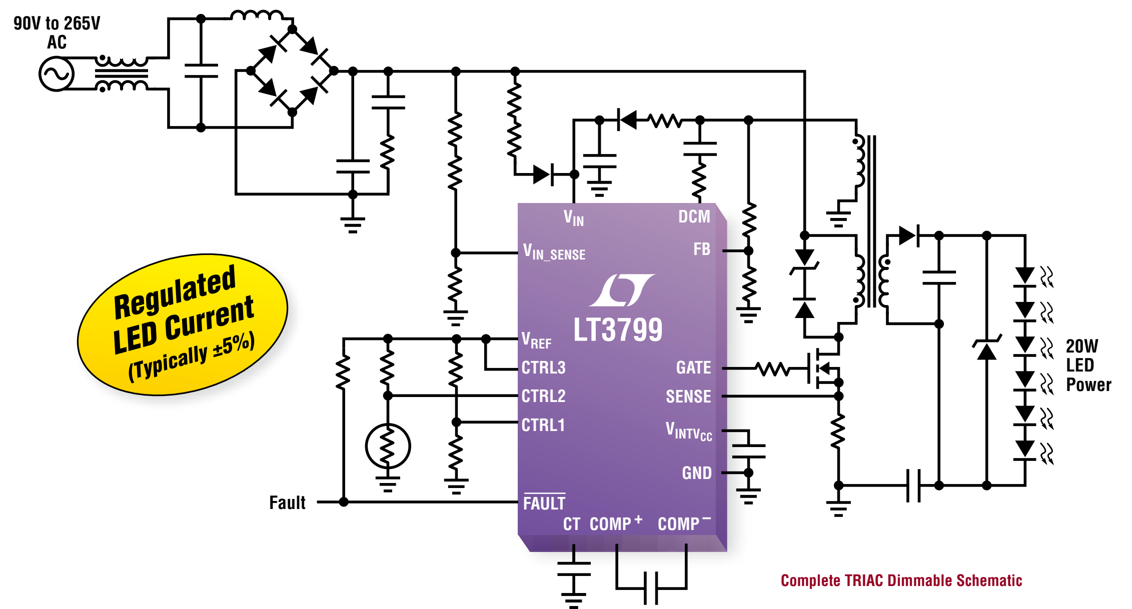
June 2011

PSD EUROPE

Power Systems Design: Empowering Global Innovation

SPECIAL REPORT: RENEWABLE ENERGY (PG 31)

Isolated LED Current Control with Active PFC

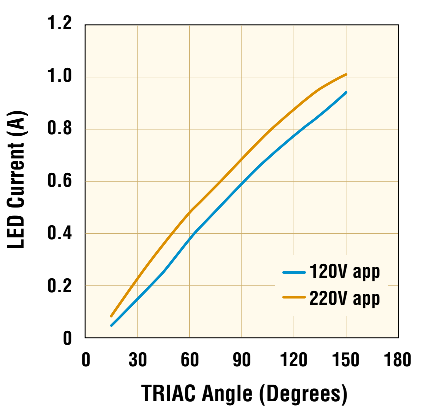


Complete TRIAC Dimmable Schematic

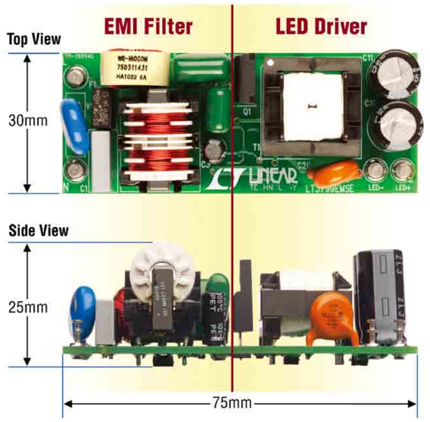
TRIAC Dimmable LED Driver Needs No Opto-coupler

Our LT®3799 isolated LED controller with active power factor correction (PFC) is specifically designed for driving LEDs over a wide input range of 24V to 480V+. It is ideal for LED applications requiring 4W to over 100W of LED power and is compatible with standard TRIAC in-wall dimmers. The LT3799's unique current sensing scheme delivers a well regulated current to the secondary side with no opto-coupler, enabling it to provide ±5% LED current accuracy. It also offers low harmonic distortion while delivering efficiencies as high as 90%. Open and short LED protection ensures long term reliability and a simple, compact solution footprint addresses a wide range of applications.

LED Current vs TRIAC Angle



LT3799 Demo Board (25W)



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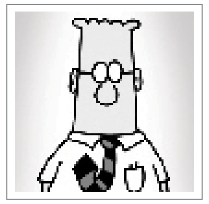

PSD EUROPE

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Registration of copyright: January 2004
ISSN number: 1613-6365

Volume 8, Issue 5

RENEWABLE REVOLUTION

Welcome to this issue of PSDE where we carry a feature on Renewable Energy. Our industry has pioneered this new and clean way of energy generation. But the problem does not just rest with the provision of this natural power. The distribution of this power poses several questions, now in deep discussion with the various National and International bodies that need to agree the standards for transmission, metering and communication within the new, so-called 'smart grid'.

At the May PCIM in Europe, I saw several new additions to the renewable energy field and you can see the video interviews we recorded – both on you tube and on our website.

Among several others, I interviewed on video Helmut Doenges, Marketing Director of Magnetec who make high performance Current Transformers made of nanocrystalline soft magnetic materials, who provide an ideal transducer principle for renewable energy applications. The sophistication of these magnetic materials far out-strips the conventional magnetic iron core and can provide huge gains in energy efficiency in renewable applications.

In a previous issue we talked about the countries all over the world looking forward to replace, extend or modernize their grid infrastructure. In many cases, this is with the development and installation of new and intelligent smart metering devices to make smart grids overall reliable and efficient.

Of course, it is always easier to use existing transducer principles in meter solutions without any changes to promote a new product for smart grid technology. But now new and innovative products offer a huge potential and high level of safety and reliability in terms of a consumer friendly energy measurement.

Such innovations are developed in close cooperation with the needs between utilities and meter manufacturers, and also between the utilities and the consumer. It is important that the solution is not only driven by price, but also by the quality and attractiveness of the product innovation. This means more security and reliability in the energy measurement within the smart grid and will be a good argument to penetrate the smart grid business.

I hope you enjoy this renewable energy issue and our new online service. Please keep your valuable feedback coming in and do check out Dilbert at the back of the magazine. We all need a laugh sometime!

All the best,

Cliff
Editorial Director & Editor-in-Chief,
Power Systems Design
Cliff.Keys@powersystemsdesign.com

ENERGY HARVESTING REFERENCE DESIGN

Silicon Laboratories has introduced the industry's most energy-efficient wireless sensor node solution powered by a solar energy harvesting source. The new turnkey energy harvesting reference design enables developers to implement self-sustaining, ultra-low-power wireless sensor networks for home and building automation, security systems, industrial control applications, medical monitoring devices, asset tracking systems and infrastructure and agricultural monitoring systems.

The market for energy harvesting devices is poised to grow exponentially this decade. Although systems powered by harvested energy sources have existed for many years, developers have been challenged to implement wireless sensor nodes within very low power budgets. Silicon Labs has met this design challenge by creating a wireless energy harvesting system based on its Si10xx wireless microcontroller (MCU) family. The industry's most power-efficient, single-chip MCU and wireless transceiver solution, the Si10xx can perform control and wireless interface functions at ultra-low power levels.

In addition to being environmentally friendly and virtually inexhaustible, harvested energy provides a cost-effective, convenient alternative to batteries in many applications such as wireless networking systems. Batteries can be costly and inconvenient to replace, especially in large-scale wireless sensor node applications, and they are unreliable in extreme temperature conditions. Wireless sensor nodes often use batteries because they are placed in locations where it is not possible or convenient to run mains power. Energy harvesting simplifies these applications by eliminating the inconvenience of replacing batteries in inaccessible locations.

Silicon Labs' comprehensive energy harvesting reference design includes wireless network and USB software and a complete circuit design with RF layout, bill of materials (BOM), schematics and Gerber files.

The design consists of three components:
Solar-powered wireless sensor

node measures temperature, light level and charge level, using an Si10xx wireless MCU to control the sensor system and transmit data wirelessly and a thin-film battery to store harvested energy.

Wireless USB adapter connects the wireless sensor node to a PC for displaying sensor data; the adapter features Silicon Labs' Si4431 EZRadioPRO® transceiver with an MCU running USB-HID class software and EZMac® wireless software stack. Wireless sensor network GUI displays data from up to four sensor nodes.

The thin film battery used in the energy harvesting reference design has a capacity of 0.7mAh. In direct sunlight and can be recharged fully in only two hours. While in sleep mode, the wireless sensor node will retain a charge for 7,000 hours. If the wireless system is transmitting continuously, it will operate non-stop for about three hours, although it is designed to constantly recharge itself at an appropriate level to keep the thin-film battery from completely discharging.

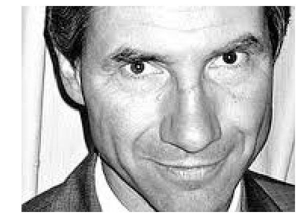
Silicon Labs' energy harvesting reference design accommodates a wide range of harvested energy sources. An on-board bypass connector gives developers the flexibility to bypass the solar cell and tap other energy harvesting sources such as vibration (piezoelectric), thermal and RF.

Silicon Labs energy harvesting reference design is available now and priced at $45(USD).

For more information, visit www.silabs.com/pr/energyharvesting.

For more details about Silicon Labs' Si10xx wireless MCU family, visit www.silabs.com/pr/wirelessmcu.

POWERING RENEWABLES



Reported by Cliff Keys, Editorial Director, Editor-in-Chief, Power Systems Design

Renewable Energy covers many forms; I asked LEM CEO, François Gabella, a few questions on his own perspective on what LEM brings to the party.

Q) In Renewable Energy, you've got to measure what you're using or generating and how the changes you make are effective. How can LEM help here?

A) Renewable energy is a unique market with Solar being the biggest part at the moment. There is an extremely broad range of transducers in this market to serve both small and large installations. All of this requires accuracy to maximize performance to be able to extract as much energy as possible and also it is a question of reliability; once installed on the roof or indeed, in a remote location, the installation needs to be maintenance-free otherwise high maintenance costs can result. This is where LEM makes a significant contribution.

Q) Engineers and consumers will be in close contact with these Renewable energy products. Are there also Safety issues to consider?

A) With the extremely dangerous voltages present in many installations there needs to be a great emphasis on safety. LEM has at PCIM launched a range of leakage current transducers which provide information to the system to cut off the supply when a tiny leakage current is detected.

Q) As the renewable industry grows rapidly, what is the impact on component suppliers?

A) After the tragedy in Japan with Nuclear energy, there is a growing interest in safer and less volatile means of power generation. This is a tremendous opportunity for the Renewable Energy sector and this will be twofold; there will be a huge increase in the number of installations using renewable sources, and the power grids will need to become much more flexible to manage the variation in flows throughout the time of day and the prevailing weather conditions. LEM is continuing to develop products to measure and monitor these variations to enable a truly 'smart' grid operation.

Q) Another booming industry that keeps pollution down is the electric vehicle. But it's no good charging all the battery electronics if the net result is to use too much electrical energy due to inefficiency in the vehicle's design. Is LEM involved in this industry

A) There are several popular and impressive statistics out there at the moment and generally the forecast for EVs is that this market is going to develop rapidly and governments will start to apply more pressure to accelerate the adoption and also the industrialization of those vehicles will bring the cost down to consumer levels. There are two main areas where

LEM can contribute; firstly, we are researching and investing in the area concerning the battery management where we have over 10 years experience to date. Batteries are becoming more sophisticated and the current flowing in and out needs to be critically monitored and controlled. Secondly, the drive-chain needs to be accurately controlled and this is a traditional part of LEM's business and an area where we have a huge amount of expertise. Whether you are looking at concept autos or production vehicles, you will find that LEM's products are found in over 70% of them, demonstrating how seriously we take this market.

Q) These are booming industries and have attracted many manufacturers to 'jump on the bandwagon'. Why should a designer in the Renewable field especially come specifically to LEM for a solution, rather that the rest. What do you have that the others do not?

A) Of course, we are expecting to see more competition in these new and fast-growing markets, having said that, we feel we are very well armed and positioned in this area. LEM's core business has been in the area of transducers for almost 40 years. We are living transducers 24 hours a day and feel that we have the broadest range of products suiting all applications in the marketplace; we focus on quality working on a worldwide basis to help our customers to specify and achieve optimum solutions. We are intensifying our R&D efforts developing more innovative products. We welcome competition, it's healthy, and we keep on driving.

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SOLAR MARKET STILL SHINES, BUT SUPPLY CHAIN WOES

By Ash Sharma

Yet again the solar PV market amazed me last year. My forecast at the start of the year of 17GW of new capacity being added was seen as bullish by most – hardly surprising considering that this would have been an increase of 125%. Amazingly, this turned out to be pessimistic! A massive surge in demand in both Germany and Italy, caused by speculation over future incentive cuts drove new installation to more than 18GW – a whopping 140% increase year-on-year.

Despite some major cuts to incentive schemes in Europe in 2009 and 2010, the industry had already added massive extra panel manufacturing capacity. This caused panel and system prices to fall sharply, sparking life back into the market and driving investment returns up, which resulted in 18GW of new annual capacity and 40GW of total PV capacity in operation by the end of 2010. Despite being smaller than the wind power industry, PV took great strides in catching up last year.

The power semiconductor industry sees PV deployment as a major driver of growth over the coming years, both from the viewpoint of inverter electronics and also panel-level voltage optimisation. Although still a relatively small opportunity now, the TAM could approach a billion dollars in the next five years. Semiconductor suppliers are well advised to keep these PV customers happy, especially considering the fall-out of last year's supply problems, when shortages of components (most notably IGBT modules) led to a massive bottleneck in inverter production. Inverters were the bane of the PV industry last year, delaying projects from being completed (and hence missing out on valuable feed-in tariffs) and inverter vendors in turn laid the blame firmly at the door of their semiconductor suppliers.

Of course, being able to view the industry from outside of the PV bubble, it's not hard to see why these inverter companies felt ignored. It wasn't just their business that was growing, the whole global economy was recovering and power semiconductors were in hot demand. In fact our latest data shows the power semiconductor market grew 40% last year, more than reversing 2009's decline. And when demand is high and suppliers are on allocation, the biggest customers typically come first and the smaller customers have to wait.

Now that the component shortage is (hopefully) behind us, I've heard that inverter suppliers are trying to ensure they don't suffer the same fate again and are actively seeking out second and third sources, trying new Chinese component vendors, moving away from customized, single-sourced parts, holding more stock and trying to provide better forecasts for demand to their suppliers.

