillations. The boundary between these two characteristics is given by equation (2) in our model.

$$Rg \geq 2\sqrt{\frac{Lg}{Cg}} \quad (2)$$

The fastest switching of the power gate can be obtained by letting both sides of equation (2) be equal. The gate current in this critically damped case exhibits the steepest slopes possible for non-oscillating waveforms. It is interesting to note that there is a maximum peak current for which the gate loop remains free of oscillations. The upper limit of that current is given by equation (3).

$$I_{max} = \frac{2}{e} \cdot \frac{Vdd}{Rg} \approx 0.74 \cdot \frac{Vdd}{Rg} \quad (3)$$

In real-life applications, the model from Fig. 4 is too simplistic to model the circuit behavior. The maximum stable peak current is typically lower than the limit of equation (3) and is often close to two thirds of Vdd/Rg. Figure 5 shows an exemplary turn-on transition from 0V to 15V with a 1.0W gate resistor where the peak current only reaches 10A instead of the theoretical maximum of 15A. Thus the 60A current rating of the 1SC2060P leaves ample reserve for even the largest MOSFET power switches.

Figure 5 also shows the acquisition of the gate charge Qg per switching transition. Qg is equivalent to the area under the gate current curve. The required drive power can easily be calculated from equation (4).

$$P_{drv} = f \cdot Vdd \cdot Qg \quad (4)$$

Equation (4) is very simple but still much more precise than the widespread approach of obtaining the required drive power from the datasheet value of the input capacitance. The curve of MOS gate charge versus input voltage is highly non-linear. As a result, only the actual gate charge value Qg can yield a correct prediction about the drive power needed in the given application.

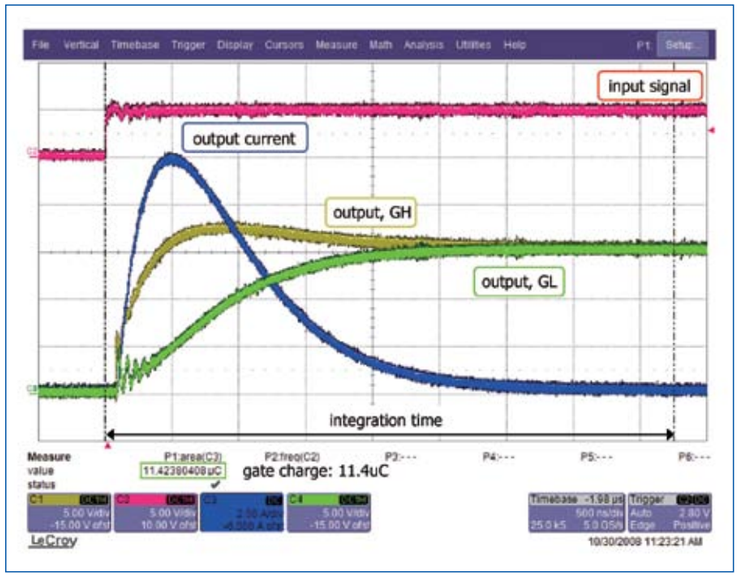


Figure5: Turn-on transition at 1W gate resistance and 15V driving voltage.

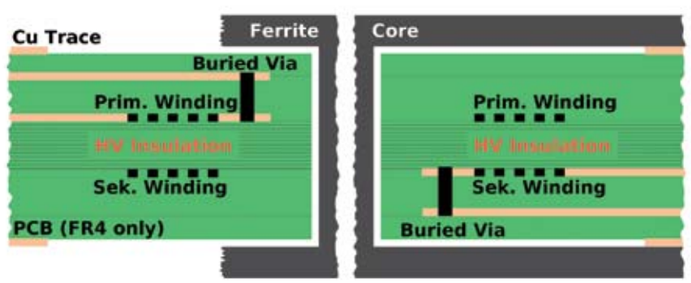


Figure6: Schematic cross section of the HV planar transformer.

Planar Transformer HV Technology

The 1SC2060P driver core comes with an ultra-flat form factor and measures only 6.5mm in height. This is achieved by using newly developed planar transformer technology. A schematic cross section is shown in Fig. 6, as already reported in PSDE of July 2008. In contrast to common planar designs in low-voltage systems, there is no interleaving of the primary and secondary windings in the layer stack. A dedicated high-voltage insulation layer is placed between the primary and secondary windings with no crossings or vias penetrating it. The specific effect of this construction is an unusually high voltage rating for the insulation of the planar transformer. The 1SC2060P provides galvanic isolation up to 1.7kV – enough even for future generations of MOS switches.

Planar transformers for high-voltage drivers are not only characterized by high power density and cost-effective automated manufacturing, they also excel in high-speed switching due to their low stray inductance.

Reliability

Power systems are generally designed to ensure high availability throughout their lifetime. It is therefore important to make sure that the reliability figures of every component in the power system are much higher than expected from the application, because the failure probabilities of the individual components add up in the system.

One of the greatest contributors to the failure rate is the number of components on the printed circuit board. The 1SC2060P uses the latest SCALE-2 chipset to reduce the component count by 80%. Supporting passive components have been carefully selected for appropriate voltage rating, temperature range and degradation over time.

The high-voltage insulation needs to withstand thousands of thermal cycles, over-voltage peaks, mechanical stress, the influence of humidity and many more parameters. Planar transformers on the printed circuit board benefit from the high stability of fiber-reinforced epoxy that has proved to maintain its characteristics in the field. Figure 7 shows the results of accelerated life testing with slow thermal cycles. The partial discharge extinction voltage is the most sensitive and dependable criterion of insulation performance. No degradation is visible after as many as 2,600 cycles. This accumulated stress is equivalent to more than 20 years under real-life application conditions. Exorbitantly harsh thermal shock cycles between –55°C and +150°C have been applied to probe even further. Again, virtually no change in insulation characteristics can be seen, as evidenced in Fig. 8. The tight 3-sigma boundaries of the partial discharge extinction voltage shown in Fig. 8 highlight the stable uniformity of the planar insulation.

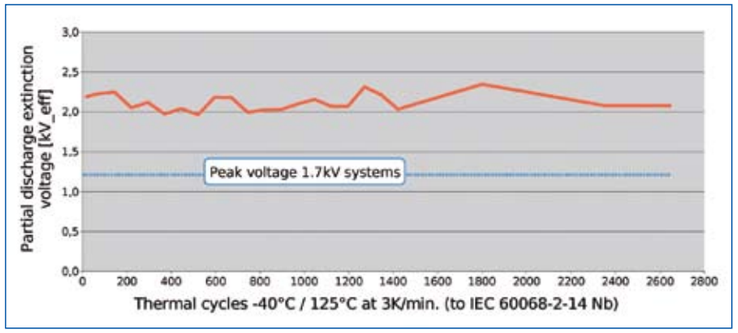


Figure7: Insulation stability versus slow thermal cycling.

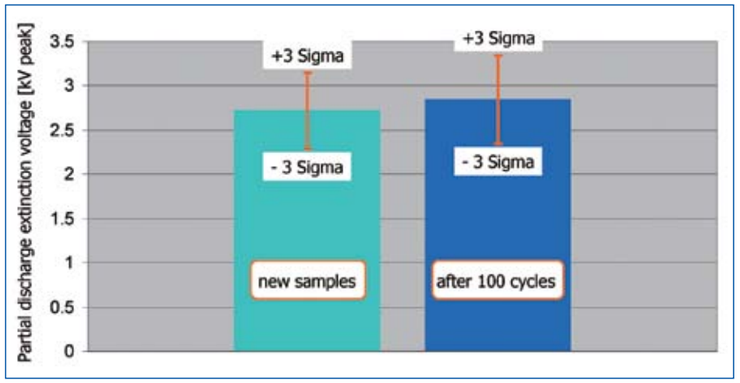


Figure8: Highly accelerated thermal shock testing (-55°C / +150°C to IEC 60068-2-14 Na).

Numerous additional tests have been performed to assess the aging behavior of the planar transformers. Mechanical shock tests up to 2000m/s^2 showed absolutely no impact on mechanical or electrical parameters. The effect of humidity has been investigated by temperature, humidity and bias testing at 85°C, 85% RH and a constant DC bias of 1500V. No failures occurred after more than 1000 hours in this truly extreme climate.

Summary

A dedicated high-frequency gate driver is needed to fully exploit the capabilities of state-of-the-art MOS power devices. The 1SC2060P driver core has been specifically designed for high-power and ultra-fast switching to satisfy this need. It employs SCALE-2 chipset technology and newly developed planar transformers for unrivalled timing precision, high power density and an attractive flat form factor. The 500kHz gate drive module has been extensively tested for performance and reliability under harsh environmental conditions.

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High-Power, High-Density Power Supply with Optimum Thermal Performance

Paralleling for complete DC/DC µModule regulator systems

Most of us are so accustomed to the easy accessibility of a wide variety of premium quality digital information that rarely is anyone aware of the technological battles on the background to innovate faster and more powerful routers, switches, servers and storage devices that are necessary to manage this massive traffic of ones and zeros. And as the battle for digital design prowess for more sophisticated systems intensifies, these innovations in faster data processing and computing are creating systems that generate so much heat, more money is spent on cooling the equipment in order to keep them operating reliably.

By Afshin Odabaee, Product Marketing Engineer and Alan Chern, Assistant Applications Engineer, Power µModule Products, Linear Technology Corp.

Based on a study sponsored by AMD and conducted by Lawrence Berkeley National Laboratory, in 2005 the total power consumption of US servers was 0.6% of the overall US electricity consumption. This figure doubles to 1.2% when the cost of cooling equipment is added. This is more than the electricity consumed by color televisions.

The increase in power consumed by these systems is also motivating DC/DC regulator designers to introduce new methods for better power and thermal management. Power management and heat dissipation has become such a crucial factor for these system designers that the decision of selecting a DC/DC regulator is no longer just limited to satisfying the load requirement such as the core and I/O supplies on a FPGA. A larger scale is now influencing the selection of these DC/DC regulators starting from each IC as its load, to each PCB, to each rack, to each cabinet, to each cluster and finally to each server farm. The battle to control heat dissipation and distribute power more efficiently has also intensified.

The optimum operation and reliability of these digital equipments highly depends on the performance of the DC/DC converters that are used as distributed DC power for IC such as FPGAs, ASICs, transceivers and memory modules as well as RF amplifiers and sensors. Also, aside from the electrical performance such as the accuracy of regulation or transient response to a varying load current, the thermal performance has become a more crucial factor in selecting a DC/DC regulator.

In a recent discussion with a system designer, the requirement for his power supply was to regulate 1.5V and deliver up to 40A of current to a load that consisted of four FPGAs. This is up to 60W of power that must be delivered in a small area with lowest profile (height) possible to allow smooth flow of air for cooling. The power supply had to be surface-mountable and operate at high enough efficiency to minimize heat dissipation. He also demanded the simplest possible solution so his time could be dedicated to the more complex tasks. Aside from precise electrical performance, this solution must quickly expel heat generated during DC to DC conversion so that the circuit and surrounding ICs do not over heat. Such solution requires an innovative design to meet these criteria:

Figure 1. Four DC/DC µModule regulator systems current share to regulate 1.5V at 48A with only 2.8mm profile and 15mm x 15mm of board area. Each µModule weighs only 1.7g and has an IC form-factor that can easily be used with any pick-and –place machine during board assembly.