The latter will possibly prove the most difficult. Massive oversupply occurred last year (as the supply bottleneck unwound and double-orders got fulfilled) and currently demand is very weak. But a major surge in demand is anticipated due to further incentive changes in major markets, as well as the implications on energy policy of the Fukushima nuclear disaster. IMS Research is predicting another fine year for the PV industry, with new capacity reaching 21GW in 2011 - a further 15% increase. The outlook changes somewhat for 2012, with PV demand forecast to fall to 20GW triggering a free-fall in prices amidst industry-wide over-capacity. Following a 'bad' 2012, industry growth is set to accelerate again to double-digit rates and by 2015 a projected 160GW of PV capacity will have been installed globally. That's quite an opportunity for power semiconductor companies!

Author: By Ash Sharma
Senior Research Director
IMS Research

www.imsresearch.com

POWER SUPPLY DEVELOPMENT DIARY PART XIII

By Dr. Ray Ridley

This article continues the series in which Dr. Ridley documents the processes involved in taking a power supply from the initial design to the full-power prototype. At this point in the design, the second layout of the PC board is complete, with several significant changes to the power specifications being implemented. The new power supply layout is an opportunity to redesign magnetics components, starting with the current transformer.

Current Sensing Using a Current Transformer

When working with high power supplies, above 100 W or so, the best way to sense the current in the power stage is usually with a current transformer. This approach has the following advantages over resistive sensing of the current:

1. Sense voltage can be large (>1 V).
2. Dissipation can be arbitrarily low.
3. Galvanic isolation eliminates grounding problems. (very important for bridge current-balancing.)

A current transformer consists of a multi-turn secondary wound on an ungapped core, and a single turn primary which usually consists of just a wire jumper on the board, or a copper strap.

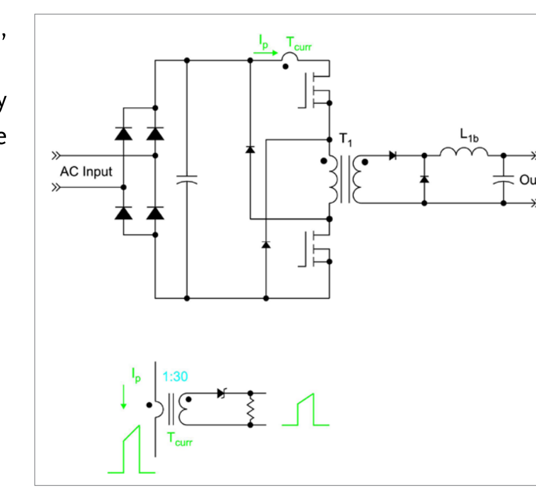

Figure 1: Forward Converter with Current Transformer Placement and Waveforms

Figure 1 shows the schematic of the forward converter with a current transformer in the high side of the input rail, above the drain of the upper FET. The location of the current transformer is important – it should be placed in a part of the circuit where the common-mode ac voltage is small, and where only the desired current is sensed. If the current transformer in Figure 1 were placed on the return of the input rail, it would also sense the gate drive current pulse in addition to the drain current.

The first consideration in selecting a current transformer is the turns ratio. The primary side of the transformer is driven by the current in the power stage, and is set by the load and power stage operating conditions. If you want a given signal size for the control circuit to use, the turns ratio of the current transformer will determine how much voltage drop, and hence how much dissipation, will be seen on the primary. The lower the dissipation that you want, the higher the turns count of the current transformer.

Current Transformer Termination

Proper termination of the current transformer is important. Once the secondary current is found from the primary current and the turns ratio, the value of the terminating resistor is defined to give the desired output voltage. For example, for the forward converter in this article, the peak input current is 4 A at full load, and the desired current sense voltage is 4 V, scaled to work with the UC3825 controller. The loading resistor on the current transformer is therefore equal to the turns count in this case.

As shown in Figure 1, a zener diode is placed in series with the termination resistor. This is the most effective and simplest way to implement a current transformer circuit. When the power current is flowing in the primary, the zener diode conducts, and its presence does not affect the size of the output signal.

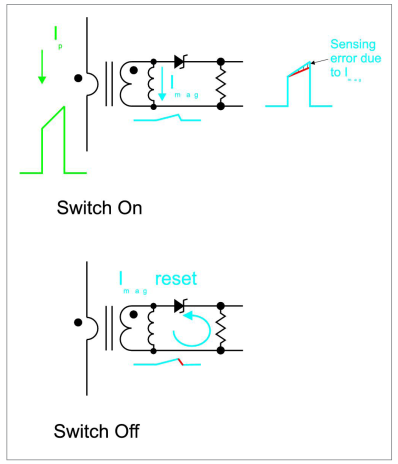

Figure 2: Current Transformer with Magnetizing Inductance

The zener diode is used to provide reset of the magnetizing current of the transformer, as illustrated in Figure 2. In this schematic, the magnetizing inductance is shown on the secondary side of the transformer. When the power circuit is on, voltage is applied across this inductance according to the voltage generated by the load resistor. The magnetizing current increases during this period. This current will subtract from the reflected primary current flowing through the load resistor, and this will affect the accuracy of the current sensing, as shown in the waveform at the output of the current transformer network.

When the switch is turned off, the magnetizing current must continue to flow. It cannot flow in the primary of the current transformer, so it flows up through the loading resistor, and backwards through the zener diode. The zener provides a reset voltage across this inductance, and a 15 V zener will quickly reset the magnetizing inductance back to zero.

You will see many other schemes for resetting a current transformer in application notes. Sometimes a regular signal diode is used in place of the zener. This results in a large reset voltage, limited only by the breakdown of the diode, or a resonant voltage. This large voltage can adversely affect the control circuit in some cases. Other application notes use resistors on the secondary side of the current transformer, but these do not provide a proper reset. The zener solution is the simplest and most effective way to reset the transformer.

Current Transformer Parasitic Elements

It is very important to measure the magnetizing inductance of a current transformer in order to ensure that you are getting the sensing accuracy that you want. It is also important to measure the leakage inductance of the current transformer network, and the winding capacitance. These elements are shown in Figure 3, with the leakage inductance reflected to the primary of the transformer.

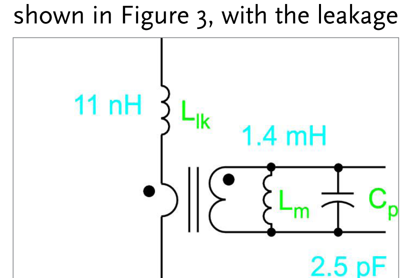

Figure 3: Current Transformer with Leakage Inductance and Winding Capacitance

The leakage inductance of the current transformer network is very important since it will affect the power circuit waveforms if it becomes too large. The leakage is measured by looking at the impedance from the secondary of the transformer, then reflecting the value by the turns ratio squared to the primary side. This leakage value should always be considerably less than the leakage inductance of the main power transformer.

It is interesting to note that the leakage inductance of the current transformer does not determine the bandwidth of the current sensing network. (For normal applications of a transformer, when the leakage impedance reaches the load impedance, that is the bandwidth of the system.) For a current transformer network, it is the capacitance of the windings that determines the bandwidth, so this parameter must also be measured carefully. Since the current sensing network must have very wide bandwidth in order to protect the power circuit properly, the capacitance must be kept as low as possible.

All of the parasitic parameters of the current transformer can be measured as described in the last article in this magazine [1]. On the first pass of the power stage design, an off-the-shelf current transformer was used from Pulse Engineering, as shown in Figure 4. The redesigned transformer, customized for the specific power requirements of this power stage, is also shown.

	Pulse Engineering 51886	Custom Design
Turns Ratio	50:1	30:1
Magnetizing Inductance	8.8 mH	1.4 mH
Capacitance	7 pF	2.5 pF
Sensing Error	1.7%	5.4%
Primary Leakage Inductance	22 nH*	11 nH*
Bandwidth	450 MHz	2.2 GHz

Table 1 – Current Transformer Performance Measurements

Both current transformers are constructed using a single layer of winding around a ferrite toroid. This provides the lowest-capacitance structure, and is most commonly used for high performance current transformers.

Table 1 compares the characteristics of the two transformers. The standard part from Pulse Engineering is a good generic part to use in a very wide range of power applications for current up to 20 A, but is quite large for this particular application. The custom design is wound on a much smaller core, and its only drawback is that the magnetizing inductance is lower, and sensing accuracy is less than the standard design.

The capacitance of the custom transformer is very low, 2.5 pF, and the primary side leakage inductance is just 11 nH. This leakage is very low compared to the power transformer leakage inductance of 3.5 μH.

Summary

Designing a custom transformer for your application can optimize the performance for the given space on your board. It is often difficult to find the exact current transformer in a standard part that is small enough for your circuit requirements.

Good current transformer design is not that difficult, consisting of a single layer of wire on a toroidal ferrite core. If the correct termination circuit is used, including a zener reset diode, you should be able to get very good performance out of your current transformer network, and this is the preferred approach for high-power designs.

References

"Transformer Impedance Measurements", Ray Ridley, Power Systems Design Magazine, June 2011.

Author: Dr. Ray Ridley
President, Ridley Engineering
www.ridleyengineering.com

DRIVING 3.3KV IGBT MODULES MADE EASY

Cost-effective and compact dual-channel driver core

By Olivier Garcia, Jan Thalheim and Markus Rätz

The new 3.3kV dual-channel driver core 2SC0535T2A0-33 (2SC0535T in brief) from CONCEPT allows IGBT modules of the voltage class up to 3.3kV to be driven with full design flexibility in a wide range of applications such as traction, renewables, industry as well as HVDC and STATCOM.

The gate driver is a key component of power electronics systems. It connects the signal electronics with the high-voltage parts (e.g. IGBT modules) of the power converter. Properly designed gate drivers ensure safe driving of the IGBT modules in normal operation as well as in a fault condition such as system overload or IGBT short-circuit. High availability and reliability are mandatory, as the dysfunction of only a single gate driver in a power converter may lead to overall system failure or reduced performance.

On the other hand, the design cycles of power electronics systems are getting shorter and the pressure on the required flexibility and costs is steadily increasing. With the introduction of the brand-new 3.3kV dual-channel gate driver core 2SC0535T, CONCEPT has set itself the ambitious goal of providing easy ways of driving high-voltage IGBT modules up to 3.3kV with full flexibility, high reliability, high performance, reduced space requirements and low cost. This is made possible thanks to the uncompromising integration of CONCEPT's SCALE-2 technology. The outstanding features of the 2SC0535T are described below.

Figure 1: 2SC0535T SCALE-2 dual-channel IGBT driver core

Extended Ambient Temperature Range

Figure 1 shows a photograph of the 2SC0535T dual-channel driver core. With a footprint of only 59.2mmx76.5mm and a total height of 25mm, it can deliver a gate output power of up to 5W per channel with a gate current capability of ±35A over the full ambient temperature range from -55°C to 85°C. This makes it possible to drive 3.3kV IGBT modules at the high switching frequencies required in applications such as induction heating. Even 1.2kV or 1.7kV IGBT modules connected in series or in multilevel topologies can be driven with the minimum gate resistance, thus reducing switching losses and increasing the overall power converter efficiency. The negative temperature range has been extended from the industrial standard of -40°C to -55°C to even allow IGBT modules to be controlled at the extremely low temperatures required in certain traction applications.

Isolation up to 3.3kV and 50kV/μs

The driver isolation is designed to comply with the EN50178, EN50124-1 and IEC60077-1 standards in overvoltage category 2 and pollution degree 2, providing reinforced isolation between the primary and secondary sides. The related clearance and creepage distances given in Table 1 are dimensioned to fulfill these standards.

They allow the potential of 3.3kV IGBT modules at maximum DC link voltages to be fully exploited. Moreover, the total coupling capacitance in the range of 20pF between the primary side and each secondary side confers a dv/dt robustness of up to 50kV/μs thanks to the outstanding capability of the SCALE-2 technology. This guarantees that the signal information will be transferred reliably even at a high DC link voltage and with ultra-fast switching operations.

Monitoring Functions

The desaturation protection

Clearance distance primary-secondary	25mm
Creepage distance primary-secondary	44mm
Clearance distance secondary-secondary	14mm
Creepage distance secondary-secondary	22mm

Table 1: Clearance and creepage distances of the 2SC0535T

network with resistors as shown in Figs. 2 and 3 allows a robust design of the short-circuit protection function of the IGBT modules with short-circuit durations in the range of 5-10μs. The IGBT modules can be used with the maximum DC link voltage at double the nominal current without risking any false tripping of the desaturation protection function. If required, the threshold limit for desaturation protection can easily be increased by a simple resistive voltage divider (Rd in Figs. 2 and 3). Furthermore, the use of high-voltage diodes is completely avoided.

The patent pending circuits proposed in Figs. 2 and 3 also offer an important advantage. The transient voltage suppressor (TVS) chain is connected to the resistor network at node (1). This allows a high-ohmic resistor network Rvce1...Rvce3 to be used while keeping a constant voltage at (1) in the IGBT short-circuit condition over a wide range of the DC-link voltage, typically of 50% to 100% of its maximum value. The voltage at (1) is then basically determined by the clamping voltage of the TVS D1. This leads to an almost constant short-circuit duration, even at lower DC link voltages. If the connection between the resistor network and the TVS chain is removed, the short-circuit duration becomes higher as soon as the DC link voltage is reduced. As an alternative, the resistance value of the resistor network Rvce1...Rvce3 can be reduced in order to avoid higher IGBT short-circuit durations at lower DC link voltages, although this leads to high power losses in the resistor network and therefore a greatly increased space requirement. Supply undervoltage monitoring is implemented on the driver primary side as well as on both secondary sides to avoid IGBT modules being driven with inadequate gate-emitter voltages.

In the failure condition (undervoltage monitoring or IGBT short-circuit), the corresponding driver channel is turned off and a fault feedback is transmitted immediately to the corresponding status output. The driver is then kept in the off-state during the blocking time, which is programmed with a resistor Rb at pin TB (see Figure 4) in a range between 10us and 130ms. The status signals SO1 and SO2 allow simple monitoring of the driver channels.

Advanced Active Clamping (AAC)

Active clamping is a widely used technique to reduce the collector-emitter voltage of the IGBT during the turn-off event. The IGBT is

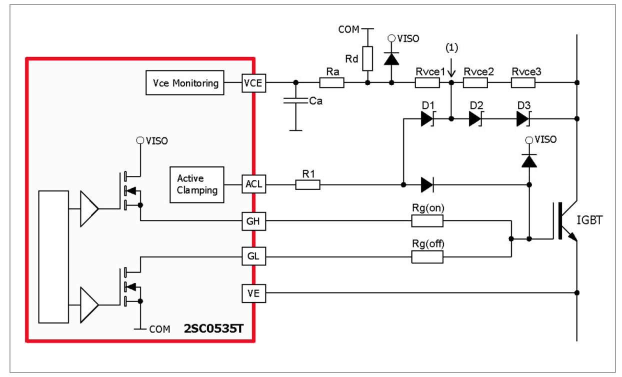

Figure 2: External circuit for Advanced Active Clamping (AAC) using 2SC0535T (only one channel is represented)

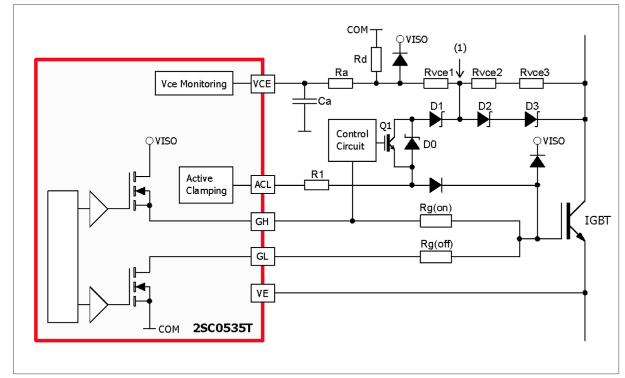

Figure 3: External circuit for Dynamic Advanced Active Clamping (DA2C) using 2SC0535T (only one channel is represented)

partially turned on as soon as its collector-emitter voltage exceeds a predefined threshold. The IGBT is then maintained in linear operation, thus reducing the fall rate of the collector current and therefore the collector-emitter overvoltage.

Basic active clamping topologies implement a single feedback path from the IGBT's collector through TVS to the IGBT gate. The 2SC0535T supports SCALE-2 Advanced Active Clamping (AAC), where the feedback is also provided to the driver's secondary side at pin ACL (see Figure 2): as soon as the voltage on the right side of the resistor R1 increases due to the active clamping activity, the turn-off MOSFET of the driver connected to GL is progressively switched off in order to improve the effectiveness of the active clamping and to reduce the losses in the TVS.

Dynamic Advanced Active Clamping (DA2C)

The maximum DC link voltage must be limited during operation as well as in the off-state condition when using AAC to avoid thermal overload or even static conduction of the TVS. The circuit of AAC in Figure 2 can be extended with a switch (e.g. IGBT or MOSFET) and one or more paralleled TVS as well as a small control circuit as shown in Figure 3 to address this drawback.

The resulting circuit, known as Dynamic Advanced Active Clamping (DA2C), allows the DC link voltage in the IGBT off-state to be further increased by opening Q1 in the IGBT off-state. Q1 is turned on as soon as the driver channel is turned on. It is kept in the on-state for about 15 to 20μs after IGBT turn-off thanks to a timer included in the control circuit, thus ensuring an adequate level of active clamping during the IGBT turn-off event.

In several traction, wind-turbine or solar-inverter applications, an extended range of the DC link voltage is required when all IGBT modules are in the off-state. In case of an inverter failure, all IGBTs are usually turned off to bring the system to a safe state. The energy stored in the inverter phase inductances is then fed into the DC link, leading to an immediate increase of its voltage.

Direct Paralleling

The turn-on and turn-off signal propagation delay is shorter than 100ns. The delay deviation in series production as well as the delay jitter are almost negligible. This timing precision allows direct paralleling of IGBT drivers for parallel-connected IGBT modules. Each IGBT module is then driven with its own 2SC0535T driver. This driving method has several advantages over the conventional approach, where one driver controls several parallel-connected IGBT modules.

Additional product features

The threshold levels of the input signals INA and INB are 2.6V for turn-on and 1.3V for turn-off. They allow the unrestricted use of an input signal logic level of between 3.3V and 15V. A simple resistive voltage divider can be used to increase the threshold levels and therefore the signal-to-noise ratio at the input if required (R1 and R2 in Figure 4).

The driving mode is selected with a resistor Rm at the MOD pin. In direct mode, both driver channels work fully independently. In half-bridge mode, only one driver channel is in the on-state while the other is in the off-state. At commutation, a programmable half-bridge dead time of 0.6µs to 4.1µs is programmable with the resistor Rm shown in Figure 4. The DC/DC converter generates an unregulated isolated 25V supply voltage from the primary 15V supply voltage for each driver channel that can vary slightly depending on the driver load and temperature. The secondary voltage is divided into a regulated and stable +15V for the on-state gate-emitter voltage of the IGBT and an unregulated -10V for the off-state gate-emitter voltage. Thanks to the regulated +15V in the on-state, the gate-emitter voltage can be efficiently clamped with a Schottky diode to the +15V as shown in Figs. 2 and 3. This gate-emitter clamping method is considerably more effective than using transient voltage suppressors between the gate and emitter. The latter does not allow the gate-emitter voltage to be limited to 15V in the short-circuit condition, as some clamping voltage reserve must be included in view of the component tolerances and temperature dependence in order to avoid static conduction and therefore overload in the on-state.

Increased Reliability

2SC0535T drivers benefit from the high integration level of the SCALE-2 technology. This leads to a reduced board space optimized to comply with the given isolation standards. Moreover, it is well known that the reliability of a properly designed electronics system is directly related to the number and choice of the components used. Like all SCALE-2 drivers, 2SC0535T drivers feature a minimum number of carefully selected highly reliable components. This immediately results in an increased MTBF compared to the discrete solutions available on the market.

Optimum Space Requirement and Cost Performance

2SC0535T drivers allow the use of any IGBT module up to 3.3kV and offer full flexibility in terms of switching speed and features during the power converter design. The driver core can be assembled on a common printed circuit board, which is in any case needed to design additional electronics, thus saving space and costs. Moreover, no fiber-optic interface is required, as the galvanic separation of the driving signals is realized with transformers, thus further reducing costs. A fiber-optic interface may still be used if required.

The pricing of the 2SC0535T is extremely competitive. With a target price of US$75 for two channels at quantities of 1000 items, the 2SC0535T sets a new benchmark for driving 3.3kV IGBT modules.

True Second Source

The recent events relating to the earthquake in Japan have shown how important second sources of critical components are. The primary-side LDI and secondary-side IGD ASICs have been developed on the basis of two semiconductor processes and can consequently be produced in two independent foundries. A third production site is currently being evaluated. The ASICs are packaged by two different companies. The transformer production has also been released by two manufacturers. All other components of the driver have defined second sources. The printed circuit board can be assembled by two independent companies. Beyond that, CONCEPT invests considerable effort in maintaining safety stocks in order to ensure that even in the case of a component shortage on the global market, the gate drivers can continue to be manufactured and delivered to satisfy the customer demand at all times.

Applications

A wide range of applications such as traction, wind power, solar converters, induction heating and medium-voltage drives, as well as HVDC and STATCOM is made possible with 2SC0535T drivers. Any IGBT module of the voltage class up to 3.3kV can be safely driven in two-level topologies. Moreover, 2SC0535T drivers can be applied to three-level converters based on 1.2kV to 3.3kV IGBT modules. Even 1.2kV and 1.7kV IGBT modules can be connected directly in series under certain application conditions.

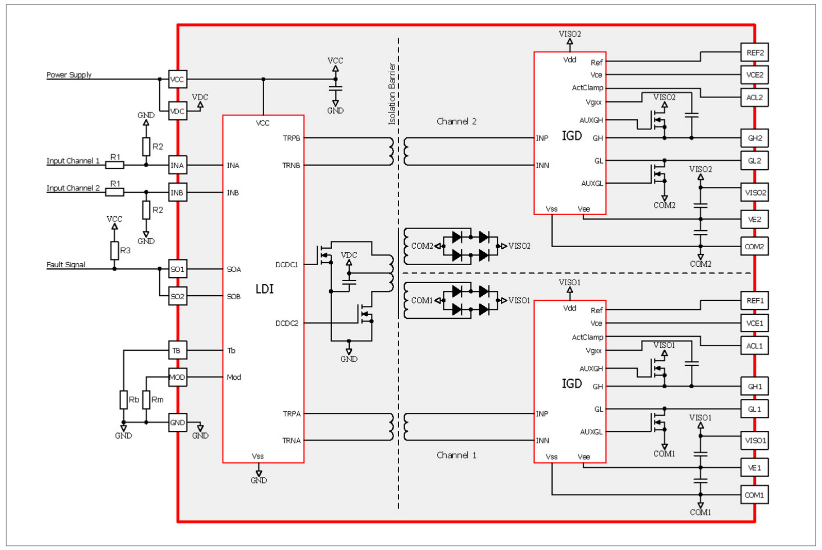

Figure 4: Block diagram of 2SC0535T with application circuitry of primary side

As already mentioned, the clearance and creepage distances were designed to fulfill the requirements of pollution degree 2 for 3.3kV IGBT modules. The design also complies with the requirements for pollution degree 3 for 1.7kV systems. CONCEPT will soon provide basic boards to further facilitate the application of 2SC0535T drivers: they are assembled with all the components required to drive IGBT modules safely except for gate resistors, which must be determined by the user to adapt the basic board to the given application.

Summary

The 3.3kV dual-channel IGBT driver core 2SC0535T based on the SCALE-2 technology from CONCEPT sets a new standard in driver performance in terms of features, reliability, flexibility, space requirements and costs of driving IGBT modules of the voltage class up to 3.3kV in two-level and multilevel topologies.

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POWERFUL SOFTWARE SIMULATION

Crucial for cleaner, greener engine design

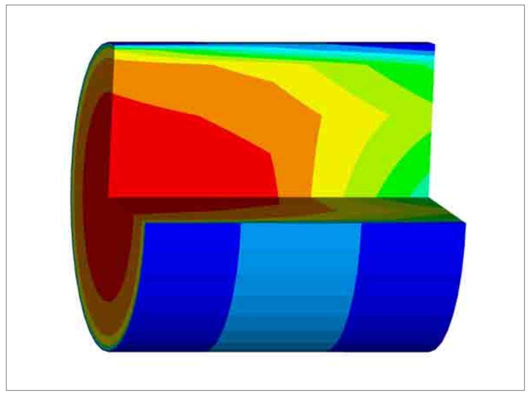
By Bob Tickel

Cummins uses simulation software from ANSYS to reduce weight, improve fuel economy and reduce environmentally harmful emissions of engines

The phrase "environmentally responsible" doesn't seem to fit into a sentence with the terms 18-wheel tractor trailer and heavy-duty truck. As a world-leading manufacturer of commercial engines and related systems, Cummins Inc., is working to change that perception one design at a time, developing next-generation technologies that are revolutionising the international trucking industry.

Using software from ANSYS, Cummins is developing and testing radical improvements in engine design, including the use of alternative materials and smaller engine footprints that reduce weight, improve fuel economy and reduce emissions — while also boosting performance. The work of the corporate research and technology organisation focuses on developing new, environmentally responsible technologies for the company's core engine business.

Cummins' recent product development efforts target a great deal of attention on fuel economy and emissions — and with good reason. Government environmental standards grow more challenging every year. Because commercial trucking is a low-margin business, every improvement that Cummins makes in fuel economy adds to its customers' successes. Beyond these practical considerations, Cummins invests in environmentally responsible engine technologies because it is the right thing to do. The company wants the trucking industry to be viewed as an environmental steward and champion, not one of the "bad guys."



Caption: Figure 1: By using software from ANSYS to predict maximum temperatures and temperature distribution within its new diesel particulate filter under diverse conditions, Cummins engineers can ensure that the manufactured component will have acceptable durability.

Building the Truck of the Future

In recognition of its environmental technology leadership, Cummins recently received nearly $54 million in funding from the U.S. Department of Energy (DOE) to support two projects aimed at improving fuel efficiency in both heavy- and light-duty vehicles.

About $39 million will fund Cummins' development of a new "supertruck" — a highly efficient and clean diesel fuelled Class 8 (heavy-duty) truck that is expected to set a new industry standard for green technology. Another $15 million in funding will support the development of advanced-technology powertrains for light-duty vehicles.

The resulting improvements in engine system efficiency will mean significantly lower fuel and petroleum consumption by these vehicles as well as a significant reduction in greenhouse gas emissions.

Though details of this work are proprietary, Cummins is using software from ANSYS to simulate engine performance and achieve the ambitious goals defined by the DOE: Improve Class 8 vehicle freight efficiency by 50 percent and achieve a 40 percent improvement in fuel economy in light-duty vehicles.

Cummins used ANSYS technology to enhance a number of features in its new ISX15 design, including the new Cummins after-treatment system that incorporates a revolutionary diesel particulate filter (DPF) targeted at meeting the new emissions standards.

The DPF removes diesel particulate matter or soot from the exhaust gas of a diesel engine. Cummins used ANSYS software to simulate typical operating loads and make predictions about the new DPF's performance and reliability. Engineering simulation predicted both peak temperatures and temperature distribution inside this component under a range of operating conditions. These thermal analyses were critical as they revealed the peak temperatures and temperature gradients within the filter, which ultimately determine the thermal fatigue and life of the component.

Subsequent field and bench tests confirmed the simulation predictions, as did actual road results. Engineers can rarely rely on virtual testing alone, but software from ANSYS confirmed that the Cummins design process was moving in the right direction — and that the results would be as team members expected.

Using Simulation to Rev Up Ongoing Engine Improvements

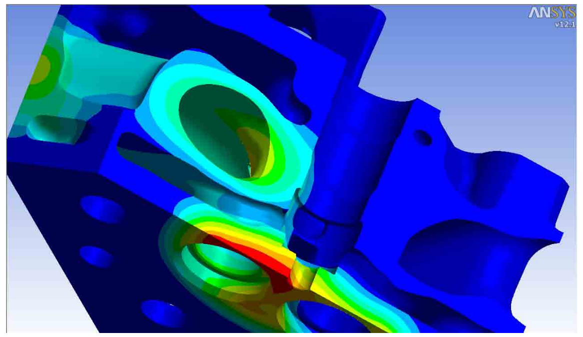
Environmental standards and customer needs are an ever-evolving target. So the Cummins team uses engineering simulation to improve engine features and boost performance. Design changes that reduce emissions and fuel consumption often result in higher temperatures and pressures within the engine, which require Cummins engineers to continually test the limits of conventional engine designs.

Most materials used in diesel engines exhibit reduced strength as temperature rises. The combination of high pressure/temperature and reduced strength places stress on components such as the cylinder head, a geometrically complex casting that serves many functions including transferring engine oil and coolant, in-taking air and exhausting gas. Cummins engineers use multiphysics software from ANSYS to combine thermal and structural analyses in their work on this sophisticated engine component.

Simulation tools from ANSYS enable the Cummins engineering team to evaluate the use of new materials across the entire topological surface of cylinder heads and other engine components. Working in a simulated environment gives these engineers the freedom to tweak existing engine designs — as well as to arrive at some "clean-sheet" designs that may have the power to revolutionise engine performance.

The team recently used software from ANSYS to predict temperature profiles in cylinder heads under various operating conditions. The thermal results were used to determine how this component would perform in the real world, as well as its threshold for both low-cycle and high-cycle fatigue.

Since cylinder heads are long-lead-time, expensive components, the Cummins team must be sure that a new design is right before moving forward. Using simulation tools from ANSYS, Cummins engineers can not only create



Caption: Figure 2: Cummins engineers can easily test the effectiveness of new materials, new designs and other innovations — and predict their long-term effect on overall engine performance. For example, Cummins engineers used software from ANSYS to simulate the impact of new materials on a cylinder head design.

more exacting test results but also pursue increased productivity by incorporating capabilities such as conjugate heat transfer modelling in their designs.