1. Very low profile for efficient air flow and to prevent thermal shadow on surrounding ICs
2. High efficiency to minimize heat dissipation
3. Current sharing capability to spread the heat evenly, eliminate hot spots and minimize or eliminate the need for heat sinks
4. Complete DC/DC circuit in a surface-mount package that includes the DC/DC controller, MOSFETs, inductor, capacitors and compensation circuitry for a quick and easy solution

Innovation in DC/DC Design

The innovation is a modular but surface-mount approach that uses efficient DC/DC conversion, precise current sharing and low thermal impedance packaging to deliver the output power while requiring minimal cooling. A system using this solution depends on fewer fans or slower fan speed, as well as few to no heat sinks. These contrib-

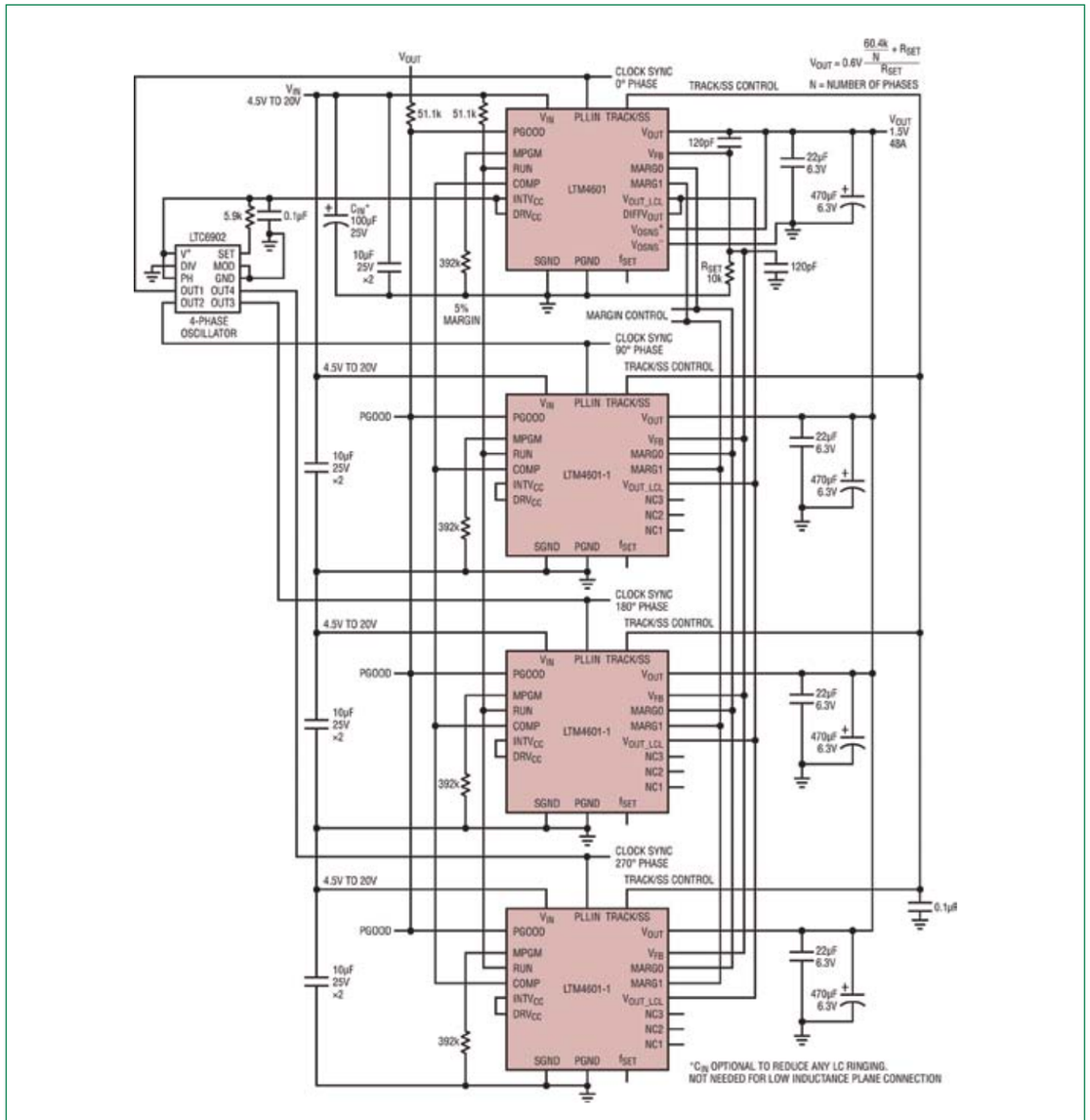

Figure 2. Simply parallel multiple DC/DC µModule regulator systems to achieve higher output current. Board layout is as easy as copying and pasting each block.

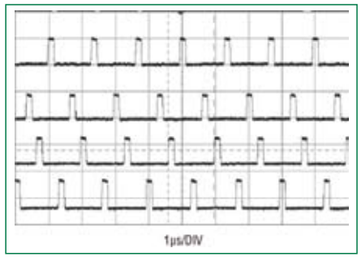

Figure 3. By operating each DC/DC µModule 90° out-of-phase, the input and output ripples are reduced which also reduces requirement for input and output capacitors. Photo shows individual µModule switching waveforms for figure 2.

ute to a lower cost system that is also consuming less power to remove heat. Figure 1 shows a test board for such circuit. The design regulates 1.5V output while delivering 40A (up to 48A) of load current. Each "black square" is a complete DC/DC circuit and is housed in a 15mm x 15mm x 2.8mm surface-mount package. With a few input and output capacitors and resistors, the design using these DC/DC µModule systems is as simple as it's shown in the photo.

DC/DC µModule Regulators: A Complete System in an LGA Package

The LTM4601 µModule DC/DC regulator is a high performance power module shrunk down to an IC form factor. It is a completely integrated solution—including the PWM controller, inductor, input and output capacitors, ultralow $R_{DS(ON)}$ FETs, Schottky diodes and compensation circuitry. Only external bulk input and output capacitors and one resistor are needed to set the output from 0.6V to 5V. The supply can produce 12A (more if paralleled) from a wide input range of 4.5V to 20V, making it extremely versatile. The pin compatible LTM4601HV extends the input range to 28V.

Another significant advantage of the LTM4601 over power-module- or IC-based systems is its ability to easily scale up as loads increase. If load requirements are greater than one µModule regulator can produce, simply add more modules in parallel. The design of a parallel system involves little more than copying and pasting the layout of each 15mm x 15mm µModule regulator. Electrical layout issues are taken care of within the µModule package; there are no external inductors, switches or other components to worry about.

Additional features include output voltage tracking and margining. The switching frequency, typically 850kHz at full load can be adjusted by an external clock for synchronization should frequency harmonics be a concern.

48A (72W) from Four Parallel µModule Regulators

Figure 2 shows a regulator comprising four parallel LTM4601s, which can produce up to 48A (4 x 12A) output. The regulators are synchronized but operate 90° out of phase with respect to each other, thereby reducing the amplitude of input and output ripple currents through cancellation. The attenuated ripple in turn decreases the external capacitor RMS current rating and size requirements, further reducing solution cost and board space.

Synchronization and phase shifting is implemented via the LTC6902 oscillator, which provides four clock outputs, each 90° phase shifted (for 2- or 3-phase relationships, the LTC6902 can be adjusted via a resistor.). The clock signals serve as input to the PLLIN (phase-lock-loop in) pins of the four LTM4601s. The phase-lock loop of the LTM4601 comprise of a phase detector and a voltage controlled oscillator, which combine to lock onto the rising edge of an external clock with a frequency range of 850kHz ±30%. The phase-lock loop is turned on when a pulse of at least 400ns and 2V amplitude at the PLLIN pin is detected, though it is disabled during start-up. Figure 3 shows the switching waveforms of four LTM4601 µModule regulators in parallel.

Only one resistor is required to set the output voltage in a parallel setup, but the value of the resistor depends on the number of LTM4601s used. This is because the effective

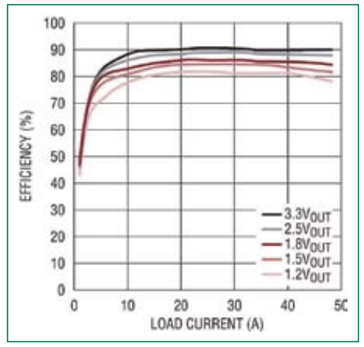

Figure 4: Efficiency of the four DC/DC µModules in parallel remains high over a wide range of output voltages at 12V input.

value of the top (internal) feedback resistor changes as you parallel LTM4601s. The LTM4601's reference voltage is 0.6V and its internal top feedback resistor value is 60.4k ohm, so the relationship between V_{OUT}, the output voltage setting resistor (R_{FB}) and the number of modules (n) placed in parallel is:

$$V_{OUT} = 0.6V \frac{\frac{60.4K}{n} + R_{FB}}{R_{FB}}$$

η is the number of paralleled modules.

Figure 4 illustrates the system's high efficiency over the vast output current range up to 48A. The system performs impressively with no dipping in the efficiency curve for a broad range of output voltages.

Layout

Layout of the parallel µModule regulators is relatively simple, in that there are few electrical design considerations. Nevertheless, if the intent of a design is to minimize the required PCB area, thermal considerations become paramount, so the important parameters are spacing, vias, airflow and planes.

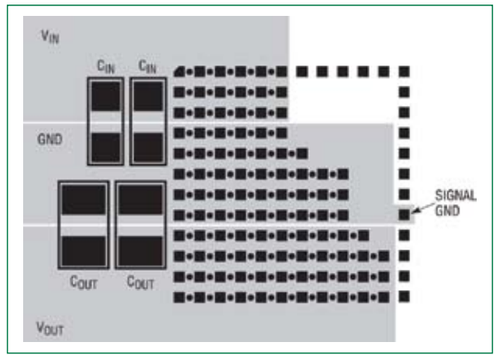

Figure 5- The LTM4601's pin layout provides simple power plane placement and easy paralleling capability (copy & paste approach).

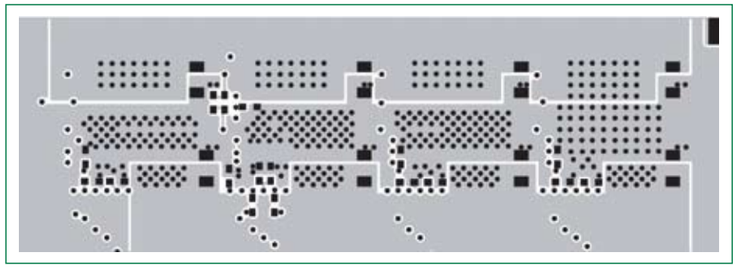

Figure 6: Bottom layer planes for figure 1 circuit.

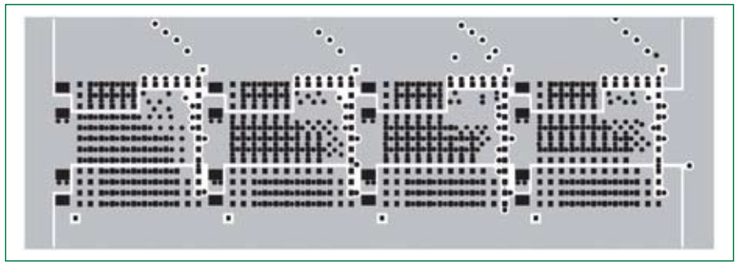

Figure 7: Top layer planes for figure 1 circuit.

The LTM4601 µModule regulator has a unique LGA package footprint, which allows solid attachment to the PCB while enhancing thermal heat sinking. The footprint itself simplifies layout of the power and ground planes, as shown in Figure 5. Laying out four parallel µModule regulators is just as easy, as shown in Figures 6 and 7. If laid out properly, the LGA packaging and the power planes alone can provide enough heat sinking to keep the LTM4601 cool.

Figure 8 is a thermal image of Figure 1 (DC1043A) board with surface temperature readings at specific locations. Cursors 1 to 4 give a rough estimation of the surface temperature on each module. Cursors 5 to 7 indicate the surface temperature of the PCB. Notice the difference in temperature between the inner two regulators, cursors 1 and 2, and the outside ones, cursors 3 and 4. The LTM4601 µModule regulators placed on the outside have large planes to the left and right promoting heat sinking to cool the part down a few degrees. The inner two only have small top and bottom planes to draw heat away, thus becoming slightly warmer than the outside two. Further heat dissipation is possible by adding vias underneath the part. Vias provide a path to the power planes and into the PCB, which helps draw heat away. Vias should not be placed directly under the pads.

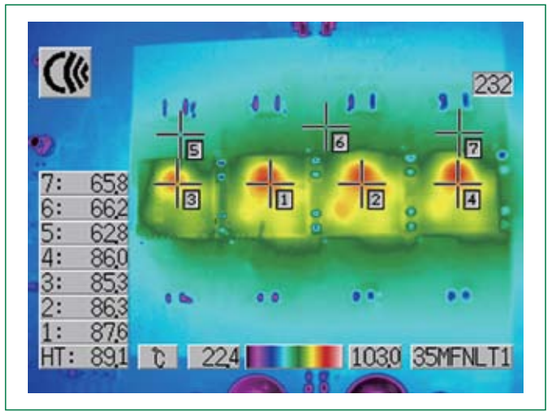

Figure 8: Thermograph of 48A, 1.5V circuit of figure 1 shows balanced power sharing among each DC/DC µModule and low temperature rise even without airflow (VIN=20V to 1.5VOUT at 40A).

Airflow also has a substantial effect on the thermal balance of the system. Note the difference in temperature between Figure 8 and Figure 9. In Figure 9, a 200LFM airflow travels evenly from the bottom to the top of the demo board, causing a 20°C drop across the board compared to the no air flow case in Figure 8.

The direction of airflow is also important. In Figure 10 the airflow travels inside a 50°C chamber from right to left, pushing the heat from one µModule regulator to the next, creating a stacking

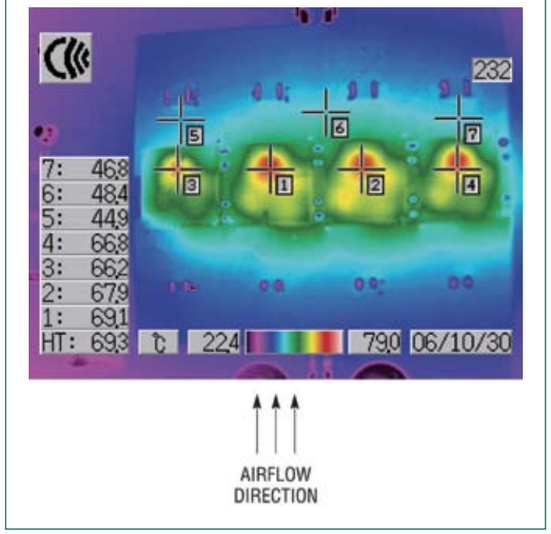

Figure 9: Thermograph of four parallel LTM4601 with 200LFM bottom-to-top airflow (20VIN to 1.5VOUT at 40A).