Without analysis-led design to introduce new materials and new part configurations, Cummins would have to rely instead on very expensive, time-consuming endurance tests to verify the engineering team's designs. ANSYS is a key enabler to Cummins, reducing the company's overall cost of development by minimising its investment in physical engine testing. This approach allows the design of a more environmentally friendly engine without compromising cost or performance.

Shifting Gears: ANSYS Creates a Cultural Change

With so many engine components and performance aspects to consider, the Cummins engineering team must perform a wide range of structural simulation and analysis. According to Bob Tickel, director of structural and dynamic analysis at Cummins, software from ANSYS is the only single-vendor tool with the technical breadth and depth to meet this challenge.

Recently, the Cummins corporate research and technology team began the switch from the traditional interface for ANSYS software to the ANSYS Workbench platform, a decision based primarily on the product's improved geometry import, cleanup and meshing capabilities. Tickel anticipates a 50 percent reduction in throughput time based upon the move to ANSYS Workbench.

"The ANSYS Workbench environment provides access to the best multiphysics tools we need to conduct many types of simulation and analysis," said Tickel. "Whether our need is thermal, structural, dynamic or static engineering analysis, ANSYS Workbench provides the flexibility and versatility to accommodate our needs — as well as the multiphysics capabilities to link the results of our various simulations."

Tickel noted that the efficiency and cost effectiveness of engineering simulation has resulted in a complete cultural change at Cummins. "The ease of using simulation tools from ANSYS has helped to transform our organization from a test-centric culture to an analysis-centric one," said Tickel.

"When investigating a new material or other design enhancement, traditionally we would build new parts and conduct physical tests as a first step — which represented a time- and cost-intensive approach," he said. "Today, we focus more attention on upfront analysis, only moving to part-building and testing for those design improvements that we can verify first using ANSYS tools. This new cultural approach has not only saved us time and money, but allowed us to selectively focus our attention on those design enhancements that are shown to hold the greatest promise for revolutionising future engine designs."

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COOLING THE CIRCUITS

Analysis of power supply single speed air-mover & entire enclosure system fan

By Dave Mellor

The need for forced-air cooling should be assessed at an early stage in system electronics enclosure design. The full range of implications needs to be considered in detail for a successful outcome.

Typical densely packaged electronic systems and power supplies use a fan for forced-air cooling. Power supply cooling technology often employs computer electronic thermal management techniques including the following:

- Thermal vias
- MOSFET surface mount packaging
- Power transfer by bonding exposed leads to a thermal plan on printed circuit boards
- Metalized substrates
- Isolation materials
- Laminar bus bars
- Direct bond copper
- Isolated metal substrates
- Glass on epoxy
- Thick film on ceramic
- Copper on ceramic

The need for forced-air cooling should be assessed at an early stage in system electronics enclosure design. It is important that the systems designer have electrical, mechanical, magnetic, thermal, acoustic and chemical knowledge to design good airflow to heat-generating components. Critically, the design must allow adequate space and power for cooling components. The first stage in designing a forced-air cooling system is to estimate the required airflow. The primary variable depends on the heat generated within the enclosure and the maximum temperature rise permitted. AC input power is a good initial estimate of the power dissipated within the enclosure. In estimating the power dissipated within a system, the power dissipation figure used should be a worst-case estimate for a fully loaded system.

Airflow calculations using heat dissipation and temperature rise for system impedance characteristics

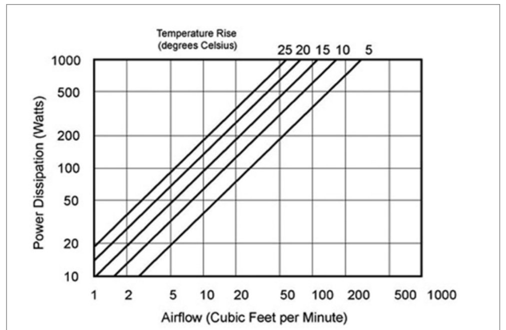
The required airflow is obtained either by calculation or from a standard graph. The equation for calculating the required airflow through an electronics enclosure is as follows:

$Q = 1.76\ W / Tc$

Where:
Q = Airflow required in CFM
W = Heat dissipated in Watts
Tc = Temperature rise above inlet temp °C

For example, what airflow does a system need that dissipates or consumes 300 Watts, allowing only a 10 degree C rise? The above equation results in 52.8 CFM.

This equation can be graphed on



Power Dissipation vs. Airflow for Various Temperature Increases

Figure 1

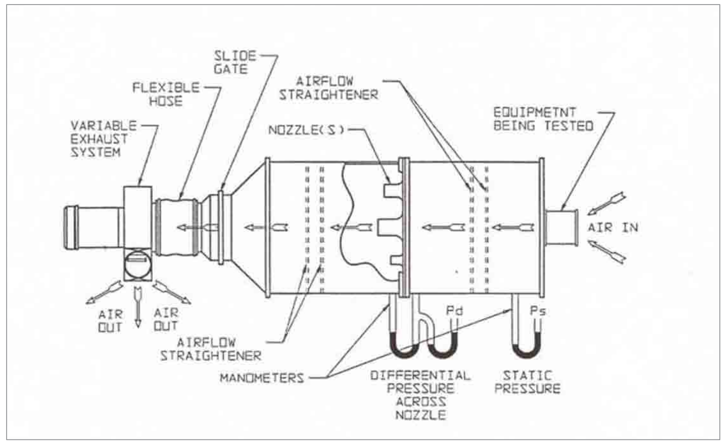
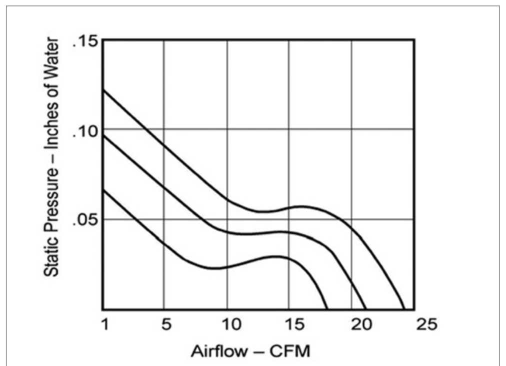


Figure 3



Typical Relationship between Airflow and Static Pressure for an Axial Cooling Fan

Figure 2

the following logarithmic chart (Figure 1) with the vertical axis representing the heat to be removed and the horizontal axis representing the airflow; both axes are logarithmic. The sloping lines define the temperature rise in degrees C.

System impedance

Because obstructions in the airflow path cause static pressure within the enclosure, determining the actual airflow needed by a fan mounted in an enclosure is more complex. Figure 2 shows the nonlinear relationship between airflow and static pressure for a typical fan. Obstructions should be minimized to achieve maximum airflow. Air guiding devices, in the form of baffles, may be necessary to direct the airflow over the components that need cooling.

Static pressure for an axial cooling fan

The experimental method of finding airflow through an enclosure is in accurate and time-consuming. An airflow chamber is required, as shown in Figure 3, and care must be taken to simulate accurately the electronics enclosure being tested.

The following rules-of-thumb can be used to estimate airflow resistance:

- An empty enclosure usually reduces airflow by 5 to 20%
- A densely packed enclosure reduces airflow by 60% or more
- Most large tower computer electronic enclosures have a static pressure of between 0.05 and 0.15 inches, H2O.

Assuming a dense package, the fan in the previous example should be capable of delivering 80 CFM in free air, instead of 52.8 CFM. Designers need to be aware that fan manufacturers use the most optimistic figures to represent their products.

Intake, exhaust, and baffles

System designers have the option of mounting an air-cooling device to exhaust warm air from the enclosure or to blow cool air into the enclosure.

Theoretically, the same volume of air is used to dissipate heat. However, depending on the application, each arrangement has advantages and disadvantages.

Incoming air flows in a laminar fashion to allow for a uniformly distributed airflow in the enclosure. This is important in eliminating stagnant air and possible hot spots.

Air exhausted out of an enclosure is turbulent. Heat dissipation in a turbulent airflow could be double that of a laminar flow with the same volumetric flow rate. Turbulent airflow is desirable.

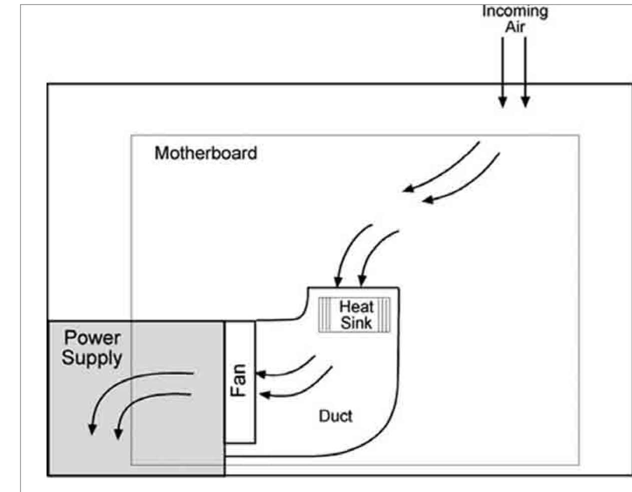
The turbulent airflow near a fan exhaust is limited to a very short distance, depending on the size of the fan. This is why it is desirable to have a heat sink, or the components that need most cooling, immediately at the fan output. Developing a well-defined airflow path through the entire enclosure is extremely important. The air-vent area should be 50 percent larger than the fan opening. This is why most system exhaust fans are placed at the output of a computer or power supply enclosure.

Recirculation is desirable for very large computer server systems. However, in most small electronic enclosures, air recirculation should be avoided. With small form factor fans, all of the airflow can be lost because of recirculation problems.

Baffles, shrouds, or ducting systems are often necessary to eliminate recirculation of the same air and to direct air onto, or away from, hot spots. Airflow will always take the path of least resistance. Physical subassemblies and components within the enclosure, such as large capacitors and circuit boards, can be intelligently positioned to direct the airflow to places that require cooling. Natural convection cooling should take precedence in electronic enclosure designs. Therefore, a systems designer should place warm components above cool components.

Fans used to exhaust heat from electronics enclosures reduce the pressure within the enclosure and dust is drawn in through all the vents and openings. Dust accumulation can produce many problems. Because exhaust fans tend to operate under hotter conditions, exhaust fans can have only half the life of an intake fan.

In general, it is best to use a single fan that ventilates an entire enclosure, including the power supply, as shown in Figure 4.



Top View of Computer Chassis

Figure 4

Notice that this system recommendation uses a baffle ducting system, which evacuates hot air from the electronics enclosure while pushing air through the power supply. This is the most economical approach.

A variable speed fan is recommended in order to reduce noise and optimise energy efficiency. However, most power supply fans simply run at a fixed speed. Applying additional airflow through the power supply will not adversely affect it. With a variable speed fan, the fan circuit automatically controls the speed. For example, JMC has recently patented a software controlled SMBus/I2C, OS or BIOS-configurable intelligent fan known as the 'Intellifan'. The Intellifan is independent of analogue circuitry and imprecise thermistors. As the temperature changes the fan speed is adjusted precisely, ensuring optimum airflow at all times.

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KEEPING IT SIMPLE

Powering the new smart grid

By Ulla Pettersson

Smart grid strategies have still to be finalized as countries strive to lower their greenhouse gas emissions, increase energy efficiency and ensure security of supply. A growing number of initiatives are underway, ranging from the small and simple to implement, to the large and highly complex.

What's become clear is that smart grids are challenging to deliver, raising multiple issues around the role that market participants should play, how best to meet consumer needs, and what the optimum technologies, standards, and schemes should be.

There are two essential elements to any smart grid design: a smart meter that can measure electricity consumption by the hour at each point of delivery; and tools for the consumer to control their consumption, based on factors such as the current tariff being applied based on time of day, the loading on the energy grid, and environmental concerns – i.e. whether the energy is derived from a renewable source.

How this will be implemented in Europe will depend largely on the process of deregulation in the electricity sector, and in respect of the separation of transmission and distribution from the generation and sale of electricity. It is essential that the industry focus on flexible and well structured concepts not too complex to implement and that maintain the structural separation in liberalised markets.

A complex but pressing challenge
The Smart Energy Demand Coalition estimates that the EU could see savings of €52 billion annually by reducing losses in the electricity distribution network via automation, and by encouraging consumers to cut or alter their energy consumption.

However, there are still numerous challenges to overcome. Meters for interval measurement have already been installed for commercial and industrial users in most EU Member States, but smart meter penetration in private households is fairly low. Deployments are often based on proprietary technologies and, at up to €250 per installation, cost remains a major hurdle.

Changes in the energy mix are making commercial realisation of smart grids more pressing. The adoption of renewables to meet environmental targets makes balancing supply and demand difficult for utilities, because renewable energy sources provide intermittent power generation. At the same time, demand side management requires tools enabling consumers to better monitor and manage their energy consumption. The provision of tariff information based on time for example, will support 'peak shaving' schemes, whereby the consumer is able to purchase power from the utility when tariffs are low, while giving them the ability to turn-off appliances. Some of the more optimistic smart grid proponents also believe consumers will be able to generate their own power when tariffs are high.

Yet early efforts by utilities to gain customer acceptance of smart meters have met with limited success. A recent study by Ovum warns that unless utilities do a better job of educating consumers about the long-term benefits of smart meters, it's likely they will fall back on old power consumption habits and entire grid projects could ultimately fail. Another problem will be solving the question of who pays for the rollout of smart meters, with the solution varying according to whether it is a liberalised or regulated market.

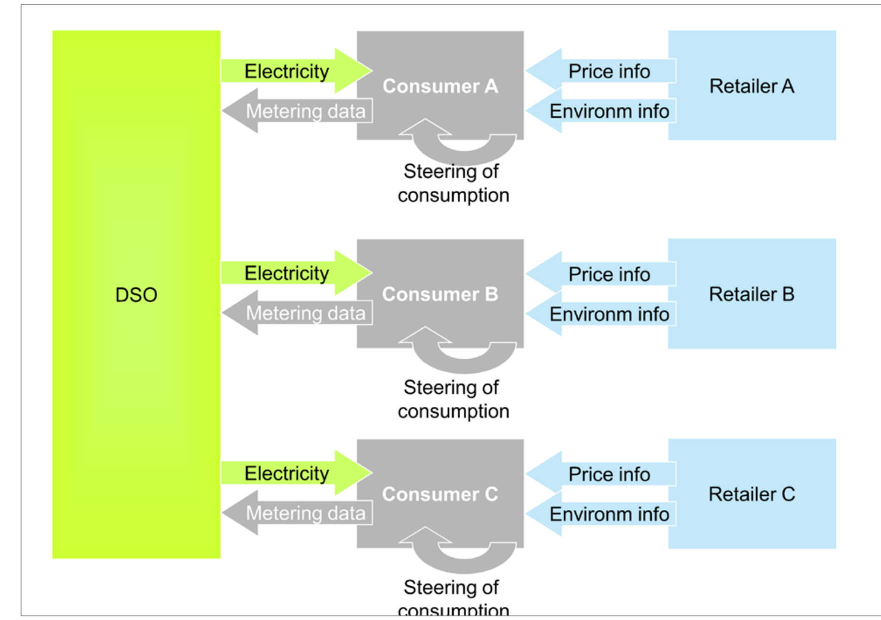

Figure 1: Method of implementing the smart grid which does support deregulation

Smart grids and market liberalisation
One of the fundamentals of the deregulation of electricity markets in Europe and worldwide has been the separation of transmission and distribution from generation and sales of electricity. This is a cornerstone for the development of a competitive market which, in respect of accepted commercial models, should be to the benefit of consumers in terms of lower prices. Having originated in the UK in 1990 with the privatisation of the electricity supply industry in England and Wales, and in Scandinavia in the mid-1990s with the development of a competitive market for power generation, full deregulation is now sweeping across Europe from north to south. However, the EU target for full deregulation by 2007 has been missed, and about 50 per cent of the markets are still making the transition to full competition.

Market structure impacts the strategies for smart meter deployment, and approaches in European markets therefore differ significantly. Ideally, the Distribution System Operator (DSO) should be responsible for the implementation of a smart meter that will measure the electricity consumption by the hour (fig 1); with energy retailers then able to supply not only electricity and electricity saving advice, but also the tools for managing consumption according to price and/or environmental concerns within the concept of a free and competitive market.

Certainly, there are no technical reasons to combine metering and the controlling of energy consumption. The data input to the controlling unit can be distributed via the internet or by wireless networking technologies such as GSM and, in a competitive electricity market it would most likely be easier for the retail supplier of electricity to submit one price tag to the consumer than for a DSO to submit many price tags from multiple retailers (fig 2). In addition, when a consumer changes supplier, it would be up to the new supplier to change the home energy management tool, whilst the DSO would have no need to be involved in the process.

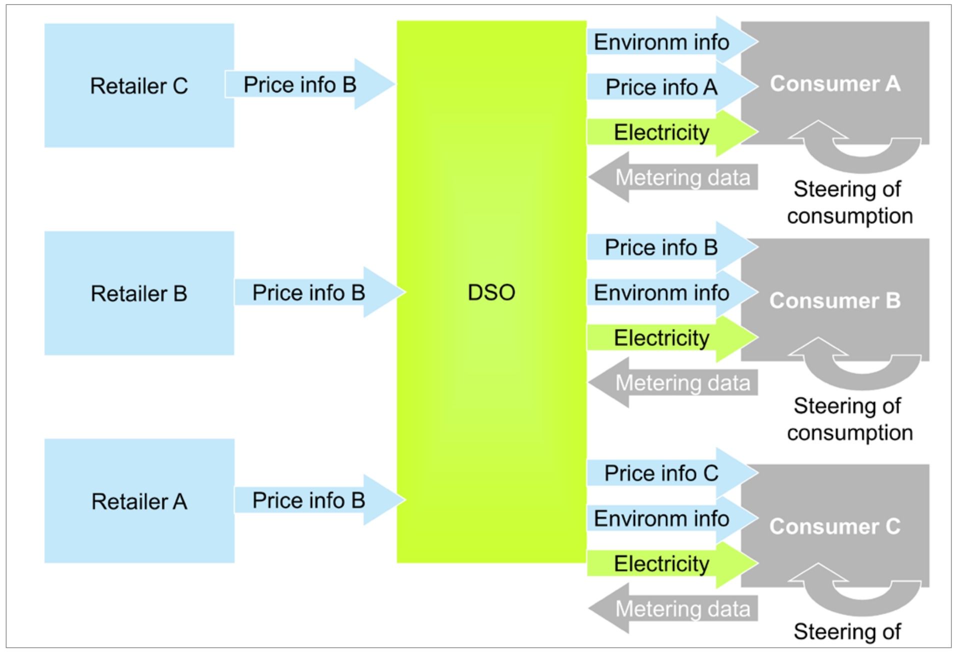

Figure 2: Smart grid solution which doesn't support the idea of deregulation

Promoting consumer choice

When designing smart grid concepts, it is essential to define the role and tasks of the DSO in a way that will release the creativity and competitive forces of a free and open market. A well-designed home energy management tool might be considered as a key differentiator for one electricity supplier, and could just as easily be introduced by a competitive player – provided it is linked to the supplier's price tag for electricity. A basic home energy management tool can be as simple as an SMS message, whereby the consumer receives an SMS when the tariff passes above a certain level, thus enabling them to make an informed decision as to whether they wish to turn off their appliance(s). It can also be extremely sophisticated, with automatic control and regulation of electricity-intensive equipment such as air conditioning, outdoor heating, washing machines and tumble dryers.

The most important consideration for any smart grid strategy is that in the same way as a consumer should have the freedom to choose their vendor of electricity based on the most competitive price, they should also have the freedom to choose the best supplier of automation services for their electricity consumption. A smart meter supplied by the grid company that is a monopoly would not afford the consumer this choice. And a consumer able to request a home energy management tool based on their personal preferences is much more likely to use it effectively.

Essentially, the change in the energy mix requires smart metering that gives consumers right tools to move their consumption of electricity according to their requirements, preferences, and in response to periods of high or low supply. Utilities will need the means to measure consumption every hour at the point of delivery, and the capability to transmit tariff information to the consumer, by the hour, if they are to successfully influence consumer behaviour. Crucially, metering must be the responsibility of the DSO, not the retailer, if smart grids are to be implemented without compromising the important separation of transmission and distribution from generation and sales of electricity.

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Special Report: RENEWABLE ENERGY

PSD EUROPE

Power Systems Design: Empowering Global Innovation

Inside:

RENEWABLE ENERGY

The challenge of managing the risk

By Jerry Douglas and Eldred Clark

Recognising, defining and dealing with renewable energy risks have never been more of a priority. Projects tend to be complex, innovative and often pioneering, which is why it pays to have insurance in place.

The EU's binding target to source 20% of the Continent's energy needs from renewables by 2020 has played a major role in elevating the importance of renewable energy development. National Action Plans (NAPs) based on these targets were defined across electricity, heating and cooling, as well as transport.

The remaining time for governments to comply with these target requirements is now relatively short. Producers, entrepreneurs, financiers and operators across the entire renewable energy sector therefore need to ensure they can deliver projects successfully.

The pivotal role of insurance

Risk identification, management and transfer are crucial components for project success in the increasingly target€driven renewable energy landscape. However, all too often these essential elements are not considered early enough in the project. Indeed, failure to appropriately manage, control and transfer risk is one of the factors most likely to jeopardise a renewable energy business whether at the financing, construction, handover or operational stage. Working through potential risks with expert partners, right from the outset, will make a major difference to the smooth running and outcome of a project.

Yet finding appropriate and quality insurance coverage is not always easy for project owners and operators because experienced underwriters may not be sufficiently satisfied with the risk profile of the operation. Many entrepreneurs and operators have yet to realise the full extent of the complexity of the risk factors actually faced, or the assurances that professional insurers will seek in order to provide cover at viable rates. Prototype technologies may be involved, which are notoriously difficult to assess and insure. In addition, across all new renewable technologies, industry standards and best practices relating to construction, operation, safety and risk, have yet to evolve and be formalised. This makes risk benchmarking difficult. Project owners frequently leave it late to engage in dialogue with insurers, meaning they are missing out on valuable input that could well make or break a project later on and, ultimately impact on the future success of their business.

Expertise, strength and service

Insurance buyers in this forward€ looking industry need assurances that a potential insurer has both sector expertise and balance sheet strength. The importance of informed and disciplined underwriting and claims management cannot be over emphasised, especially in recessionary times.

The purpose of insurance is to deliver financial compensation in the event of the sudden, accidental or unforeseen. In addition, leading insurance companies and the reinsurers that back them are averse to speculative risk, and not willing to engage in unrealistic underwriting that would damage their own bottom line or ability to honour future claims.

Assessing true exposure is therefore a key component to securely underwriting new or innovative projects in renewable energy – both at the construction and the operational stage.

Renewable and alternate energy

Renewable energy technologies are now increasingly being exploited – include wind, solar and photovoltaic, hydroelectric, geothermal, and biomass products (wood, waste), all of which pose different environmental and technological challenges.

New energy technologies also present often unique challenges from an insurance perspective. Operations can range from relatively modest and straightforward petrochemical, bioethanol or biodiesel plants, to massive, high-investment-value facilities converting waste-to-energy. Whether at the planning, building or operating stage, renewable energy projects must frequently deliver for a highly diverse group of stakeholders: financiers, governments, the EU, planning authorities, and the tax payer to name but a few.

Furthermore, 'green' power, like any other traditional energy industry, has the potential to turn 'black' overnight as a result of environmental pollution or disasters, the negative attention of environmental pressure or NIMBYism (Not In My Back Yard). The stakes for corporate reputation in this sector can therefore be extremely high.

Some renewable energy technologies have been operating for a number of years and have already experienced insurance loss scenarios. This provides operators and insurers with actuarial statistics and useful learning about foreseeable and previously less known vulnerabilities. Although people tend to think of these technologies as 'new', in actual fact many of them are not. However, the industrial scale on which they are now being constructed and operated, as well as their application in novel ways or new environments, is at the root of the many new risk issues now emerging.

Wind

For the general public, on- and off€shore wind turbines are one of the most well known and readily identifiable sources of renewable energy production. The longstanding simplicity of the windmill concept belies the complexity of what can go wrong with today's multi-megawatt producing turbines.

Most risk assessments will focus on the major mechanics and standard elements of the wind production process (e.g. gearbox failure, cable damage, nacelle or transformers), but operators ignore at their peril the potential risk to their business of damage to less obvious areas (e.g. foundations, landslip, cable damage) or the risks the weather can pose to such prominent structures (e.g. lightening, ice).

Any of these factors can halt production, and the time to repair, re-source or replace damaged components, which will often be huge and bespoke can have a devastating impact on the ability to maintain output.

Solar

There are many solar technolo-

gies in use today, including concentrating solar thermal power (CSP), solar power tower, parabolic trough, and Fresnel lens, all of which present risk issues for businesses.

For example, environmental factors can affect surrounding and supporting structures, just as much as the damage that can be done to the actual technology. The risks particular to solar technologies include the high combustibility of Organic Rankine Cycle (ORC) / Heat Transfer Fluid (HTF), the vulnerability of salt bath heat stores, and problems of reflector alignment.

Biofuels

Production of biodiesel involves the use of flammable alcohols (methanol or ethanol), while the end product is also combustible. Although production plants tend to be small, the cost of systems to mitigate the significant risk of fire, are often perceived to be disproportionate to the plant costs, something which can pose a problem to the operator and insurer alike.

Hydro

Though long established as a method of power generation (i.e. dams and turbines), hydro energy has recently been undergoing interesting developments, especially in new areas such as tidal and wave. The sometimes novel designs and extreme locations mean that very often, there can be problems with access, which results in new and challenging risk concerns alongside the more traditional areas of machinery breakdown involving often large and bespoke components. Insurers will therefore need assurances of the planning required to manage these additional challenges.

Technology integrity and verification

Because of the diversity of renewable energy projects and operations, and the fact that many are new and often still evolving, insurers will want to assess plans and operations comprehensively. They will look for the integrity of a technology, and management expertise – whether innovative or established. For example, can the technology be verified in relation to existing technologies? And if it is prototypical, they will look for points of comparison with existing and proven technologies, and then attempt to assess how far it differs. They will also want to focus on all environmental and structural aspects common to traditional industrial or power generation plants before providing cover.

The following provides an overview of some of the risk factors an owner or operator needs to be aware of, plan for and document in order to provide the appropriate answers required by a prospective insurer:

- **Standards and Guidelines** – Few official standards or best practices exist for many renewable processes. However, insurers will look for compliance with those that do.
- **Status of warranties and Liquidated Damages** – Insurance policies will change when warranties expire, meaning the plant will become more expensive to insure. Limitations on warranties can also give a false sense of security. A warranty will cover breakdown in machinery, but it will not cover other losses in production (e.g. business interruption, consequential loss), the sum of which can amount to more than the value of the broken part itself. Thus it is important to arrange additional cover for all such eventualities.
- **Protection of Assets** – From the very outset of a project, insurers will require evidence that full risk management vigilance has been undertaken to protect assets against insurable perils.
- **Power Grid/Reticulation and Grid Connections** – Focus on the core activity of a renewable energy production plant must not neglect the protection of all supporting structures and technologies. Cabling in particular, requires its own protection strategy because damage to it will jeopardise normal operations and output. In the case of one transformer fed by many wind turbines for example, the impact of its failure can be totally devastating.
- **Contingency Planning** – Well run businesses of all kinds need a contingency or crisis plan to be able to respond effectively to any unforeseen events that might halt operations.
- **Maintainability** – Insurers will want to see regular monitoring and inspection of facilities, and that servicing reports and repair documentation is thorough and up to date.
- **Natural Elements** – Renewable energy production facilities can be particularly vulnerable to extremes of weather (wind speed, snow/ice, flood etc.), and those that use the weather to operate are especially at risk. Understanding exactly how your plant could be affected by extreme weather conditions will enable better construction of the plant from the outset.
- **Claims, communication and partnership** – Owners and operators of renewable and alternate energy projects need to seek assurance that all potential threats have been considered and planned for (e.g. comprehensive transport, construction, liabilities to people, staff and the environment, fire, business interruption etc.) because any one aspect can potentially jeopardise a whole operation.

With the right partner and expertise in place, it is possible to obtain comprehensive risk management and seamless risk transfer, which can be highly effective in supporting the successful rollout and handover to the operational phase of a project, or for supporting long term production continuity.

Complex businesses, especially those that break new ground, operate best when there is transparent and frequent communication between insurers, their engineers, and intermediaries such as brokers and client organisations. The earlier insurers become a true ‘partner’ in a renewable energy project, the more value they will be able to deliver over the long term.

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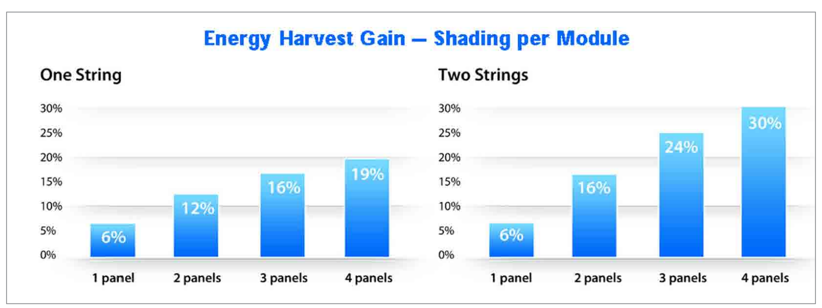
SOLAR POWER OPTIMIZATION

Designing for extreme reliability

By Rob Dixon

Solar industry insiders have declared this "The Year for Power Optimization." Distributed electronics like maximum power point tracking (MPPT) power optimizers and microinverters are growing in popularity because of their ability to increase the energy-generating capacity, or energy harvest, of solar arrays.

These electronics bring a brand-new intelligence to solar energy generation with power-optimizing electronics bringing a faster return on investment (ROI) for system owners by recovering and using power otherwise lost due to shading, mismatch effects or other obstructions.