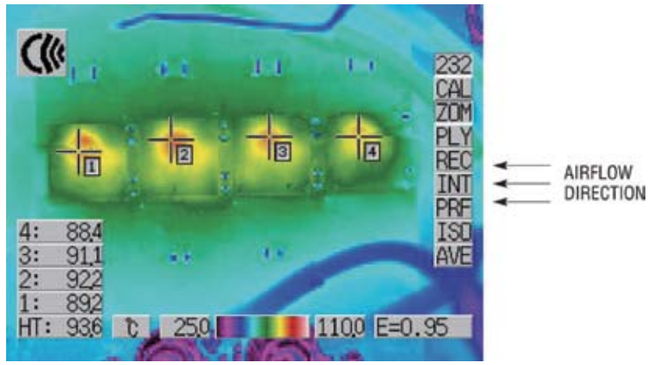

Figure 10: Thermograph of four parallel LTM4601 with 400LFM right-to-left airflow in 50ºC ambient chamber (12VIN to 1.0VOUT at 40A).

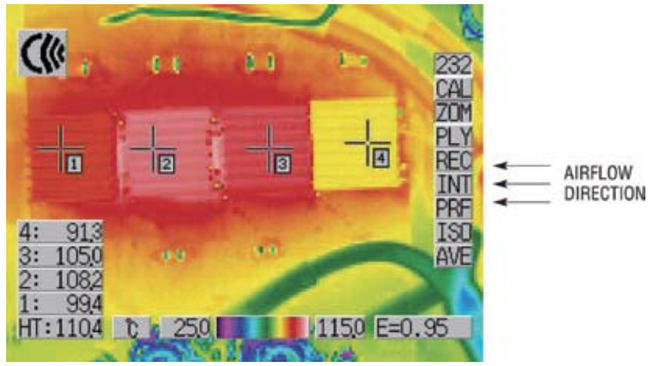

Figure 11: Thermograph of four parallel LTM4601 with BGA heatsinks and 400LFM right-to-left airflow in a 75ºC ambient chamber (12VIN to 1.0V_{OUT} at 40A).

effect. The µModule device on the right, the closest to the airflow source, is the coolest. The leftmost µModule regulator has a slightly higher temperature because of spillover heat from the other LTM4601 µModule regulators.

Heat transfer to the PCB also changes with airflow. In Figure 8, heat transfers evenly to both left and right sides of the PCB. In Figure 10, most of the heat moves to the left side. Figure 11 shows an extreme case of heat stacking from one µModule device to the next. Each of the four µModule regulators is fitted with a BGA heat sink and entire board is operated in a chamber with an ambient temperature of 75°C simulating an actual application.

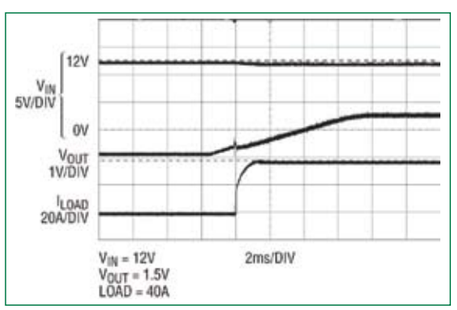

Figure 12: Controlled soft start is important in proper startup of the FPGA or the system as a whole; Soft-start current and voltage ramp for four DC/DC µModules in parallel.

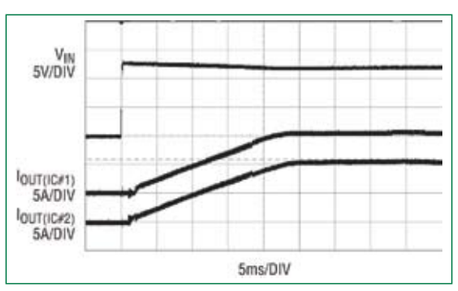

Figure 13: Each DC/DC µModule starts and ends by sharing the load current evenly and balanced, a crucial feature to prevent one regulator from overheating; Two parallel LTM4601s, as each rises to a nominal 10A each, 20A total.

Start-Up, Soft-Start and Current Sharing

The soft-start feature of the LTM4601 prevents large inrush currents at start-up by slowly ramping the output voltage to its nominal value. The relation of start-up time to V_{OUT} and the soft-start capacitor (C_{SS}) is:

$$V_{OUT(MARGIN)} = \frac{\%V_{OUT}}{100} \bullet V_{OUT}$$

$$t_{SOFTSTART} = 0.8 \bullet \left(0.6V - V_{OUT(MARGIN)}\right) \bullet \frac{C_{ss}}{1.5\mu A}$$

For example, a 0.1µF soft-start capacitor yields a nominal 8ms ramp (see Figure 12) with no margining.

Current sharing among parallel regulators is well balanced through start-up to full load. Figure 13 shows an evenly distributed output current curve for a 2-parallel LTM4601 system, as each rises to a nominal 10A each, 20A total.

Conclusion

The DC/DC µModule regulators are self-contained and complete systems in an IC form factor. The low profile, high efficiency and current sharing capability allow practical high power solutions for the new generation of digital systems. Thermal performance is impressive at 48A of output current with balanced current sharing and smooth uniform start-up. The ease and simplicity of this design minimizes development time while saving board space.

www.linear.com

Distributed Power Architecture

Past, present and ever-evolving

Distributed power architecture (DPA) is widely used in high availability applications that support complex loads. DPA has proven to be a very flexible approach that has evolved over time to match the industry's need for efficiency, protection and changing load requirements.

By Paul Greenland, VP Marketing, Power Management Group, Semtech Corporation

The future for DPA looks bright as it is the basis for the "power supply on a chip" concept that could be the future of system design. Properly applied, a distributed power system yields a number of key advantages: packaging and thermal management are simplified, higher power densities are possible, electromagnetic compatibility is improved and both redundancy and reliability are enhanced.

Distributed power architectures were created to address complex modular load systems, the earliest commercial examples are telecom solid-state exchanges, shown in figure 1. The solid-state exchange consisted of a series of rack mounted line cards powered from a lead acid battery charged by a power factor corrected isolated converter called a rectifier.

To minimize corrosion, the positive terminal of the battery was the return of a -48V nominal supply. On each line card was a modular DC-DC converter, commonly known as a brick, with multiple outputs. Similar architectures also apply in military and aerospace applications. An important characteristic of distributed power architecture is the possibility of configuring a redundancy system using more DC-DC converters than the minimum required by the load. Usually (N + r) converters are used, where N is the minimum number of converters required to power the load and r is the number of redundant units, usually 1.

Technology doesn't stand still and the telecom manufacturers and service providers quickly adapted their systems to handle voice and data to provide the backbone of the Internet. This represented a massive increase in bandwidth and content, and with that evolution, simple loads evolved to complex loads, rendering the conventional distributed power architecture virtually useless. To accommodate these complex loads, the industry borrowed the DPA techniques used in personal computers where high frequency microprocessors and dual logic ASICs represented a challenge to the traditional centralized silver box power system.

For some time the more powerful microprocessors had dedicated regulators with standard specifications. Dual logic ASICs had a core, which was individually powered together with an

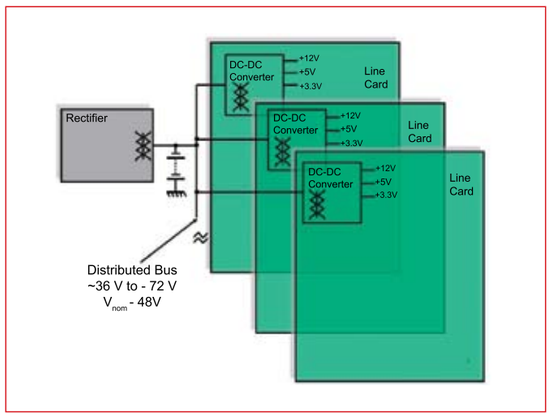

Figure 1: Conventional Distributed Power Architecture.

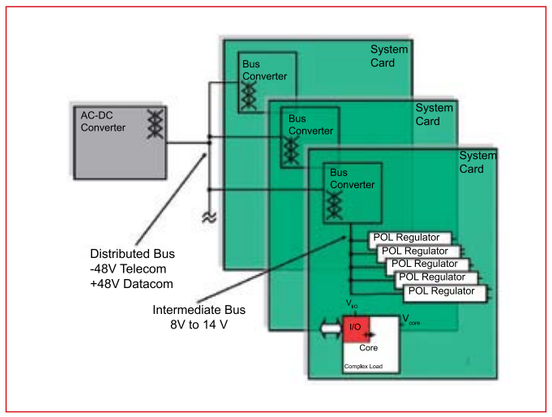

Figure 2: The Intermediate Bus Architecture.

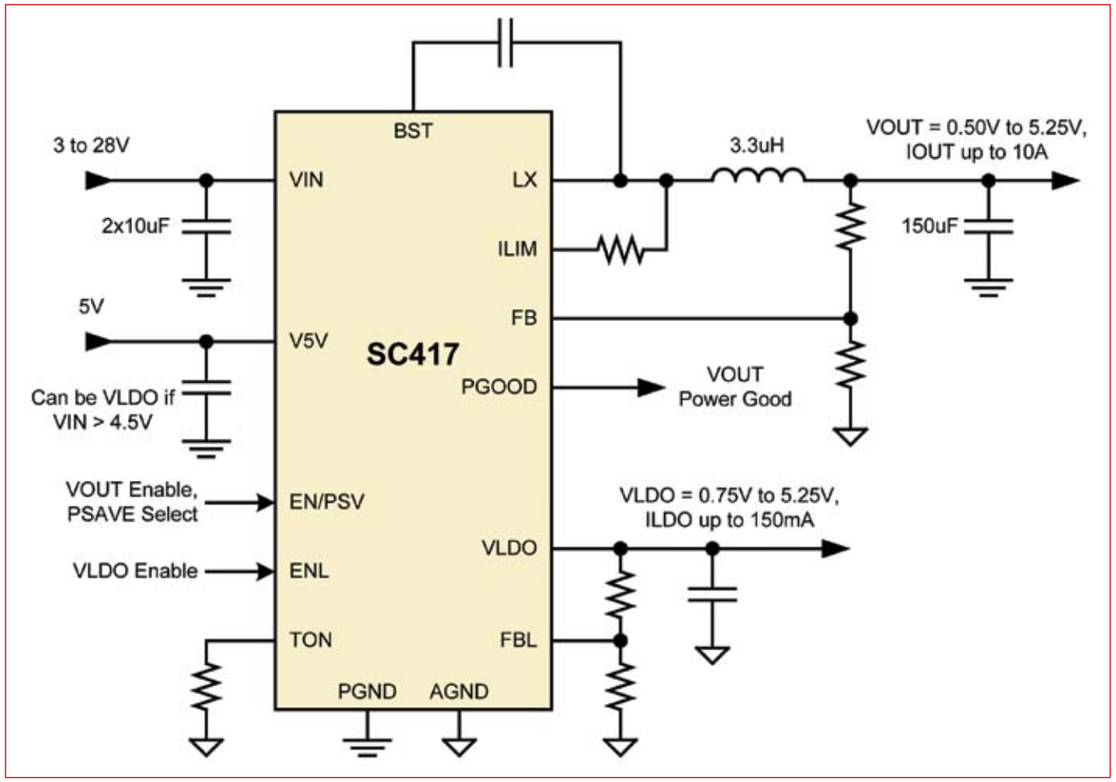

Figure 3: SC417 integrated buck regulator.

input/output (I/O) block operating from a higher voltage. The first point-of-load regulators were used in desktop PCs. Point-of-load regulation is an attractive solution particularly where energy efficiency is required. Reduced distribution losses, improved steady-state and transient regulation coupled with inherent modularity are some of the advantages of this technique. Furthermore, the AC-DC converter and point of load regulator may be optimized for their respective functions and the load is decoupled from the distributed voltage reducing crosstalk.

Energy efficiency drove the adoption of synchronous rectification as the regulated voltage fell below 3.3V and the creation of multiple operating modes such as STANDBY and SLEEP where the load consumes dramatically lower power when inactive. High current low drop out (LDOs) linear regulators are being displaced by more efficient switching regulators for the same reason. Datacom manufacturers had an additional imperative, as utilities placed an upper limit on the power consumed by a data centre that limited the number of deployed servers at its heart. The only option for service providers wishing to boost bandwidth and throughput is to improve the efficiency of the distributed power system particularly where the ability to cool a facility is also constrained.

As the macro or system-level challenges multiplied, the data networking load technology was also evolving. The typical mid-range Ethernet board can contain as many as 40 power rails. Many of the loads in these applications are the deep sub-micron, CMOS integrated circuits. With decreasing feature size, integrated circuit designers face the challenge that the quality of the clock distribution and clock recovery circuits suffer as the VI characteristics of the smallest transistors degrade. I/O circuits, particularly those that contain phase-locked loops (PLLs) become increasingly sensitive to noise and ripple as feature size drops below 90nm. This places increased demands on the point-of-load regulators, which have to accommodate substantial high-frequency load changes without deviating outside the output voltage regulation band. This is almost impossible to achieve without placing the regulator virtually at the terminals of the load IC, literally at the point of load where parasitics, especially trace inductance and resistance, may be minimized.