For example, Azuray power optimizers harvest up to 99.2 percent of the available energy from mismatched modules, resulting in an overall increase in energy production. Typical energy increases range from five percent to more than 25 percent. With this increase in energy harvest, system owners draw less energy from the grid and enjoy a higher energy savings over the life of their photovoltaic (PV) array.

Companies who are committed to high quality, long life and extreme reliability offer their customers greater increases in energy harvest and higher confidence that ROI forecasts remain consistent over time.

With a growing variety of power optimization solutions on the market, understanding which key factors play critical roles in system performance and reliability is crucial. At Azuray Technologies, we emphasize the following key factors to ensure that extreme reliability is maintained throughout our AP line of power optimizers.

Temperature Range

According to the standard thermal acceleration of failure rate, the failure rate for a given component doubles for every 10-degree increase in temperature. Therefore, for every 10 degrees of operational rating in the same environment, the failure rate for a part at a specific temperature is cut in half. A +105°C rated part has four times the reliability of an +85°C rated part, at any given temperature. Likewise, a +125°C rated part has 16 times the reliability of a +85°C rated part.

Heating an electronic device above its temperature rating significantly stresses and, in some cases, overstresses the power optimization components. This risks the PV array's ability to increase energy harvest. Thus, a component's temperature rating can fundamentally affect the reliability of both the component itself and the entire product.

The common temperature range for companies offering power optimizers or microinverters is -40°C to +70°C. However, dark-colored roofs in the sweltering sun sometimes exceed that range and soar to temperatures of +85°C. Because these products are made of commercial/industrial-grade components rated at +85°C, they have at most a 15-degree margin between their manufacturer-specified rating and the thermal limits of the +85°C components. Despite that narrow margin, many manufacturers still use +85°C rated components in their power optimizers and microinverters.

Though these inferior parts may reduce the initial cost to system owners, they may also degrade system efficiency and performance. Ultimately this increases long-term costs, through replacement and repairs.

At Azuray Technologies, we believe the use of +85°C rated parts can diminish the extreme reliability of our power optimization products, so we exclude them from the mission-critical applications of our Azuray AP products. Instead, we use the most rugged and highest-capability components available. These are typically automotive/military-grade components designed for the high temperatures (+105°C and +125°C) and high stresses of the automotive, aerospace and military industries.

The AP300 provides Maximum Power Point Tracking (MPPT) optimization, within junction box housing, to increase solar energy harvest by up to 25 percent

Using the highest-capability parts provides lower stress ratios on components in Azuray products than those of its competitors. This directly improves lifetime product failure rates as well as product durability and safety in stressful conditions.

Component Derating

Component derating guidelines were developed in the 1960s by NASA and military suppliers as a way to enhance the reliability of systems by operating components below design specifications. Azuray agrees with industry experts that employing U.S. Department of Defense-based derating in circuit construction makes circuits more reliable and improves their performance. Derating guidelines are not industry requirements and are not typically implemented when +85C components are used in solar power applications.

Azuray is committed to following strict derating guidelines as provided by the Reliability Information Analysis Center (RIAC), a U.S. Department of Defense Technical Center. Azuray's product designs meet or exceed the level of component stress derating recommended for mission-critical and long-life military/aeronautical applications. In addition, we have identified other potential risks to a fault-free, 25-year life for our products and, in many cases, have added derating for specific components that result in more robust and durable products in our AP line.

AFR over MTBF

To ensure the extreme reliability of our AP product line, we uphold a company philosophy that Annualized Failure Rate (AFR) is a more informative indication of reliability than Mean Time Between Failure (MTBF). Other power optimization electronics manufacturers may publish their highest MTBF rate as a way to establish a perception of reliability. However, we find MTBF as a metric of reliability to be disingenuous and misleading because it is often portrayed as an indication of "how long it will last." In fact, MTBF is an expression of the constant failure rate and does not predict when a specific item will fail. By definition, there is a greater-than-50-percent probability that any given item will fail by the time the MTBF is reached, making it a poor predictor of useful life.

Azuray instead takes the predicted lifetime from a simulation (MTBF) and generates an AFR to estimate the reliability over the useful life of the product based on actual, measured field conditions (mission profiling).

Design Margin

Another critical aspect of the extreme reliability of the AP product line is Azuray's utmost attention to design margin. Margin is the degree to which a product is designed to handle stress above its operating environment. The higher the design margin, the more robust the product. Having superior design margin due to component selection and aggressive derating vastly reduces the risk of failure when temperatures rise above the product's +70°C rating.

Through Highly Accelerated Life Tests (HALT) and component selection, Azuray is able to show the AP product line has the capability to operate well beyond the stated range of operation. In fact, during the final HALT series, the AP300 evidenced a design margin so high it reached the thermal and vibration limits of the test chambers without failing. With test chambers reaching +120°C, this represents a significant design safety margin beyond the specified product operating limits.

High-quality components, high temperature limits, superior margins and strong reliability models are all key factors in designing solar power optimization products that exhibit extreme reliability over their lifespan. These essential considerations indicate if products have been designed with long-term reliability as a primary requirement or not. When they have, they can be trusted to last as long as the solar modules they serve.

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SHUNT CHARGER SYSTEMS

Harvest Power & Protect Battery Packs

By Steve Knoth

Energy harvesting ICs can convert an appropriate transducer's output into an electric current for a battery charger device. Recent technology developments have pushed energy harvesting to the point of commercial viability.

Many energy harvesting applications inherently have intermittent or low-power sources. And, so many implementations will want to charge a battery for a backup power source. Shunt voltage references are simple to use; they have been around for many years and are in a myriad of products. However, they cannot effectively charge a battery. To configure one to do such a task is extremely cumbersome. Moreover, the ability to accurately and safely charge a Lithium-Ion/Polymer, coin cell or a thin film battery from a low-current source or an intermittent harvested energy source has been difficult to attain safely.

Design Challenges for Low Power Consumption Chargers

Typical battery charger ICs require a constant DC input voltage and cannot handle bursts of energy. However, intermittent energy harvesting sources such as indoor photovoltaic arrays or piezoelectric transducers provide bursts of power. A unique IC with sub-1uA quiescent operating current is necessary to charge a battery from this type of energy source.

Lithium-Ion/Polymer chemistry batteries provide the high performance features necessary for portable electronic devices but must be treated with care. They can become unstable if charged over 100mV beyond their recommended float voltage.

Shunt Architecture Basics & Benefits

A shunt reference is a current-fed, two terminal device that draws no current until the target voltage is reached and is used like a Zener diode and is often shown on a circuit schematic as a Zener diode. However, most shunt references are actually based on a bandgap reference voltage. This requires only a single external resistor to regulate its output voltage making it extremely easy to use. There is no maximum input voltage limit, and the minimum input voltage is set by the value of the reference voltage because some headroom is required for proper operation. Further, shunt references have good stability over a wide range of currents. Many shunts are also stable with large or small capacitive loads.

A Simple Solution

Any solution to satisfy the battery charger IC design constraints would have to combine a shunt regulator's characteristics and those of a battery charging IC with the ability to charge from low power continuous or intermittent sources. Such a device would also need to protect and extract the maximum performance from a Lithium-ion/Polymer battery, coin cell, or thin film battery or battery pack.

Linear Technology developed the industry's first shunt-architecture battery chargers, the LTC4070

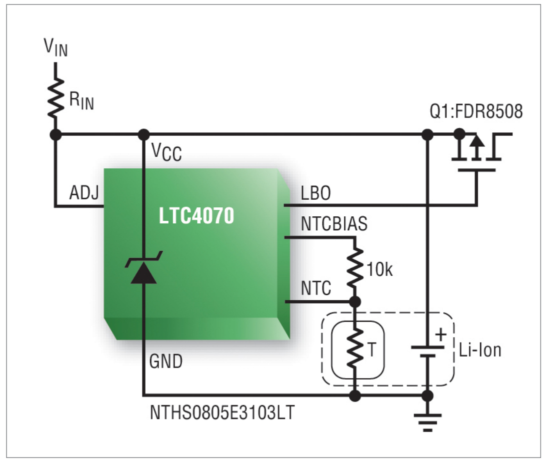

Figure 1: LTC4070 Typical Application Circuit

and the LTC4071 to address these applications. With its 450nA operating current, the IC protects batteries and charges them from previously unusable very low current, intermittent or continuous charging sources. The LTC4070's charge current may be boosted from 50mA up to 500mA with the addition of an external PMOS shunt device. An internal thermal battery conditioner reduces the float voltage to protect Li-Ion/Polymer cells at elevated battery temperatures. Multiple-cell battery stacks can be charged and balanced by configuring several LTC4070s in series. Housed in a low profile (0.75mm) 8-lead 2mm x 3mm DFN package, or in an 8-lead MSOP package, the devices are rated for operation from -40°C to 125°C.

With pin-selectable settings of 4.0V, 4.1V, and 4.2V, the LTC4070's 1% accurate battery float voltage allows the user to make tradeoffs between battery energy density and lifetime. Independent low battery and high battery supervisory status outputs indicate a discharged or fully charged battery. In conjunction with an external P-FET in series with the load, the low battery status output enables a latch-off function that automatically disconnects the system load from the battery to protect the battery from deep discharge.

The LTC4070 provides a simple, reliable, and high performance battery protection and charging solution by preventing the battery voltage from exceeding a programmed level. Its shunt architecture requires just one resistor between the input supply and the battery to handle a wide range of battery applications. When the input supply is removed and the battery voltage is below the high battery output threshold, the LTC4070 consumes just 450nA from the battery.

While the battery voltage is below the programmed float voltage, the charge rate is determined by the input voltage, the battery voltage, and the input resistor:

ICHG = (VIN – VBAT) / RIN

As the battery voltage approaches the float voltage, the LTC4070 shunts current away from the battery thereby reducing the charge current. The LTC4070 can shunt up to 50mA with a float voltage accuracy of ±1% over temperature. The shunt current limits the maximum charge current, but the 50mA internal capability can be increased by adding an external P-channel MOSFET (Figure 1).

Internally, the LTC4070 features a P-channel MOSFET being driven by amplifier EA (Figure 2). Zero current will flow in that device until the voltage between VCC and GND reaches VF (i.e. the shunt voltage). VF can be modified by ADJ and NTC, but it is always between 3.8V and 4.2V. If the VCC voltage is below this level, then the current in the PFET is zero. If the voltage across VCC attempts to rise above VF, then current will flow in that device in an attempt to prevent the voltage from rising – this is the shunt current.

The operating current is the current required to power all of the rest of the circuitry in the chip. If no external power supply is present, then this is the current that will be drawn from the battery.

When the battery voltage is low, more voltage is placed across the input resistor, so the current into the battery (i.e. charge current) is slightly bigger than when the battery is fully charged. When the battery is fully charged, no current goes into the battery, and all of the input current goes into the shunt.

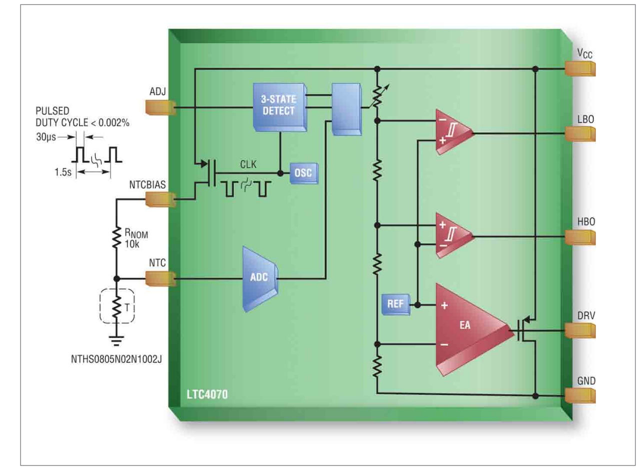

Figure 2: LTC4070 Block Diagram

Operating current is important because is sets a lower limit on the current capability of "practical" input sources. Obviously, an input source with just 100nA of drive capability would not be able to charge a battery with LTC4070. However, with 1uA of drive capability, there is a small amount of current left to charge. If 10uA of drive capability is available, then more than 90% of that current is available for charging.

Protecting Batteries

The LTC4070 measures battery temperature with a negative temperature coefficient thermistor thermally coupled to the battery. NTC thermistors have temperature characteristics which are specified in resistance-temperature conversion tables. Internal NTC circuitry protects the battery from excessive heat by reducing the float voltage for each 10°C rise in temperature above 40°C (Figure 3). A ratio of resistor values to measure battery temperature. The LTC4070 contains an internal fixed resistor voltage divider from NTCBIAS to GND with four tap points. The voltages at these tap points are periodically compared against the voltage at the NTC pin to measure battery temperature. To conserve power, the battery temperature is measured periodically by biasing the

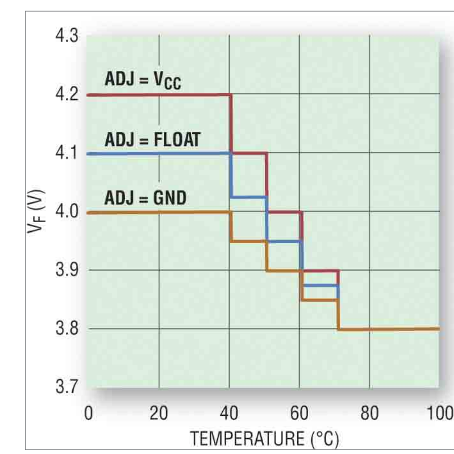

Figure 2: LTC4070 Block Diagram

NTCBIAS pin to VCC about once every 1.5 seconds.

Other Key Features

The LTC4070 has a built-in 3-state decoder connected to the ADJ pin to provide three programmable float voltages: 4.0V, 4.1V, or 4.2V. The float voltage is programmed to 4.0V when ADJ is tied to GND, 4.1V when ADJ is floating, and 4.2V when ADJ is tied to VCC. The state of the ADJ pin is sampled about once every 1.5 seconds. When it is being sampled, the LTC4070 applies a relatively low impedance voltage at the ADJ pin. This technique prevents low level board leakage from corrupting the programmed float voltage. Eliminating resistors not only saves solution size but reduces quiescent current as high-valued resistors are not needed. The device also contains status outputs and signaling capability.

Battery Pack Protection

The LTC4071 is also a shunt battery charger system, and the first with integrated battery pack protection including low battery disconnect but with lower 50mA charge current capability, higher 550nA quiescent current and no LBO. The low battery disconnect is a critical function required to protect low capacity batteries from damage due to self-discharge. LTC4070 can perform a low battery disconnect function with the LBO and an external P-FET, the IC will continue to consume full IQ (about 0.5uA) from the battery. Even this battery drain current can damage a low capacity battery overnight. Conversely, the LTC4071 integrates a complete low battery disconnect which consumes nearly zero current from the battery when disconnected (<1nA at room temperature and <25nA at 125°C).