This brings us to the subject of load technology matching; the point of load regulator has to match the requirements of the load: voltage regulation, transient response, settling time and dynamic output impedance for optimum system performance. Low voltage loads, particularly those operating below 3.3V benefit from the high-frequency switching capabilities of CMOS controllers and regulators, which have a limited input voltage breakdown that is usually below 6V. For this reason, among others, in the distributed power architecture shown in figure 2 includes an intermediate bus voltage, which has historically been 8V to 14V but is now moving below 6V. Lower load voltages, particularly core voltages are moving below 1V and large conversion (or step-down) ratios are inefficient enough without adding in the turns ratio term introduced by a transformer-isolated converter, which also carries an efficiency penalty. Consequently, the reduced intermediate bus voltage represents an improvement in efficiency and power density with true point of load implementation.

The SC417 integrated buck regulator shown in figure 3 provides flexibility of application together with high power density and complex load matching electrical performance. It was specifically designed to pre-regulate CMOS point-of-load regulators, which often run from multiple or semi-regulated power sources, such as the ubiquitous AC adapter or lump-in-a-cord adapter.

Distributed power architectures are continually evolving to embrace the requirements of load technology matching, increased load capacity and energy efficiency. A new chapter to this story is just beginning and may end with a dedicated regulator inside the package with its complex load. This is being called a “Power Supply on a Chip” in some quarters. Complex load IC manufacturers consider this to be an attractive scenario as they spend a disproportionate amount of applications resource troubleshooting power supply issues. This extra work would be virtually eliminated with the capability of placing the power supply inside the package, matched to its load and powered from a standard rail. Considerable development work is required to make this a mass production-worthy reality. For instance, the height or profile of the integrated regulator solution including the filter inductor has to be approximately half a millimeter to fit inside the package. But the promise of this solution is enough to ensure that the DPA will be the dominant way of designing power architectures to meet complex needs well into the future.

www.semtech.com

PowerPack Power Systems Design

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http://www.fairchildsemi.com/products/digitalpower/index.html

Texas Instruments

TI's New Eight-Channel Sequencer and Monitor with Non-Volatile Error Logging, UCD9081, Supports the Latest Generation Microprocessors, ASICs and DSPs, to Improve System Reliability and Ease Eequencing on Boards with Multiple Points of Load.

The sequencer operates from a 3.3-V supply and does not require external memory or a clock, to help reduce board space in a variety of equipment, including telecommunication switches, servers, industrial, networking and test equipment. The UCD9081 is available from Texas Instruments and its authorized distributors in a 32-pin QFN package. Application notes, evaluation modules and the GUI software tool for the UCD9081 are also available online at

www.ti.com/ucd9081-pr

International Rectifier

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IR features a range of innovative products and platforms addressing applications for lighting, AC-DC, audio and appliances including the iMOTION™ integrated design platform for variable speed motor drive, as well as the latest X-Phase® and DirectFET® MOSFET chipsets, SupIRBuck™ family of integrated voltage regulators and iPOWIR™ integrated power conversion stage product line for computing and communications applications. In addition, IR's DC-DC converters and modules for high reliability applications, and benchmark MOSFETs, IGBTs and high-voltage ICs for a diverse range of applications will be on display.

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Renewable Energy

Industrial Fiber Optics in Renewables

Wind turbine and wind farm applications

Global warming and climate changes from CO_2 emissions of traditional energy sources, such as those powered by fossil fuels, have created huge markets for alternative power generation. Wind turbine energy has become a popular alternative to meet the fast growing energy demand. Unlike fossil fuels, which are a limited and diminishing resource, wind energy is limitless and readily available.

By Alek Indra, Technical Marketing Engineer, Avago Technologies, Singapore

Conversion of wind energy into utility grade AC power requires power electronics, such as rectifiers and inverters. In a high power generation system, galvanic insulation becomes very important to ensure the quality and reliability of the power generation. Fiber optic components offer protection by providing insulation from high-voltage glitches and unwanted signals into power electronic devices.

Avago Technologies offers highly reliable industrial fiber optic components for data-acquisition/control and isolation in the power generation market. Featuring out-standing performance in high insulation voltage and high immunity to EMI, these products are able to be installed and operate in close proximity to power-carrying conduits which emit disruptive electrical interference. As the demand for renewable energy grows globally, wind turbine designs are becoming larger and larger. Avago's industrial fiber products offer a wide range of data-rate and link lengths for many applications in this power generation market.

Key applications for industrial fiber optic components in wind turbine system include:

- Power electronic gate driver for rectifiers and inverters
- Control and communication boards
- Turbine control units
- Condition monitoring systems
- Wind farm networking

Wind turbine power is used to convert kinetic energy into electrical energy

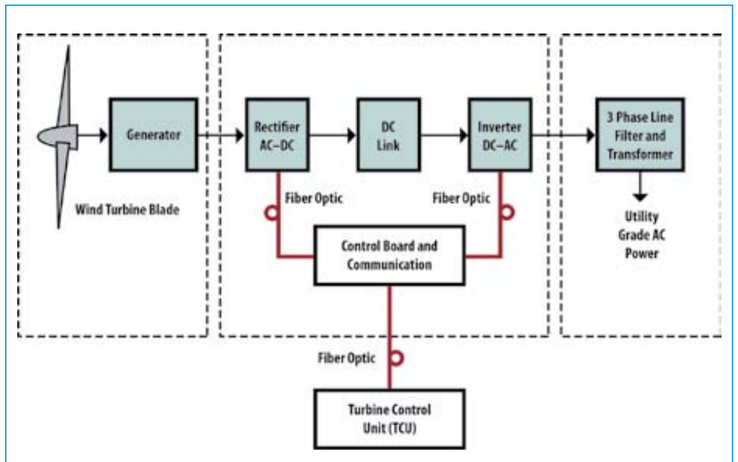

Figure 1: Wind turbine power generation block diagram.

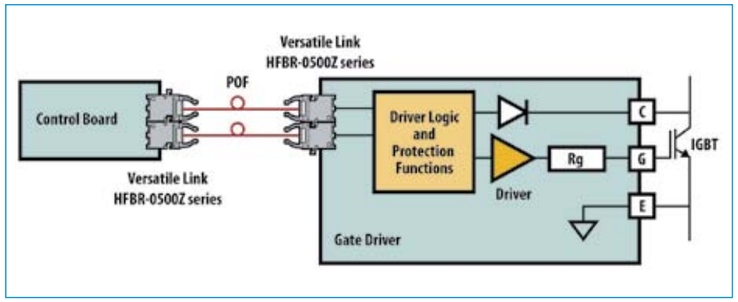

Figure 2: IGBT's Gate Driver Block Diagram.

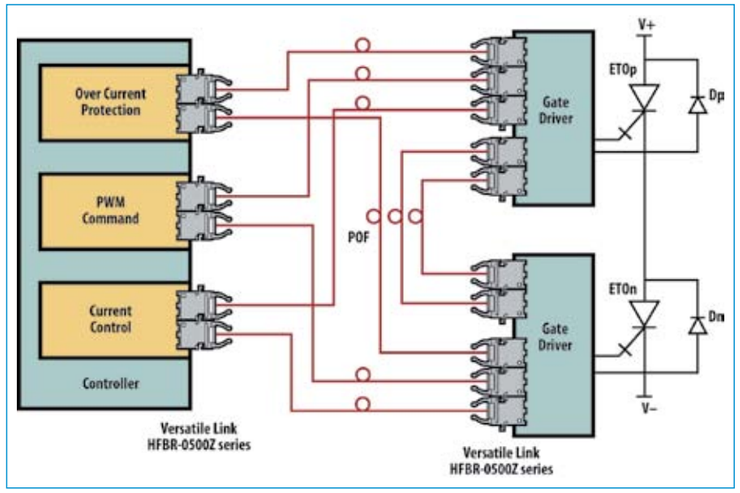

Figure 3: ETO's two-level voltage source converter phase leg block diagram.

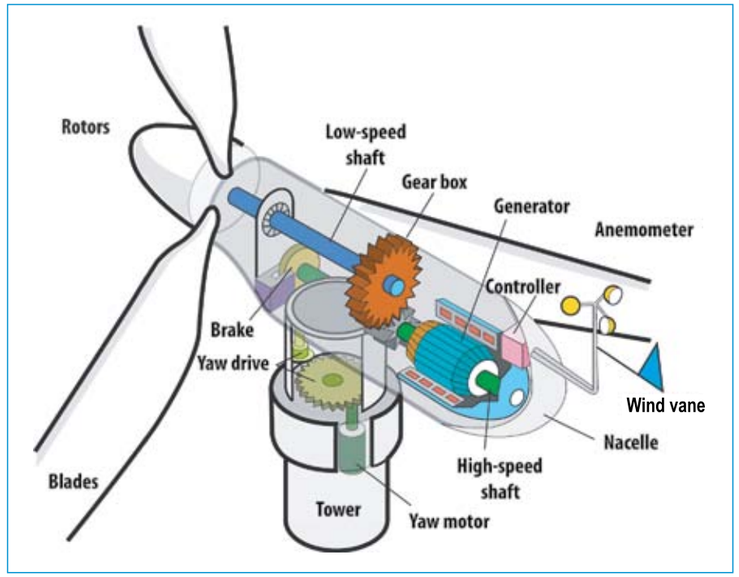

Figure 4: Elements within a wind turbine nacelle requiring fiber communications. (Wind Turbine Development: Location of Manufacturing Activity, S. George and S. Matt, "Renewable Energy Policy Project", September 2004)

through use of a generator. As wind conditions vary, the electrical energy created from the generator needs to be converted for usability. A rectifier, inverter, transformer and filter are needed within the wind turbine, in order for utility-grade AC power to be transmitted over long distances (Figure 1).

A transformer is usually installed at the bottom of the tower to provide voltage conversion from the low voltage generated by the wind turbine, to medium/high voltage for transmission.

Rectifier and Inverter

The rectifier and inverter are key components in the wind turbine system. The rectifier converts noisy AC power to DC power, while the inverter converts DC power to clean and reliable AC power. The switching of these devices is usually controlled by a DSP embedded controller via a fiber optic link, to provide efficient and reliable switching control with high galvanic isolation capability.

There are numerous rectifier and inverter control switches available:

- Insulated Gate Bipolar Transistor (IGBT)
- Gate Turn Off Thyristor (GTO)
- Integrated Gate Commutated Thyristor (IGCT)
- Symmetrical Gate Commutated Thyristor (SGCT)
- Emitter Turn Off Thyristor (ETO)

Fiber optic components are commonly used to control a high voltage and current switching device, with reliable control and feedback signals (Figures 2 and 3).

Condition Monitoring System

Most modern wind turbines have intelligent features to monitor and control the system to accommodate varying wind conditions. For example, atmospheric sensors detect wind speed and direction. Other sensors monitor the condition and strength of the turbine's parts to avoid run-to-failure.

Wind turbines need to withstand extreme weather conditions, such as storms and lightning. In these types of conditions, it is important to ensure that the turbine's monitoring system is designed to provide high voltage and current isolation. Fiber optics becomes a preferred choice of medium as it offers much higher voltage and current isolation properties compared to optocouplers and other similar components.

In the nacelle of the wind turbine (Figure 4), short link distances using fiber optics can utilize POF (plastic optical fiber) and Avago's HFBR-0500Z products. Connectors with snap-in, latching and screw-in designs are various options designers can select from. Avago's versatile link sub-family allows field connector capabilities for POF and the associated connectors, allowing for field repairs, maintenance and installation.

Besides good isolation properties, these products provide excellent signal

Common Avago Fiber Optic Components Part Numbers

			Distance[1]	
Part Numbers	Description	Data Rate	POF (1mm)	HCS® (200im)
HFBR-151Z	650 nm, Transmitter	DC – 5 MBd	20 m	
HFBR-51Z	650 nm, Receiver			
HFBR-15Z	650 nm, Transmitter	DC – 1 MBd	45 m	
HFBR-5Z	650 nm, Receiver			
HFBR-158Z	650 nm, Transmitter	DC – 10 MBd	40 m	300 m
HFBR-58Z	650 nm, Receive r			

Notes:
1. Optical link distance varies with operating data rate. Lower data rate allows longer optical link distance.
HCS is a registered trademark of OFS

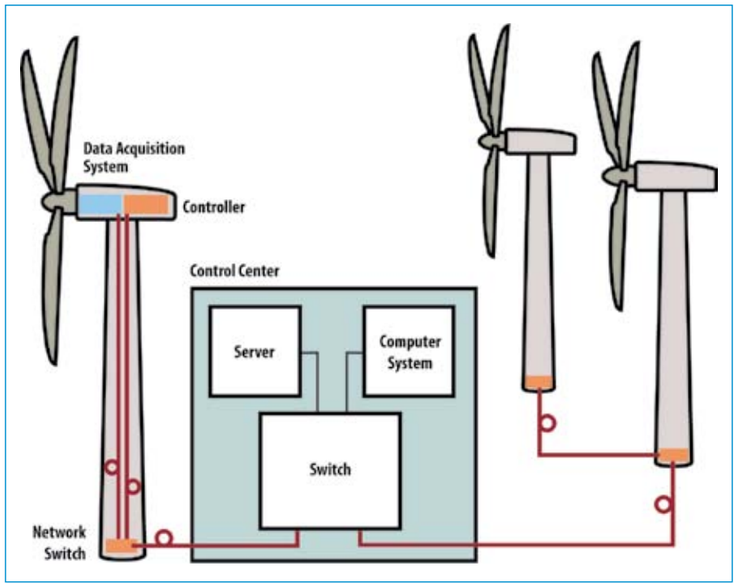

Figure 5: Wind farming configuration.

Common Avago Fiber Optic Components Part Numbers

				Distance[1]	
Part Numbers	Description	Data Rate	POF (1mm)	HCS® (200im)	62,5um/125um
HFBR-157Z	650 nm, Transmitter	160 MBd	50 m	50 m	-
HFBR-56Z	650 nm, Receiver	125 MBd	30 m	100 m	-
AFBR-5978Z	650 nm, Transceiver	125 MBd	50 m	100 m	-
HFBR-14X4Z	80 nm, Transmitter	160 MBd	-	-	500 m
HFBR-4X6Z	80 nm, Receiver				
HFBR-11TZ	100 nm, Transmitter	160 MBd	-	-	2km
HFBR-16TZ	100 nm, Receiver				

Notes:
1. Optical link distance varies with operating data rate. Lower data rate allows longer optical link distance.
HCS is a registered trademark of OFS

integrity as they are immune to electromagnetic interference (EMI). It becomes an excellent solution for monitoring system communications over long distances with reliable data transmission in high voltage/current applications.

For greater ESD and EMI protection, Avago's HFBR-0506AMZ series offers a metalized packaging that provides excellent shielding. The SMA-styled connector also works well in areas with vibration and mechanical shocks.

Wind Turbine and Wind Farm Networking

Data collected from the condition monitoring systems, with the use of short-link POF fiber links in individual wind turbines, are typically multiplexed into HCS (hard-clad silica) or multi-mode fiber cables. The longer link distances of HCS and multi-mode fiber may be needed if wind turbine towers are greater than 100meters in height. Fiber cables are both robust, offer greater resistance to harsh environmental elements and are lightweight. All of these are requirements for vertical cabling in wind turbine towers.

Industry standard connectors like the ST/ST-thread and SMA are all available from Avago. The HFBR-0400Z series operates over both HCS and multi-mode fiber, which offer greater bandwidth and link distance as compared to the POF solution. These parts are commonly used in wind turbine towers and over long distance wind farm networks.

Avago Technologies has developed a series of fiber optic transmitters, receivers and transceivers for wind turbine monitoring systems and networking applications. Avago offers parts from 650nm, 820nm or 1300nm, which have data rates up to 160MBd to meet industry customers' needs over various link distances.

www.avagotech.com

Minimize Losses in Solar Panels

Rectifier technology maximizes efficiency

Energy efficiency and 'green power' have become buzzwords of the semiconductor industry over the last 18 months, as manufacturers introduces innovative products to meet stringent new energy efficiency legislation. The industry, however, has on the whole paid little attention to the rapidly growing renewable energy market.

By Ian Moulding, Business Manager, Diodes Incorporated

Renewable energy is concerned with the generation of electricity from sustainable natural resources that include biomass, hydro power, wind power and solar energy. The solar panels market is forecast to quadruple in value to 80 Billion dollars by 2016 (source: Clean Edge Inc, 2007). This is just one example of growth in renewable energy that will see it displace gas to become the second largest source of electricity generation after coal, by 2016 (source:IEA, 2007).

A solar panel operates on the principle of the photovoltaic effect, whereby a suitably doped PN junction diode will become forward biased when photons hit its surface, causing a current to flow. Solar panels are constructed from a number of photovoltaic modules that are electrically connected in series to achieve a desired DC output voltage and/or in parallel to provide the requisite current rating. Bypass diodes are connected in parallel with each photovoltaic module in order to provide a conduction path around the photovoltaic module during 'dark' conditions to avoid overheating. The minimization of heat is essential, since overheating will reduce the overall efficiency of the solar panel,

Solar panel systems can be either "off grid" or "grid connected" systems. In the former, the DC output from the solar panel feeds a battery/charger. These systems are used in remote or portable applications such as caravans and boats. Grid connected systems feature an additional inverter stage that converts the DC input into an AC output that is synchronized to the public electrical grid. The most successful example of a grid connected system is in Germany, the 'feed-in' system. This rewards individuals, who have invested in solar power, with an attractive price for selling the electricity they produce back to the utility company. Such tariffs are fixed for long periods of time (twenty years or more) allowing the individual investor to see the long-term benefit. As a result of this approach there has been rapid growth in the solar panel market in Germany to such an extent that in Germany solar power accounts for 39% of the megawatts generated globally by solar panel systems during 2007.

The bypass diode plays a critical role in the safe and reliable operation of the solar panel and must fully meet the stringent requirements of IEC61730-2 Solar Safety Standards. The bypass diode actually has two key functions:

Firstly, as already mentioned, it provides an alternative conduction path, as shown in Fig1a, when one or more of the photovoltaic modules do not conduct due to 'dark' conditions.

These conditions occur when one or more of the photovoltaic modules are obscured by cloud or other external interference such as the overhanging branches of a tree or when the photovoltaic module is faulty. In such circumstances, the current is instead conducted via the bypass diode. Ideally the losses during this mode of operation would be zero; however the conduction losses of a PN junction diode are less than ideal as it has a forward voltage (V_F) of typically 0.6V. When 10A of current is flowing from the photovoltaic cells this equates to a power loss of:

$$P = V*I = 0.6*10 = 6W$$

Such losses impact the overall efficiency of the system and are one of the factors that limit the typical efficiency of a solar panel to around twenty percent.

Secondly, during normal operation, current will flow through the photovoltaic modules, as shown in Fig1b. In this mode of operation, the bypass diodes will be operating in reverse blocking mode and the bypass diode should have a VRRM that is sufficiently large enough to block the DC voltage across the terminals therefore avoiding reverse breakdown conditions. Moreover, it should also possess a low reverse leakage current (I_R) specification to prevent the energy stored in the battery leaking away, thereby maintaining the efficiency of the system.

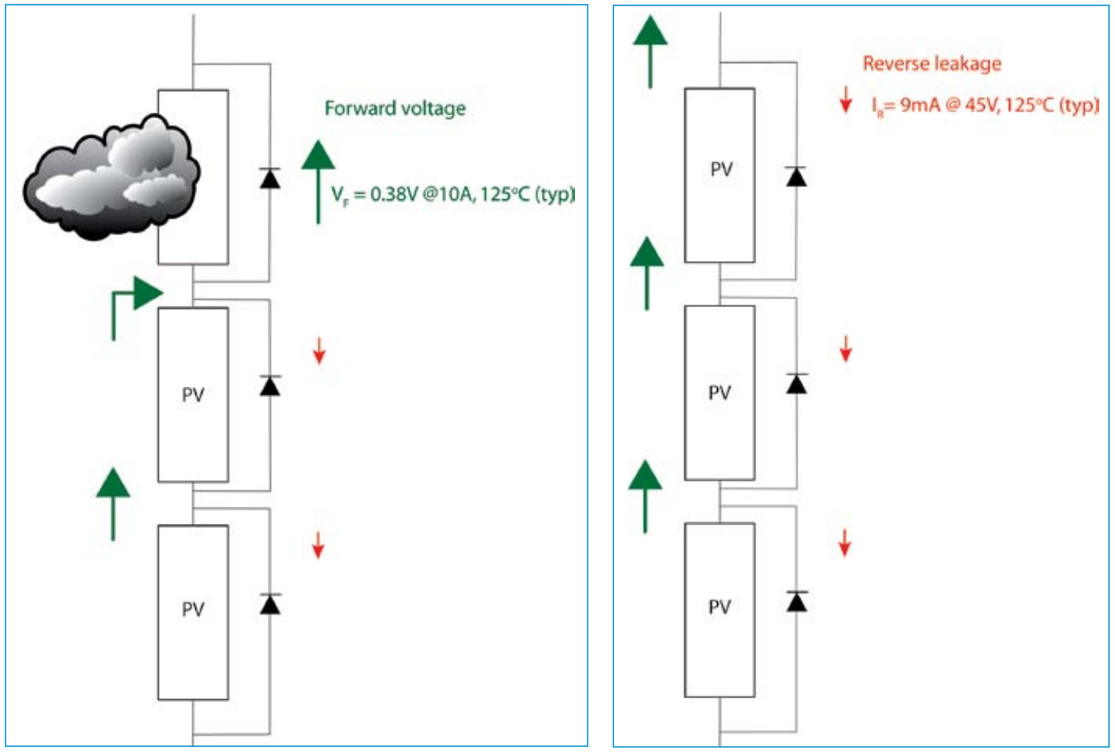

Figure 1a: Bypass diode operation during partial shade conditions.
Figure 1b: Bypass diode operation during normal conditions.

Schottky diodes are an attractive alternative to PN diodes since they possess a lower forward voltage (V_F) at reasonable leakage currents (I_R). However, the lower reliability of the Schottky metal barrier contact within the device limits its operation at high temperatures, and reduces its reverse and forward surge withstand capability. Consequently, the performance of a Schottky diode degrades rapidly with temperature, limiting the junction temperature (T_J) of a typical Schottky diode to 150oC. In order to comply with the thermal test requirements of IEC 61730-2 the junction temperature of the bypass diode must be able to support 170°C, depending upon the forward voltage (V_F) of the diode. Schottky diodes are therefore unsuitable for use as a bypass diode.

It is clear from the preceding discussion that there is a need for a two terminal semiconductor device that possesses low (V_F), low leakage current (I_R) and high reliability at high temperatures, in order that the stringent requirements of solar panel applications can be met. Super Barrier Rectifier (SBR™), a unique patented power rectifier technology from Diodes Incorporated meets the need. SBR utilizes a metal oxide semiconductor (MOS) process, to manufacture a superior two terminal device that has a lower forward voltage (V_F) than comparable Schottky diodes, while possessing the thermal stability and high reliability of PN junction diodes such as ultrafast diodes.

The SBR10U45SP5 is one of a family of bypass diodes that Diodes Incorporated has introduced to meet the needs of the rapidly growing solar panel market. As can be seen, from table 1, the device has a typical forward voltage (V_F) of just 0.38V. Substituting this device into the earlier equation would result in:

P = V*I = 0.38*10 = 3.8W

Part No.	V_F (V) typ@25°C	I_F(A)	Ta(°C)	Rthja(°C/W)	Pd(W)	Tj (°C)	Tjmax (°C)
SBR10U45SP5	0.38	10.0	75.1	20.3	3.6	147.8	200.0

Table 1: Summary performance of an SBR diode under IEC61730-2 thermal test.

This represents a reduction in bypass diode power dissipation of 57%. Therefore, the lower V_F of Super Barrier Rectifiers significantly reduces the power dissipation in the bypass diode, increasing solar cell power generation and overall efficiency. Similarly, the higher stability of SBR at higher temperature is illustrated in Fig 2.

This demonstrates that the SBR has a higher specified maximum junction temperature (T_J) than a Schottky diode and ensures that it meets the requirements of IEC61730-2. It is therefore significantly less likely to enter into thermal runaway.

An additional benefit of the super barrier rectifier technology is that it is a high density process, enabling high performance devices to be specified in small footprint low profile package such as the

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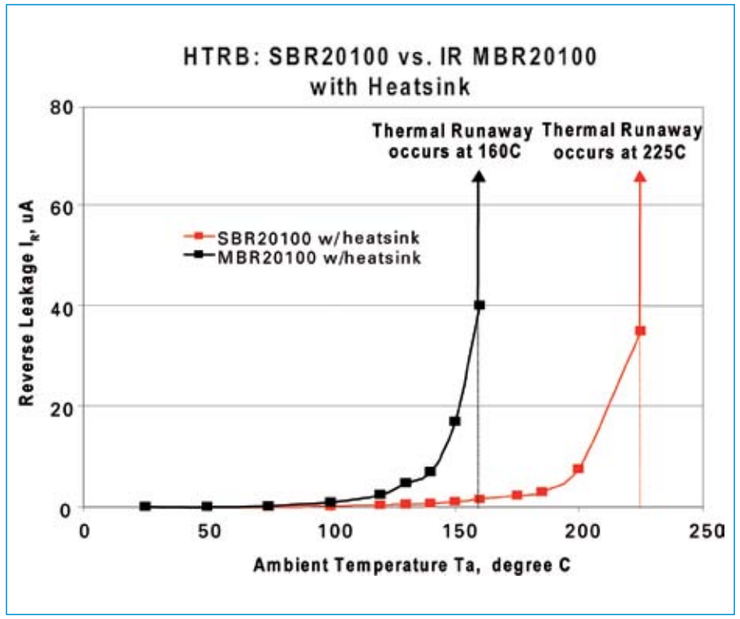


Figure 2: Comparison of IR against ambient temperature for SBR vs Schottky Diode.