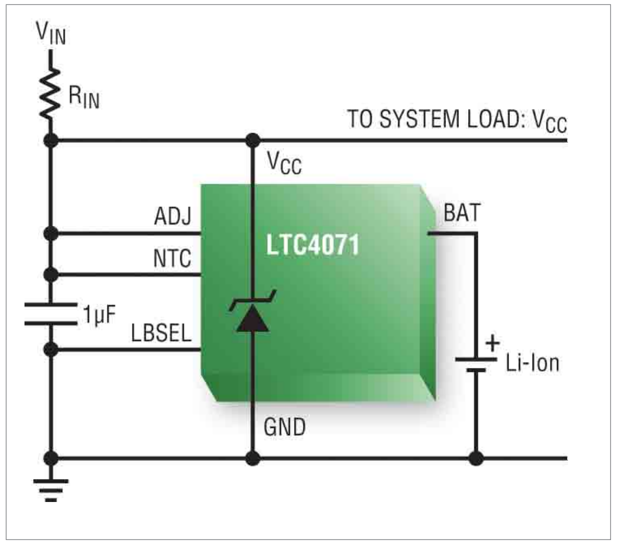

Figure 2: LTC4070 Block Diagram

To provide this function in the LTC4071, the LTC4070's LBO and DRV pin have been eliminated (Figure 4). This makes the LTC4071's maximum shunt current fixed at 50mA (LTC4070 is 50mA capable with 500mA possible with an external FET) and increases the IC's quiescent current to 550nA (LTC4070 has 450nA).

Conclusion

Low-power energy harvesting applications are now primed for conditioning by the right type of DC-DC converter or battery charger. Linear Technology developed the LTC4070 and LTC4071 shunt charger systems for Li-Ion/Polymer cells, coin cells, thin film batteries and battery packs, to provide a simple, effective battery charging and pack protection solution for cutting-edge applications with low-power sources.

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SOLAR IC SOLUTIONS

Maximize PV system efficiency and safety

By Leslie Bane

To succeed in today's competitive solar market, system designers and OEMs require a system solution which may include energy-efficient analog ICs, tools, evaluation boards, and reference designs.

As the photovoltaic (PV) market has evolved over the past thirty years, system solutions providers have continued to focus their efforts on increasing efficiency of modules, quality designs, and building arrays to withstand environmental affects for the life of the array. Because arrays are expected to function reliably and safely for over 20 years, this is a huge task for the industries providers to meet such stringent demands. In the past few years, several market enablers have emerged to help system installers, designers, and owners get the best return on investment (ROI). National Semiconductor is one of these enablers.

For over 50 years, National Semiconductor has been known for its analog expertise and reliable, energy-efficient power management products. The company continues to bring this knowledge, experience, and manufacturing capability to help customers create better PV system designs. National's energy-efficient SolarMagicTM Integrated Circuit (IC) products address the critical needs of the solar PV market by combining high-performance analog and power management solutions to enable more intelligent photovoltaic systems—simplifying complex technologies, increasing reliability and safety, while reducing cost and time to market.

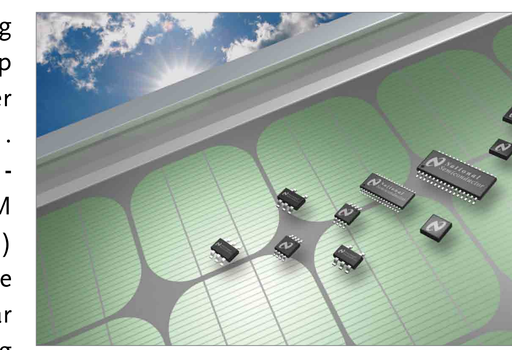

Figure 1: National Semiconductor's diverse analog IC product offering for PV

National has developed SolarMagic ICs for the entire PV chain from module-level electronics like DC/DC power optimizers, DC/AC microinverters, and Maximum Power Point Tracking (MPPT)-based battery charge controllers to smart combiner boxes and inverters with safety and communications solutions.

Solar PV Array Efficiency Challenges

Many mismatch factors can impact the amount of energy generated in a solar PV system. Some of these factors—shading from trees, building elements, different module tilt, orientation, and string lengths—can have an immediate and significant effect on power output. Other factors like module-to-module mismatch, module aging, and dust slowly reduce overall performance of the solar PV system over the life of the system. For example, 10% shading in the array can reduce the energy harvest of a system by as much as 50%. This significantly limits the energy output, design, and location of typical solar installations.

For years, installers designed around these mismatches or accepted the sub-optimal losses out of necessity. National's IC solutions for power optimizers and microinverters were developed to mitigate these losses.

DC/DC Power Optimizer Technology

Power optimizer technology came onto the scene in 2009 and has evolved in efficiency and form factor since then. In June 2010, National launched its SM3320 chipset to enable customers flexibility in design while bringing enhanced features such as 350W module power handling capabilities, best-in-class efficiency (99.5% peak), wide operating temperature range (-40°C to +90°C), and a tri-mode buck-boost architecture for highest system efficiency.

SolarMagic SM3320 chipset technology delivers higher PV system efficiency, lower cost per kilowatt-hour (kWh), flexible design, and lower balance of system costs. Residential and commercial rooftop installations can finally increase profit by maximizing roof utilization, recovering lost energy, and increasing energy harvest. SolarMagic technology is inverter

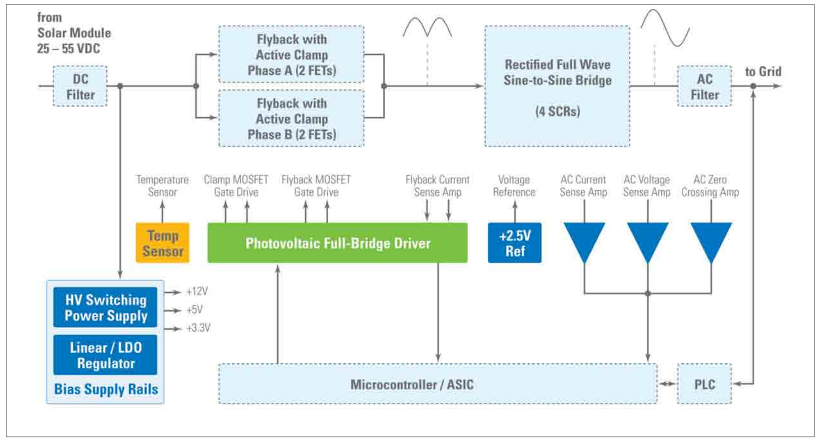

Figure 2: National's Microinverter Reference Design Block Diagram

agnostic and reduces or removes design constraints such as needing the same module layout, tilt, orientation, and string length across the array.

DC/AC Microinverter Technology

Microinverters provide DC-AC conversion at the module level and have a complementary architecture to power optimizers. They also provide some unique features such as elimination of high DC voltage levels (eliminating concerns of arcing) and complex string sizing (reducing time of installation), easily scalable array size, and reduced wiring costs. Leveraging its energy-efficient analog and power management expertise, National has expanded its SolarMagic IC product portfolio to include module-level microinverters.

Today's microinverter landscape is broken down into various architectures and offerings from the traditional topology using electrolytic capacitors with a rectified sinusoid and unfolding bridge to the advanced microinverter design offering with an intermediate high-voltage, high-efficiency DC bus using no electrolytic capacitors and ripple cancellation. Both the traditional and advanced microinverter design may include communications options like Power Line Communications (PLC) and wireless RF communications.

The SolarMagic SM72295 photovoltaic full-bridge driver is a good starting point for a microinverter design using interleaved flyback with active clamp circuitry for DC VIN of <100V. The SM72295 driver provides highly integrated functionality with four independent 3A gate drives, two current-sensing amplifiers and buffers, and built-in protection features like over-voltage and under-voltage control with a POWER GOOD indicator.

Off-Grid PV Solutions and Charge Controllers

Early PV systems were designed for small, off-grid applications, often used to charge batteries for future use in homes and buildings. However, over time systems increased in size and moved into grid-tied applications. National's MPPT digital controller and full-bridge driver ICs are designed to control highly efficient DC/DC converters commonly found in off-grid charge controller applications such as solar, automotive, marine, and street lighting applications. National's innovative charging controller products reduce system costs, improve reliability, and simplify design complexity to accelerate time to market.

The SolarMagic SM72242 enhanced MPPT controller and SM72295 full-bridge driver comprise a solid base from which to launch various PV battery-based charging designs. The charge controller reference design provides highly integrated functionality with a wide input voltage range for compatibility with most commercially available solar panels, current driving capabilities up to 100A, multi-chemistry battery support (e.g. lithium-ion, lead acid), advanced protection and battery management features, along with I2C (compliant) programming.

Safety and Arc Detection

The safety of firefighters working around energized solar panels has given rise to concern about PV system safety. As a result of this situation, in 2011 the U.S. National Electrical Code (NEC) was updated to include a new requirement (609.11) to specifically address

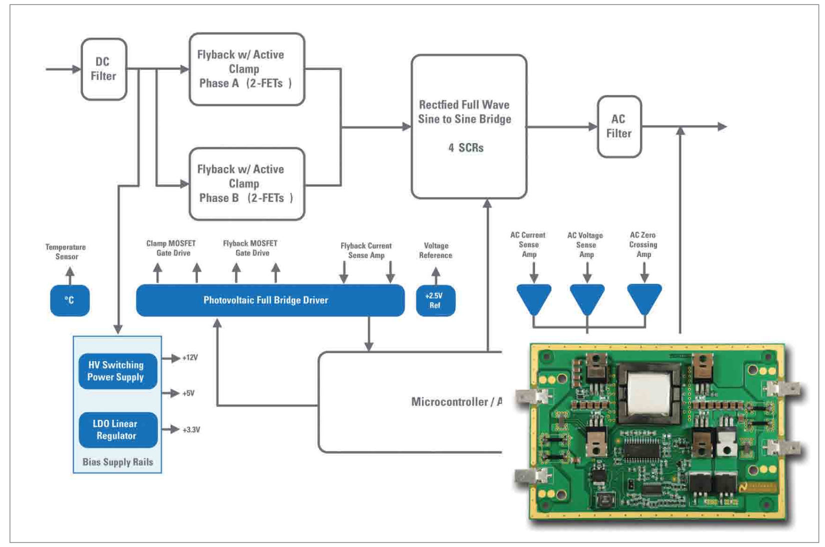

Figure 3: National's SolarMagic Evaluation Boards and Reference Designs

rooftop PV systems.

The SolarMagic SM4110 PV Safety System was designed to allow for a flexible design and scalability for any size of PV array. The system is comprised of three main components: 1) a central array shut-off and control unit (SM4110-CTX), 2) a string level transmitter (SM4110-STX), and 3) receiver units (SM3010-1A1) that go inside a junction box.

National has also developed its SolarMagic SM73201-ARC-EV reference design to specifically address the presence of an electric arc within a PV system with a unique signal processing approach (patent pending) that uses a state-of-the-art abstracted pattern recognition approach that does not require the arc signature to match a rigid pre-described absolute shape.

The arc solution operates in a temperature range of -40°C to +125°C, can detect arcs up to 100m, works with all commercially-available module technologies, and can detect all types of arcs (series, parallel, and ground). National's partners are leveraging the efficient design and small form factor of the SM73201-ARC-EV solution by integrating it within their smart combiner box or inverter.

Value of National's Solutions

Efficiency and safety along with quality and reliability are key to success in PV as the demands on products and systems continue to increase. National Semiconductor is one company in the market delivering energy-efficient products and designs while at the same time diversifying its portfolio to ensure its products fit the entire value chain within the PV industry.

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SOLAR HARVEST

Testing, characterization and evaluation of PV inverters

By Giacomo Mazzullo

In the utilization of solar panels, maximum power point tracking (MPPT) is the automatic adjustment of electrical load to achieve the greatest possible power harvest, during dynamic variations of light level, shading, temperature, and photovoltaic module characteristics.

Photovoltaic (PV) panels generate current / voltage with a highly variable behaviour due to the fluctuations in energy flow from the sun. The typical behaviour of the power generated by a panel for varying levels of sunlight is outlined in Figure 1. For each level of radiation, there is a point at which the panel gives the Maximum Power Point, or MPP.

MPPT technology

To take full advantage of the energy generated from the panel, or photovoltaic field, it is necessary that the control interface continually tracks the MPP. The electronic circuit that performs this function is known as the Maximum Power Point Tracker (MPPT).

The combination of using MPPT technology with modern photovoltaic inverters enables panel manufacturers to offer considerable performance improvements of the PV energy generation facility. Looking again to Figure 1, we see the working curve of a generic solar cell, and from that we can adapt the MPPT inverter systems to work with the entire PV array, to remain as close as possible to the MPP.

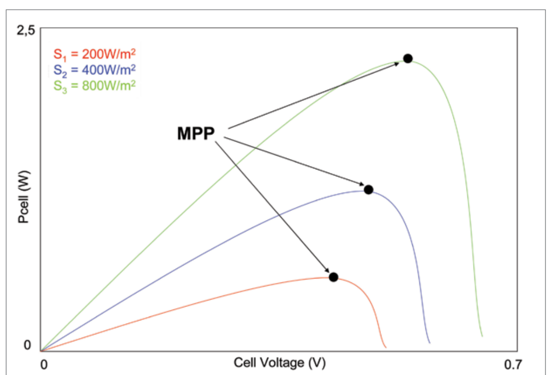

Figure 1: Power-Voltage Curve of a photovoltaic cell for differing light levels

There are two kinds of MPPT technology: analogue and digital. Both can be expressed as a transfer function (FDT) either an algorithm embedded within a microprocessor or a mathematical function that describes the operation of a complex system that consists of several components.

Simulation of a Photovoltaic field

To prove this technology and its ability to cope with the unexpected – such as rapid changes in solar intensity caused by a passing cloud – a series of tests can be carried out to simulate this by varying the voltage and current inputs to the MPPT inverter.

This is because the solar panel's electrical parameters are voltage and current, both of which are dependent on the light intensity hitting the photovoltaic cell; the worse the lighting level, the lower the output voltage and current.

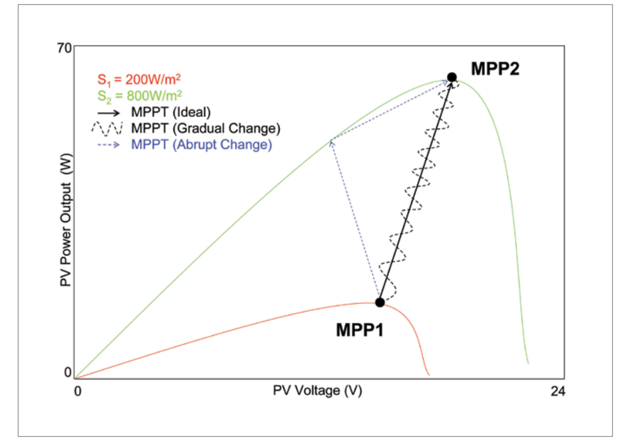

Figure 2: Tracking MPP in response to a gradual change in the intensity of solar radiation (black-dash trace) and in the case of an abrupt change where the inverter has lost control (blue-dash trace)

Simulating the actual behaviour of a photovoltaic field is very important; it enables the OEM to optimise the FDT MPPT inverter improving internal performance and efficiency. In Figure 2, the black line illustrates how close the MPPT technology tracks to the MPP, during a slow change in light intensity, while the red trace shows the loss of control when change in light intensity are too fast – under these circumstances, the use of MPPT technology is inappropriate.