PowerDI5™. With a footprint of just 23.8mm² the PowerDI5™ provides an 87% reduction in board space and a similar reduction in profile when compared with traditional power packages such as D2Pak, enabling bypass diodes to be integrated into the solar panel array instead of the junction box.

Innovations such as the super barrier rectifier technology, are contributing towards significant improvements in typical solar panel efficiencies. It is expected that innovations such as these and others in material science for example will contribute towards improving the efficiency of a solar panel from, typically 18% today to 30% within the next few years.

www.diodes.com

Democratizing Solar

AC PV modules lead the way

As the world faces the economic, environmental, and political consequences of its heavy dependence on fossil fuels for energy, the search for a suitable alternative only grows more intense.

By Nasser Kutkut VP Technology Development and Hussam Al-Atrash, Principal Engineer, Petra Solar, Inc.

The collection of solar energy through photovoltaic (PV) cells is a particularly promising technology. Sunshine is an abundant resource, while PV technology is clean, quiet, and suitable for distributed installations. Grid-tied PV technology allows the integration of PV resources into the utility grid near points of load.

Today, cost is the primary challenge facing PV power systems. Presently, the solar electricity price index ranges from 21.41¢/kWhr for industrial applications to 37.78¢/kWhr for residential applications. This price index is primarily driven by PV module cost (~40%-50% of system cost), inverter cost (<10% of system cost), balance of the system costs (~10%-20% of system cost), and labor and installation costs (~30%-40% of system cost). Since the inverter cost constitutes a small percentage of the overall system cost (<10%), a major reduction in inverter cost will not have a major impact on overall system cost. On the other hand, soft costs (labor and installation) constitute more than 1/3rd of the system cost. Reducing these costs can result in major reduction in overall system cost.

Grid-tied PV cannot yet compete with the cost of commercial power generation on a $/kWh basis. The result is that grid-tied PV is heavily dependent on government incentives and rebates. Even with incentives and rebates, the payback time on a PV system remains excessive, which cripples the growth of the distributed PV market.

Conventional String and Multi-String Inverters

The dc-ac inverter is at the heart of a grid-tie PV system. Its main function is to convert the PV output energy from its raw variable DC form to a grid-compatible AC form. Grid-tie inverters are designed to work with the grid, a stiff AC voltage source and thus are designed to behave as AC current sources. As such, they are designed to push high-quality sinusoidal output current in phase with the grid voltage. The amplitude of this output current is dependent upon the amount of power available from the PV source determined through a maximum power point tracking (MPPT) process.

Conventional grid-tie inverters can be generally classified into string and multi-string inverters. String inverters, as shown in Fig. 1, are large inverters

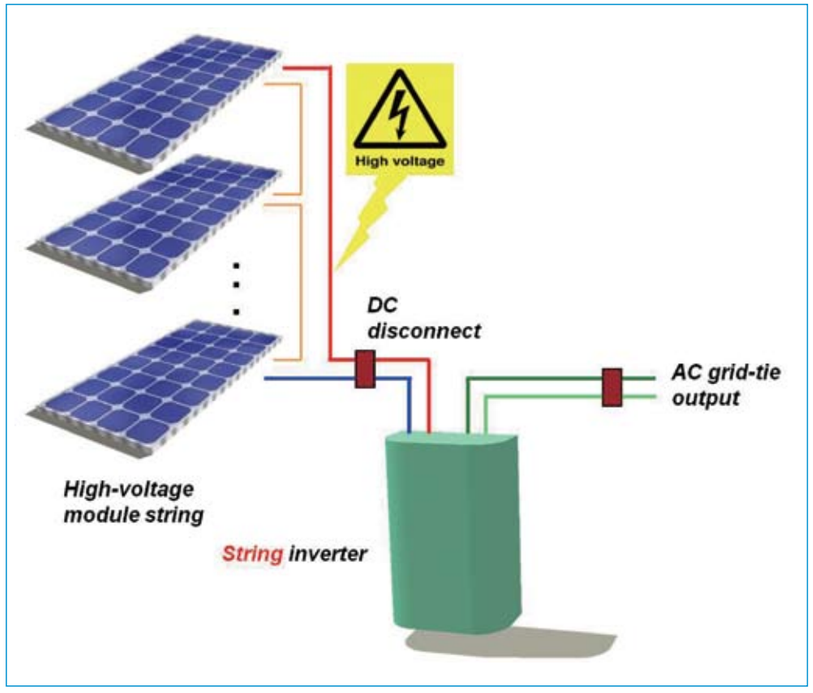


Figure 1: String inverter system architecture.

with power levels ranging from just under a kilowatt to several hundred kilowatts. These conventional inverters are often installed indoors or in protected chambers to protect them from extreme temperatures, dust, and rain. The system is built by wiring the PV panels into an array of parallel strings, each consisting of a suitable number of series-connected panels. The array output is routed to the inverter dc-input. String inverter inputs are typically designed for a high DC voltage of 150-700V.

String inverters suffer from a number of drawbacks including multiple single point failures (panels or inverter), a high-voltage DC string configuration, which represents a safety hazard, and costly installations as they require special training and special protection measures which adds to the overall system cost. All wiring is to be enclosed in special conduit, and DC protection fusing and disconnects are required. Moreover, firemen and service people need to be careful around such an array. The array is especially dangerous when the inverter or the utility is absent, since the voltage would be highest!

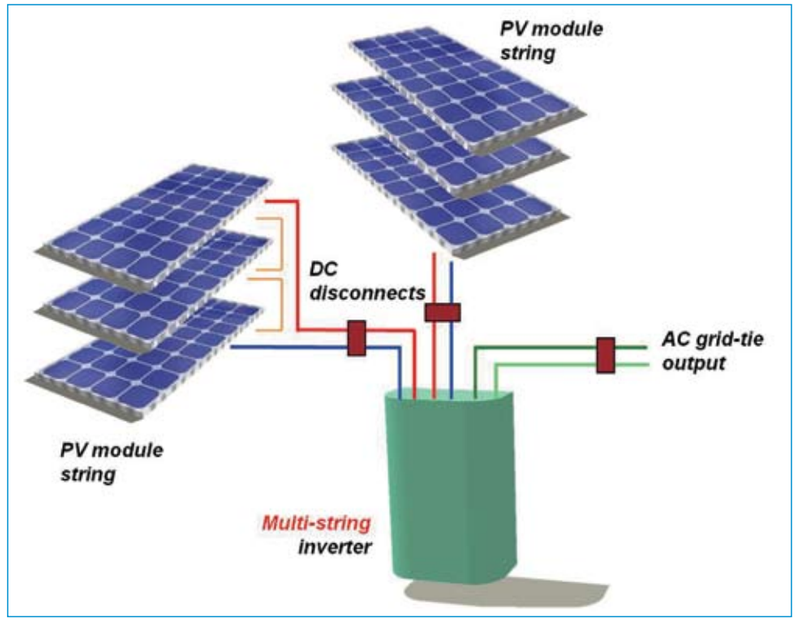


Figure 2: Multi-string inverter system architecture.

Successful string inverter installations require careful system design. Miscalculation of worst-case maximum open-circuit voltage of a panel string is a common cause of inverter failure. Panels within a string need to be very closely matched: same manufacturer, age, condition, and orientation. This is because one weak or degraded panel would limit the power output of the whole string. Since string inverters implement a single MPPT process, special attention is needed to ensure that a string does not get partially shaded by a chimney, a tree, or nearby objects.

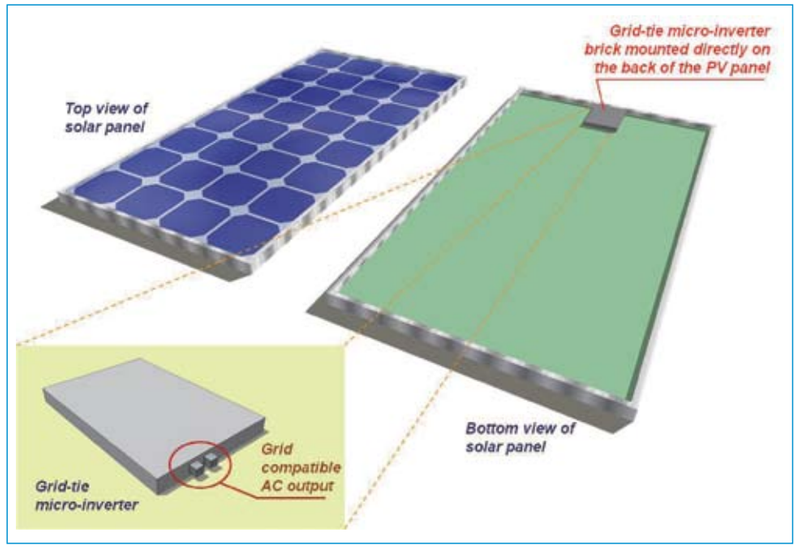


Figure 3: The AC PV module.

Multi-string inverters present a partial solution to string inverter drawbacks. A multi-string inverter accepts several dc input circuits and processes their power independently. An independent MPPT process is applied to each of these panel strings. This allows the panels to be grouped into a number of smaller groups, as shown in Fig. 2. A problem in one group does not affect the other groups. However, similar to string inverters, multi-string inverters feature a hazardous high voltage dc bus and still require installation by specialized and trained personnel adding to the overall system costs.

Micro-inverters and the rise of the AC PV Modules

Micro-inverters are small grid-tie inverters with power levels ranging from 150-250W and are designed to handle a single PV panel. In this type of system,

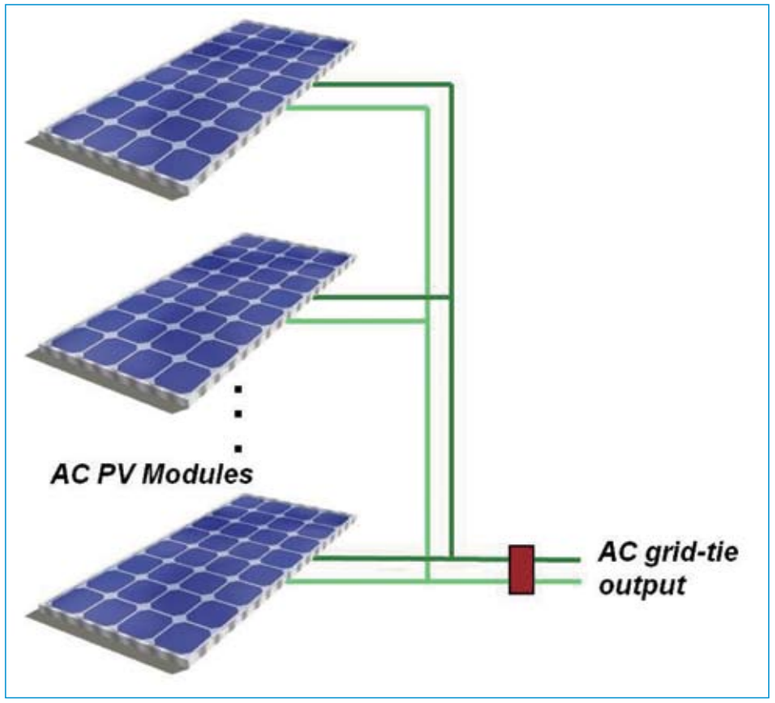


Figure 4: AC PV module based solar power system.

a micro-inverter is connected to a single panel and is installed close to it. The inverter AC output is directly routed to the AC breaker box. No series or parallel DC connections are made between panels, leaving all DC wiring at a low voltage level of a single panel (typically <60Vdc).

Taking the granularity one step further, an AC PV module is a factory assembled micro-inverter integrated into a PV panel. In such a configuration, the DC wiring is not accessible to the user and the output of the integrated module is AC. Fig. 4 shows a typical AC PV module architecture.

The AC PV module is the first modular solar power system that greatly simplifies system design and eliminates safety hazards. In addition, and since no DC wiring is accessible, installation is greatly simplified and can be easily performed by any electrician and/or end users. This translates into significant savings in installation costs and leads to lower overall system costs.

Another benefit of AC PV modules is their improved energy harvesting compared to string or multi-string inverters. Since the integrated micro-inverter operates with a single panel, a true per panel MPPT is implemented which maximizes the power output from each panel in a system. Recent studies have shown upward of 20% increased energy harvesting with micro inverters.

Finally, and since each AC PV module includes an integrated micro-inverter, larger solar power systems are AC coupled where the output of the AC PV modules are connected in parallel (Fig. 4). As a result, the AC PV modules do not need to be matched thus allowing end users to mix and match panels from various manufactures and with varying power levels. This greatly increases flexibility and eliminates single point failures thus providing for true redundancy.

AC PV Module Design Challenges

Since the core of an AC PV module is the micro inverter, the market would thus require micro-inverters to compete with string inverters in terms of performance, cost (per Watt), and efficiency. This means that a micro-inverter designer is working against the economies of scale. A micro-inverter is still required to perform the same functions as a string inverter, typically 15-25 times larger! Components do not scale down properly in size, cost, power consumption, or performance. Many, such as the controller, do not scale down at all. The addition of circuits for efficiency improvement and/or extra protection features is often not feasible.

The micro-inverter reliability requirements are even more challenging. Micro-inverters are located behind the panels making maintenance difficult or impossible. Micro-inverters are thus required to be far more reliable than string inverters. In addition, the MTBF for a micro-inverter needs to be quite high and ideally matching the PV panel. This is especially challenging since these inverters are installed outdoors and are exposed to extreme temperatures and weather. Electrolytic capacitors used in inverters are especially susceptible to elevated temperature and can become the limiters of inverter life-time.

Conclusion

In summary, the AC PV module is poised to truly "democratize solar" as it offers a budget friendly incremental installation. Unlike string inverter based system where a base residential system cost could approach upwards of $25,000, low budget end users can get started with few AC PV modules to supplement their power usage and add more modules as they go. This is the true spirit of democracy.

www.petrasolar.com

Reliability in Renewables

Hi-Rel SKiiP® IPM´s undergo unique burn-in under worst case conditions

Young developing markets such as wind power generators, solar power, electric vehicles, welding machines, electric drives, lifts, power supplies, conveyor belts and trams need highly robust solutions. As a significant innovator in the power electronics sector, many of Semikron's progressive developments have been accepted as industrial standards.

Reported by Cliff Keys, Editor-in-Chief, PSDE

The high operational reliability of the SKiiP IPM´s is further stressed and tested during unique burn-in tests only offered by SEMIKRON. Compared to suppliers of standard modules, this test is possible because of the high integration of the module. The power semiconductor, gate driver, current sensors, protective functions and matched cooling are already integrated in the IPM. SKiiP is the only intelligent power module in this power range for the wind market. During the burn-in test the module is operated in a one or four-quadrant modus and tested at elevated temperature and elevated voltage. The test ensures higher reliability of the inverter in the wind power plant.

SKiiPs are operated for approximately two hours under worst case real inverter conditions at elevated temperature and elevated voltage. All root causes of early failures are identified and eliminated. SKiiP undergoes one of two burn-in cycles. The modules are tested with cooling water at 80°C and cycling at a constant chip temperature. Junction temperature of the silicon reaches temperatures of up to 140° (IGBT3) to ensure high stress levels for the module.

The SKiiP IPM´s now powers 44 Gigawatt installed wind power capacity. The total wind power capacity installed is 94 Gigawatt. (Source: BTM Consult ApS, 03/2008) More than 15 years of experience in pressure contact technology is integrated into this power module.

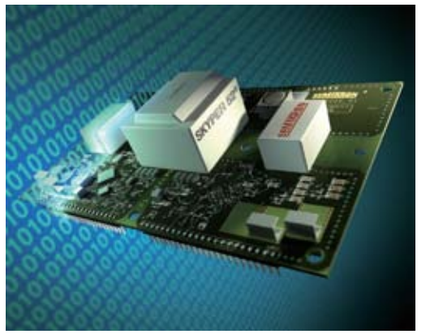
The principle of the technology is to use mechanical pressure pressing the DBC to the heat sink without soldering. This results in a homogenous pressure distribution with a thermal connection between the ceramic substrates carrying the semiconductor chips and the heat sink. An improved thermal resistance ($R_{th(j-s)}$) of 40% is reached compared to standard modules. SKiiP has no base plate and less solder layers resulting in lower thermal-mechanical stress inside the module. The thermal cycling capability is five times higher than a standard module with base plate and is reached even under the harsh climatic conditions renowned in the wind energy industry. High load and temperature cycling capability is ensured with the patented SKiiP pressure contact technology. The module is available in 1200V and 1700V for currents from 500A to 2400A.

SKiiP is the only intelligent power module for the wind market with power semiconductor, gate driver, current sensors, protective functions and matched cooling already integrated.

According to the European Renewable Energy Council, renewable energies will cover more than 35% of energy needs worldwide by the year 2030. Against the backdrop of a dynamically growing market, these intelligent integrated modules are ideal for use in wind generators and reduce production times and consequently, the all-important time to market.

Digital driver – proven control platform for IGBT modules and systems

The digital driver SKYPER 52, which has already proven to be a success in driving IGBT modules, is also being used in SEMIKRON systems. This driver boasts a wealth of functions with a minimum of components, making



The digital driver SKYPER 52 offers a high level of signal integrity, providing reliable immunity from interference signals.

the digital driver even more flexible and robust than before. SKYPER 52 offers a high level of signal integrity, providing reliable immunity from interference signals. The digital driver communicates via CAN input/output, providing the optimum interface between controller and power module. As a result, this driver is particularly suitable for use in systems that integrate power semiconductor, cooling, capacitors, driver and controller hardware.

The SKYPER digital driver transmits the commands of the controller for the power semiconductor with a high level of signal integrity, i. e. clear logic levels. As a result, the resistance to interference factors is improved. The flexibility of this driver is owing to the fact that the switching properties can be programmed individually. Voltage variation can thus be optimised and EMI immunity guaranteed. Complex filter circuits are no longer needed, which saves the user money. Thanks to the increased number of functions offered by SKYPER 52, additional settings such as sequential IGBT turn-off in the event of malfunction are possible.

SKYPER 52 works with low-voltage differential signal transmission, meaning that the gate driver can process the low-voltage 3.3V and 5V controller signals without the use of a level converter. Immunity to interference signals is thereby improved. The powerful SKYPER 52 driver can be used in applications with currents of up to 9000 A and frequencies of up to 100KHZ. The galvanic isolation between the controller and power modules can withstand voltages of up to 4KV. The digital driver is ROHS-compliant and suitable for 1200V and 1700 V IGBT modules.

In contrast to analog solutions, Semikron's digital technology offers many benefits from complex functions. The demand for easy integration of the gate control into converter solutions and the fusion of driver and controller interfaces confirm the need for a versatile digital control platform.

www.semikron.com

Renewable Energy Efficiency

Real-time control is affordable solution

Throughout the world, there is an increasing demand for renewable energy, yet system manufacturers continue to face the same issues that have always slowed the growth of this technology: increasing the total amount of power gathered and decreasing cost per watt.

By Arefeen Mohammed, Texas Instruments C2000 Systems & Applications Engineer Houston, Texas Instruments

Solar power has been around for years and, if all goes well, may grow by $21 billion by 2017, according to IMS research. One important way to help achieve these goals is by adding greater intelligence to the control of the inverter, which converts the variable voltage output of the collector into a steady voltage that is used for running applications or charging batteries. Intelligent inverters maximize power transfer from the gathering source, synchronize power output with the electrical utility, and protect the local system from potentially damaging changes in the grid.

While sun- and wind-powered systems are obvious applications, intelligent inverters can also benefit other sources of power, such as fuel cells, in order to maximize output. For all such applications, highly effective inverter control is available from 32-bit real-time microcontrollers (MCUs), which have been shown to cut conversion efficiency losses in half while significantly reducing costs. The increased cost of using a 32-bit processor can be mitigated by choosing a modern MCU that can handle most of the entire system's requirements, including AC-DC conversion, DC-DC conversion, and communication between panels in addition the demands of the inverter itself. In addition, cost-effective, highly integrated MCUs with real-time control capabilities are now available, enhancing performance and making the job of programming complex algorithms easier.

The inverter's role and stages

The main function of the inverter is to convert variable direct curre nt (DC) voltage input from the source into a clean sinusoidal 50- or 60-Hz output for use by appliances and/or feeding back into the grid. Single or multiple phases may be required by different applications. In addition to DC/AC conversion, inverters perform such functions as disconnecting the circuit to protect it from power surges, charging the battery, logging data on usage and performance, and maximum power point tracking to keep power generation as efficient as possible.

Nominal power ranges between one and several hundred kilowatts peak (KWp), allowing inverters to be designed around sophisticated source topologies, either with or without transformers, and with the integration of multiple control processors. Figure 1 shows where the inverter fits into an all-inclusive photovoltaic (PV) system that not only charges a battery and drives local AC loads, but also ties to the grid and has an alternate power source in the form of an AC generator. Similar configurations apply to wind turbines and other sources.

Transformers and protection

Because the source input is usually not high enough, the system can either

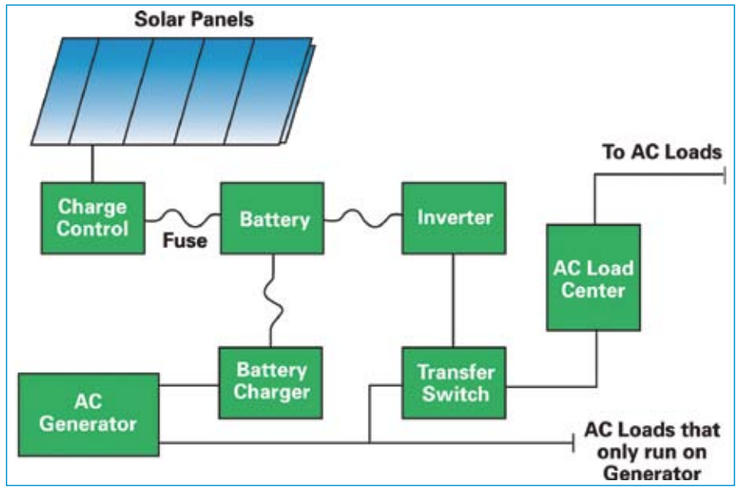


Figure1: PV and generator hybrid system.

step up the voltage with a transformer on the AC side or boost it in the DC/DC conversion stage. Just as an AC transformer inherently provides galvanic isolation, so does a phase-shifted full-bridge DC/DC converter with zero voltage switching, thus making the latter equivalently a transformer. Figure 2 shows a commonly used DC/AC circuit with transformer for single-phase inversion, based on an H-bridge configuration controlled by four pulse-width modulated (PWM) signals.

Transformers add weight, bulk and cost, and they also cause a reduction in efficiency of about two percent. On the other hand, they increase circuit protection and human safety by isolating the two sides of the circuit electrically, preventing a DC fault from flowing to the AC side, and an AC leakage current from developing a potential issue between PV panels and ground. The design may include a residual current protection device (RCD) that monitors the currents of all phases, and then trips the relay if the current exceeds a certain value. Because of the risk of current leakage, RCDs are especially important for safety in transformerless systems.

Protection of the system mandates inclusion of a relay to protect the conversion and charging circuitry against voltage surges and spikes on the grid. In addition, if a power line is damaged or the utility has to shut it down, the inverter needs to stop feeding out electricity to the utility. A "non-islanding" inverter senses that the line has been de-energized, is under- or over-voltage, or has a significant disturbance for whatever reason. When this happens, the inverter automatically disconnects from the utility grid, thereby not becoming an electricity generating "island."

Safety and programmability

An unexpected but highly valued feature of a 32-bit MCU intended for solar inverter applications is dual on-chip oscillators, which can be used for clock failure detection to enhanced reliability. The ability to run two system clocks simultaneously can also be helpful in reducing problems when the solar panels are being installed.

Because so much innovation is destined to happen in solar inverter design, perhaps the most important feature for an MCU is software programmability. This feature would allow the highest degree of flexibility in power circuit design and control.

Load balancing control is required when the panels are connected in parallel. The MCU must be able to detect the load current and increase or decrease the output voltage by turning off the output MOSFET. This requires a fast on-chip ADC to sample the voltage and current.

Since the source input is usually not high enough, the system can either step up the voltage with a transformer on the AC side or boost it in the DC/DC conversion stage. Just as an AC transformer inherently provides galvanic isolation, so does a phase-shifted full-bridge DC/DC converter with zero voltage switching, thus making the latter equivalently a transformer.

Obtaining maximum charging power

The efficiency of battery charging depends on the input voltage, which can be highly variable, depending on wind conditions for a turbine, or season, cloud cover and time of day for PV panels. Battery conditions vary, too, depending on the charge state, so sometimes it may be necessary to adjust the voltage and current ratio in order to increase the total power delivered and speed charging. Maximum power output to the battery occurs when the product

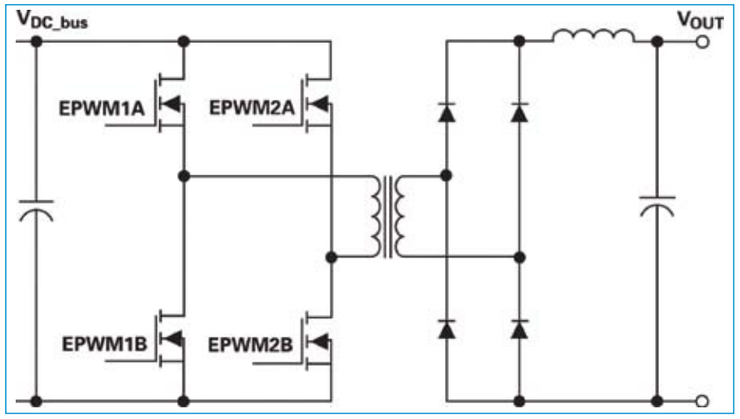


Figure2: DC/AC stage with transformer.

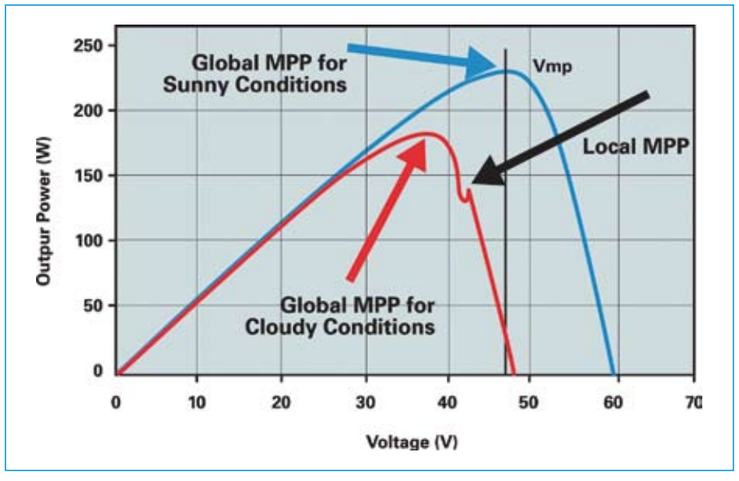
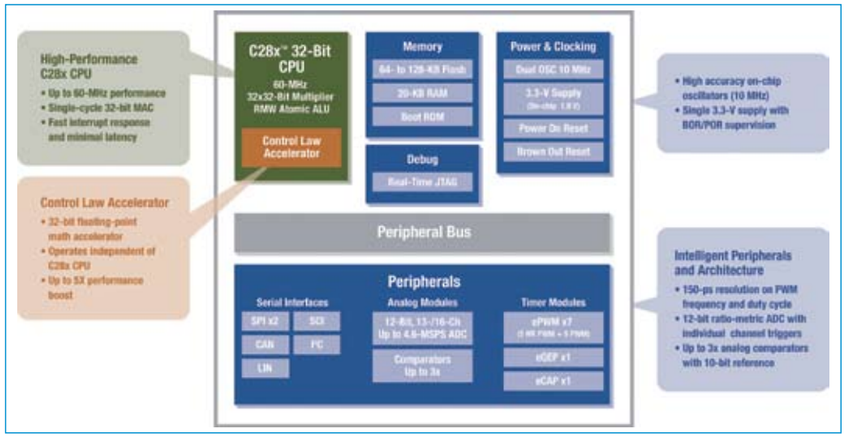


Figure3: MPP for different conditions.

Special Report – Renewable Energy



of voltage and current is at its peak, the maximum power point (MPP). MPP tracking (MPPT) is designed to determine this point and adjust the DC/DC voltage conversion in order to maximize the charging output. MPPT can increase the overall efficiency of a solar system by a third or more during winter months, and its effect in other types of systems can be significant, too. Figure 3 shows how the determination of MPP can vary with different conditions.

The most common algorithm for determining MPP is for the controller to perturb the panel's operating voltage with every MPPT cycle and observe the output. The algorithm continues oscillating around the MPP over a wide enough range to avoid local but misleading peaks in the power curve caused by, say, movement in cloud cover or a brief wind lull. To the extent that the perturb and observe algorithm oscillates away from the MPP in each cycle, it is inefficient. An alternative, the incremental inductance algorithm, solves the derivative of the power curve for 0, which is by definition a peak, then settles at the resolved voltage level. While this approach does not have the inefficiency caused by oscillation, it risks other inefficiencies because it may settle at a local peak instead of the MPP. A combined approach maintains the level determined by the incremental inductance algorithm, but scans at intervals over a wider range to avoid selecting local peaks. This approach, while the most efficient, also requires the greatest amount of performance on the part of the controller.

A 32-bit real-time microcontroller

An example of a microcontroller with advanced real-time control capabilities is Texas Instruments Piccolo™ series of microcontrollers. The Piccolo devices feature architectural advancements and enhanced peripherals in package sizes starting at 38-pins to bring the benefits of 32-bit real-time control to applications like micro-inverters that demand lower overall system costs. In addition, members of the Piccolo MCU series have integrated dual on-chip 10MHz oscillators for clock comparison, on-chip VREG with power on reset and brown out protection, multiple high resolution, 150ps PWMs, a 12-bit, 4 mega-sample/s ADC and interfaces for the I2C (PMBus), CAN, SPI, UART communications protocols.

Performance is a critical characteristic for micro-inverters. Although Piccolo devices are less expensive and have a smaller footprint than other C2000™ MCUs members, Piccolo devices retain the powerful the 32-bit TMS320C28x™ CPU, which makes computationally intensive control algorithms more efficient. Peripherals such as the enhanced pulse width modulator (ePWM) support the industry's highest resolution with frequency and duty cycle resolution down to 150 picoseconds.

TMS320F2803x devices offer 60MHz performance plus a new Control Law Accelerator (CLA), a 32-bit floating point s/w programmable math accelerator that operates independent of the C28x™ CPU. The CLA is designed to run complex, high-speed control algorithms allowing the main CPU to handle I/O and feedback loop metrics resulting in up to 5 times increased performance for some real-time control applications.

The combination of 32-bit performance, enhanced peripherals and small package sizes allows designers to add real-time control and system management with a single Piccolo microcontroller.

Micro-inverters

A relatively new option for optimizing solar system efficiency and reliability is to use micro-inverters that connect to each individual solar panel. Equipping each panel with its own micro-inverter allows the system to accommodate its changing load and atmospheric condition, which provides optimal conversion efficiency for both the individual panels and the entire system.

Micro-inverter architectures also enable simpler wiring, which translates into lower installation costs. By making consumers' solar power systems more efficient, the time taken for the system to "pay back" on the initial investment for the technology shortens.

A key to renewable energy

Renewable energy systems are continually being improved in order to achieve greater efficiency that will lower the cost per kW. While much attention is deservedly paid to improving PV panels and wind turbines, intelligent inverters can also contribute to making the technology more feasible. Variability in regulatory and operational requirements makes it important to select the right controller for the inverter, a controller that provides high performance, integration and flexibility. The expanded use of micro-inverters for a range of appropriate applications is one step toward moving solar power out of the shadows. New real-time microcontrollers will continue to help improve the efficiency and lower the cost of renewable energy.

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Power Systems Design Europe

Green Page

PSDE Green Power ENERGY EFFICIENCY

Progress vs. Politics

Reported by Cliff Keys, Editor-in-Chief, PSDE

No-one except perhaps the oil moguls wants dependency on fossil fuels. Alternative energy sources can be expensive and have a poor conversion rate. Researchers at U.S. Department of Energy's National Renewable Energy Laboratory (NREL) have set a world record in solar cell efficiency. They have been able to transform 40.8% of the light that goes through the cell into energy. This is the highest recorded efficiency of any photovoltaic device. The new solar cell, designed for space satellites and terrestrial concentrated photovoltaic arrays, uses gallium indium phosphide and gallium indium arsenide to split the solar spectrum into three parts. The three spectrums are absorbed by the cell's three junctions more efficiently.

The EU is discussing the new energy directive to produce 20% of power, including fuel and electricity, from renewables by 2020. The UK energy and climate change minister said that it was important that the EU come to an agreement to set an example to the rest of world. But it is reported that environment groups are angry that the minister is arguing for a deal while behind the scenes the UK is pushing to remove aviation from the EU 2020 target, making it easier to achieve. The Government is also facing pressure from business groups for failing to move fast enough on climate change.

US datacenters produce more greenhouse gases than Argentina and the Netherlands combined, according to a McKinsey study. Recognizing the tremendous energy consumption of these centers, architects, CTOs, power company executives, and regional leaders are now partnering to create more energy efficient data facilities. Wall Street West is a federal and state funded initiative to develop a total backup solution for key industries in New York City including financial services, hospitals and healthcare firms in the event of a disaster. It will host a roundtable discussion to explore the newest trends in improving data center energy efficiency. The panelists will examine how practitioners can take advantage of innovative design concepts as well as regional resources and economic incentives to maximize return while minimizing costs.

With all the politics currently involved in the plight of US motor companies, it's refreshing to see that Aptera Motors, founded in 2004 in California, to develop and build the safest, most energy efficient commuter vehicles on the road, begins volume production of its first vehicle, the all-electric 2e, in 2009. With streamlined aerodynamic design, lightweight composite structures and unique drive systems, the two-seater offers consumers fuel efficiency levels that are the equivalent of up to 127km per Liter (300 miles per gallon).

Nice to finish on good news!

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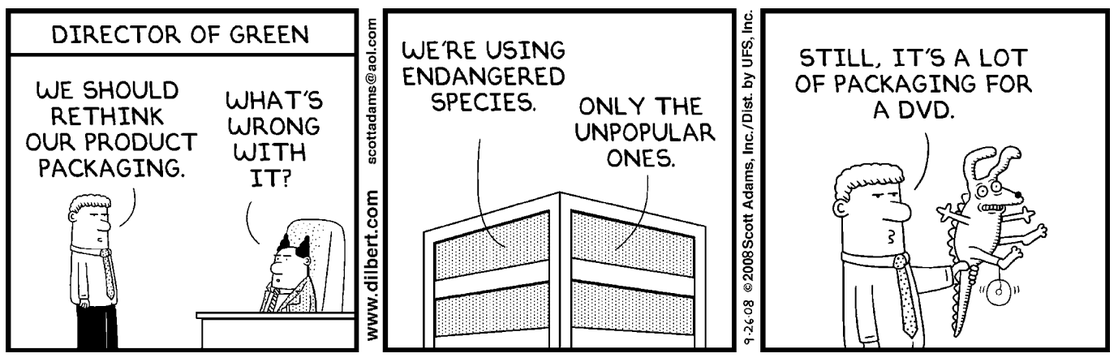

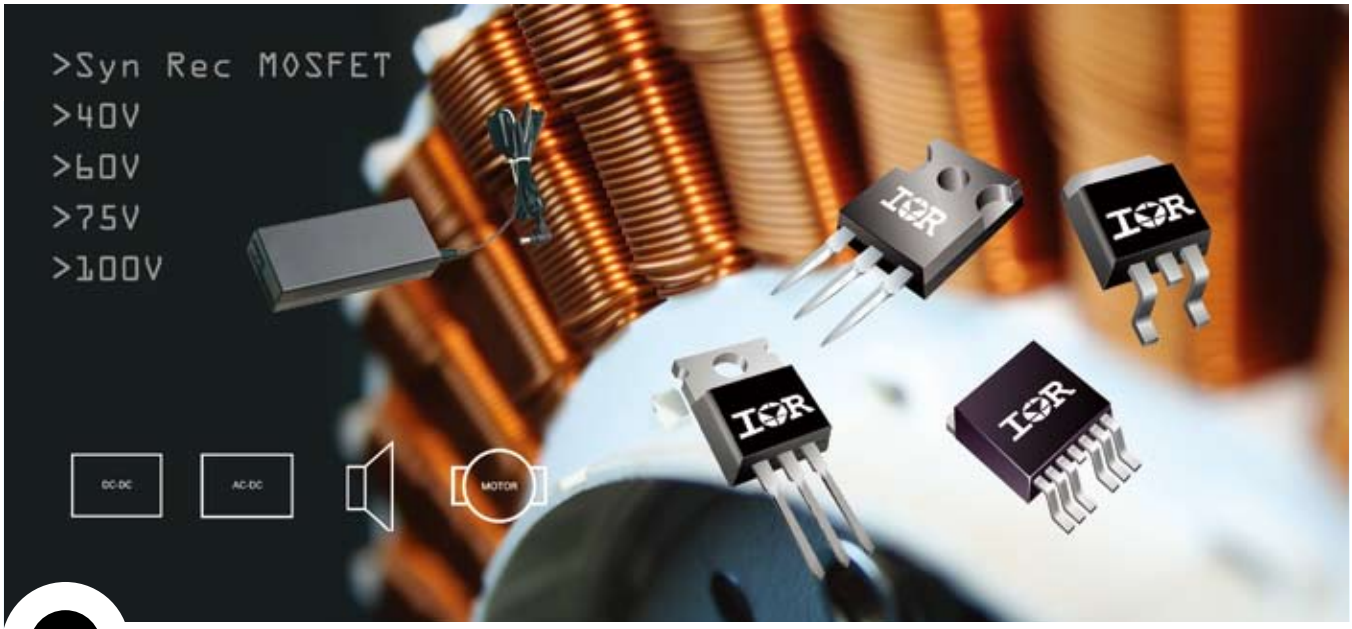

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IRFP4004PBF	40	350	1.7	220	TO-247
IRF2804SPBF	40	270	2.0	160	D²PAK
IRF2804PBF	40	270	2.3	160	TO-220
IRFB3206PBF	60	210	3.0	120	TO-220
IRFS3206PBF	60	210	3.0	120	D²PAK
IRFP3206PBF	60	200	3.0	120	TO-247
IRFB3306PBF	60	160	4.2	85	TO-220
IRFP3306PBF	60	160	4.2	85	TO-247
IRFP4368PBF	75	350	1.8	380	TO-247
IRFB3077PBF	75	210	3.3	160	TO-220
IRFP3077PBF	75	200	3.3	160	TO-247
IRF2907ZS-7PPBF	75	180	3.8	170	D²PAK-7
IRFS3207ZPBF	75	170	4.1	120	D²PAK
IRFP4468PBF	100	290	2.6	360	TO-247
IRFB4110PBF	100	180	4.5	150	TO-220
IRFP4110PBF	100	180	4.5	150	TO-247
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