An efficient choice

In order to simulate these events, programmable (laboratory) power supplies, such as the Genesys™ range from TDK-Lambda, are highly effective. With power ratings from 750W to 60kW and outputs of up to 600V, the Genesys™ series feature digital interfaces (RS232-485 and LAN interfaces.); these enable the simulation engineer to set the six pairs of VI parameters of the solar system to simulate the certain operating conditions of the photovoltaic field.

Using a sequence of several VI pairs allows the engineer to reconstruct a curve and the simulation parameters in order to see how the inverter operates. The digital interfaces of the Genesys™ power supply also enable the engineer to read the output voltage and current being absorbed, allowing the R&D team to create an automatic test report.

Figure 3: One of the many models of programmable power supplies in the Genesys™ series from TDK-Lambda

To simulate the extreme conditions – such as quick changes, drops and overshoots – FAST and PSINK options are available to the Genesys™ to respectively improve the response time to a few milliseconds and integrated active loading so that very complex simulation can be created.

How to measure the efficiency of a photovoltaic inverter

The efficiency of an inverter is the ratio between the AC and DC power consumption:

$\eta = PAC / PDC$

But in the case of inverters for photovoltaic applications, which must work with extremely variable power inputs and weather conditions that may differ from region to region, the below definition is closer to actual conditions. In the particular case of Europe, the efficiency of an inverter is defined as follows:

$\eta_{EURO} = 0.03 \cdot \eta_{5\%} + 0.06 \cdot \eta_{10\%} + 0.13 \cdot \eta_{20\%} + 0.1 \cdot \eta_{30\%} + 0.48 \cdot \eta_{50\%} + 0.2 \cdot \eta_{100\%}$

Where: $\eta_{xx\%}$ is the inverter's efficiency when the input power is xx% of maximum power handling capacity.

The result is an average efficiency that closely reflects the different conditions of radiation, and then input power, according to a weighted contribution regarded as representing the average distribution of sunshine levels recorded throughout Europe.

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WIND TURBINE MAKERS TURN TO POWER ELECTRONICS FOR ROBUST SOLUTIONS

By David G. Morrison

Solid-state lighting (SSL) or LED lighting promises energy savings, longer lamp life, and other potential benefits in general lighting applications. Spurred on by steady improvements in high-brightness LEDs, government mandates, and growing interest in green technologies, LED lighting is seeing increasing adoption in commercial applications, and to a lesser extent in residential applications.

A global wind power industry that has experienced rapid growth over the past decade predicts much more of the same in the years ahead. Power electronics engineers, who play a critical role in this industry in helping to develop wind turbines, can expect increasing demand for their skills as the turbine manufacturers gear up to meet the technical challenges of the wind power marketplace. As countries across the globe look to renewable energy to meet a growing share of their energy needs, the adoption of wind power is on the rise. As we began this past decade, the worldwide installed capacity for wind power was just approaching 20 GW, reaching that mark sometime in 2001 according to the Global Wind Energy council.1 In the ensuing years, the installation of wind power soared, driving the global capacity to 200 GW in 2010.2,3 And now there are predictions that installed capacity could grow another order of magnitude to 2300 GW by 2030, according to a study published last fall by the Global Wind Energy Council and Greenpeace International (Fig. 1.) This forecasted growth, which depends on the implementation of public policies favorable to renewable energy (a so-called "advanced scenario"), would equate to 22% of the world's electricity demands if predictions for energy consumption also hold.

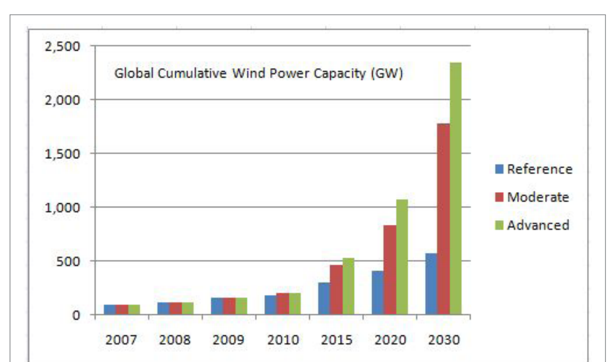

Fig 1. Forecast for growth in global cumulative wind power capacity. Source: 'Global Wind Energy Outlook 2010' published by Global Wind Energy Council and Greenpeace International.

Such statistics bode well for the manufacturers of wind turbines (and their suppliers) who will need to expand production to meet the expected demand for their products. Similarly, the continued growth of the industry means increasing opportunities for power electronics engineers. Moreover, the wind turbine industry is a global one that presents opportunities for engineers in many different countries, even within a single company, since the larger manufacturers often have multiple R&D centers in different regions.

The pie chart in Fig. 2 illustrates the global nature of the wind turbine business, depicting the breakdown of market share for the top 10 suppliers.[5] At present, several of the companies on this list have job postings for power electronics engineers and others with related experience.

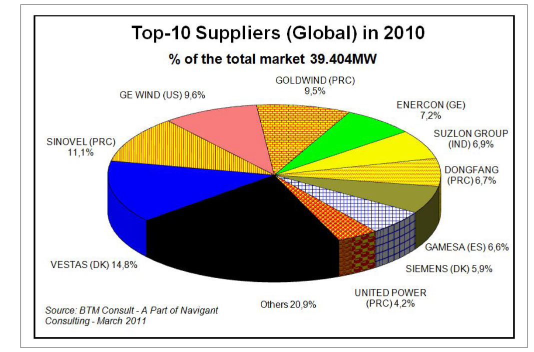

Fig 2. A breakdown of the wind turbine market by manufacturer with their percentages of the 39.4 GW of new global wind power capacity that was installed in 2010. Source: BTM Consult—A Part of Navigant Consulting.

Examples of these job openings are provided in the online version of this article (which also lists more details on the references cited in this article.) And as the "Others" slice of the pie chart suggests, there are many additional wind turbine companies that may now or in the future need power electronics engineers. Various wind power websites provide directories of these companies.

ower electronics engineers are among the many engineering specialists that are needed to advance the art of wind turbine technology. According to a Wind Turbines Industry & Trade Study published in 2009 by the U.S. International Trade Commission, wind turbine manufacturers face several fundamental technical challenges that they will need to address through R&D:

"As an emerging technology that is on the verge of price competitiveness with traditional sources of power, research and development (R&D) is critical to the wind turbine industry. OEMs are developing and testing (a) new multi-MW onshore wind turbines, (b) offshore wind turbine models, and (c) turbines that can operate in low wind or very cold climate conditions. Through their R&D programs, OEMs also seek to (1) optimize nacelle, blade, and component designs and materials, (2) improve the reliability of wind turbines, (3) improve turbine technology, and (4) tailor turbines for local markets."[7]

Most of these challenges will directly or indirectly affect the development of power electronics for wind turbines. These will not only be addressed by the turbine manufacturers who must invest in R&D, but also by publicly supported research and development. Fig. 3 shows recent levels of public spending on wind power research and how it compares with spending on other forms of renewable energy for member countries of the International Energy Agency.

While this chart provides only a snapshot in time of the monies being allotted for wind power research, it does indicate how support for wind power development varies regionally and perhaps regional differences in the expectations for wind power versus other renewable energy sources. It's also interesting to compare the levels and percentages of funding in Fig. 3 with the market positions of the leading suppliers in Fig 2. The IEA member countries who are represented in Fig 2. as being

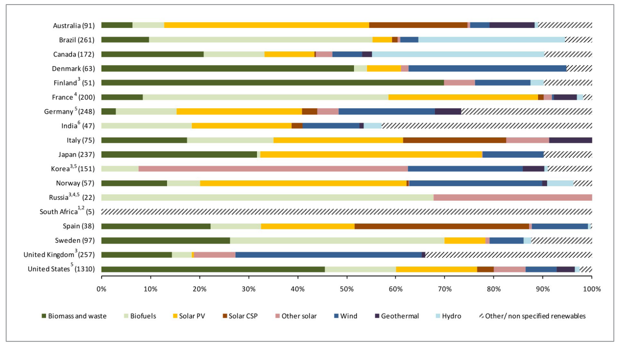

Fig. 3. Public spending on renewable energy RD&D (research, development and demonstration) in International Energy Agency member countries for the year 2010. Amounts shown next to country names are in $US million. Source: International Energy Agency.

home to the top suppliers (Denmark, United States, Germany, Spain, and India) all have public funding of wind power research, though the amounts and percentages vary widely.

While the market data offers high-level perspective on the prospective opportunities and challenges in wind power, the companies working in this field can provide more specific commentary on the obstacles they face in the development of power electronics for wind turbines. Henrik Kanstrup Jørgensen, Ph.D ME-EM, vice president of technology for Vestas Americas identifies two of the key technical challenges his company faces in this area.

According to Jørgensen, these challenges center on "the robustness of the components and maintaining high quality to ensure the turbine is working 24/7/365."

"This is a large challenge since turbines are often remotely located and thus often difficult to access," says Jørgensen. "Turbines must operate at 97-98% availability and should require physical operator assistance only a few times a year."

When asked about the possible use of newer power electronics technologies such as new topologies, digital control, and power devices such as silicon carbide, to address these challenges, Jørgensen explains that the wind turbine industry won't necessarily be the first to adopt these technologies.

"Turbines will, in the future, demand more electronics in order to be as grid friendly as possible. Wind turbines will not be first mover of these newer electronic technologies due to the demand for robustness and the competitive landscape. Future technologies will include those that control and support the energy mix and those that effectively store energy," says Jørgensen.

Both within Vestas and in the industry at large, Jørgensen sees requirements for power electronics engineers rising in the years ahead.

"We expect the demand for power electronics to grow," he says with respect to Vestas. "This growth will be largely driven by changes to the grid and transmission system."

Apparently, this demand is not expected to change anytime soon. Over the next five years Jørgensen believes that prospects for power electronics engineers in the wind turbine industry will remain "very good."

Speaking of the company's current needs Jørgensen says, "We are seeking electronic engineers who can apply power electronics in the robust, non-supervised applications required in the wind industry. We have several open positions at Vestas in North America, and we are always looking for good power electronics people globally."

About the Author

David G. Morrison is the editor of How2Power.com, a site designed to speed your search for power supply design information. Morrison is also the editor of How2Power Today, a free monthly newsletter presenting design techniques for power conversion, new power components, and career opportunities in power electronics. Subscribe to the newsletter by visiting www.how2power.com/newsletters.

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GREEN DISPLAY

By Cliff Keys, Editorial Director & Editor-in-Chief, Power Systems Design

Active matrix organic light-emitting diode (AMOLED) is rapidly becoming a popular display for smart phones, particularly high-end Android models, causing global AMOLED unit shipments to expand by nearly a factor of six from 2010 to 2015, according to new IHS iSuppli research.

As a result of these trends, global unit shipments of AMOLEDs will soar to 271.2 million units in 2015, rising at a 40.6 percent compound annual growth rate (CAGR) from 49.4 million units in 2010. AMOLED revenue is set to expand to $3.6 billion in 2015, expanding at a CAGR of 31.9 percent from $892.1 million in 2010. The growth of AMOLED shipments and revenue is being fueled by the expansion of the smart phone market.

Shipments of low-end smart phones will rise at a CAGR of 81.1 percent from 2010 to 2015. Meanwhile, mid- to high-end smart phone shipments will expand at a CAGR of 15.1 percent during the same period.

Challenges remain

AMOLED displays are currently 30 percent to 60 percent more costly to manufacture than equivalent low-temperature polysilicon (LTPS) LCD displays. AMOLED manufacturing currently requires processes that make it expensive. In particular is the use of LTPS backplanes that require laser annealing. Thus, this part of the manufacturing process starts with the costs of standard LCD, and then adds an expensive, time-consuming process that cannot currently be used on large-area glass substrates.

However, Samsung's and the industry's first 5.5-generation (5.5G) AMOLED line, set to begin operation during the second quarter, likely will bring improved efficiency that will help produce AMOLEDs at an equivalent cost as LCDs. At the 5.5G level, the large scale of production of thin film transistor arrays will spur reductions in production cost for OLED panels.

Another challenge for AMOLED is that screens using the technology suffer from reduced visibility in direct sunlight. However, Samsung has addressed this issue by reducing the space between the layers within its AMOLED display.

The organic materials used in AMOLED displays are prone to a decline in performance over the life of the display. However, material life time has improved significantly. Continued efforts among material companies and display suppliers will help further improve the lifetime of AMOLEDs.

Finally, it is still a challenge for AMOLEDs to achieve high resolution comparable to LTPS LCDs. So far, SMD has used sub-pixel rendering to drive high-pixel formats. But this area still remains a challenge to be addressed.

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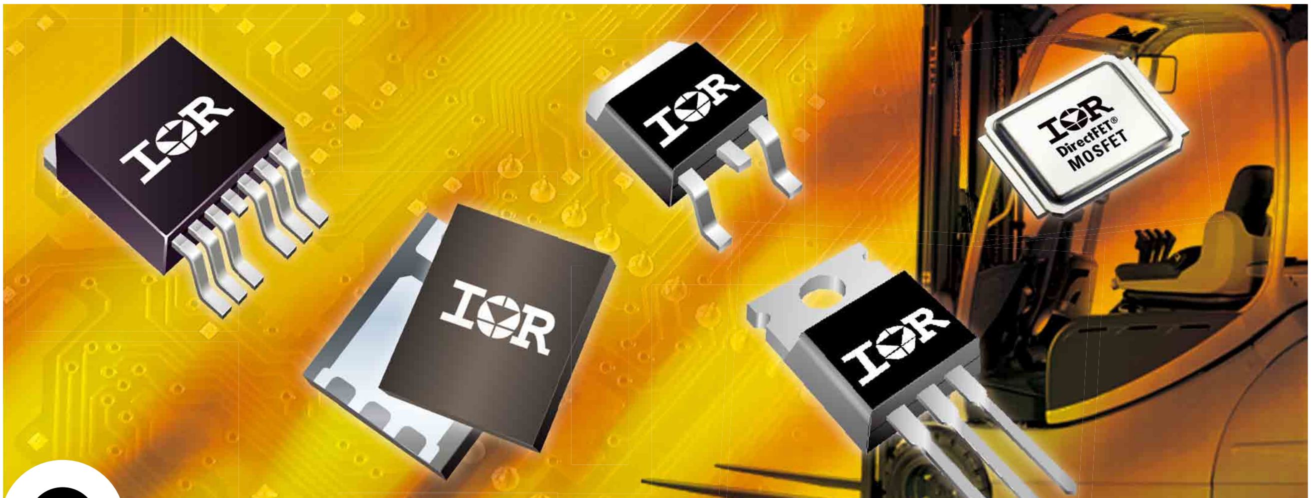

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IRFS3006-7	60	2.1	240	200	D²PAK-7
IRFS3006	60	2.5	195	200	D²PAK
IRFH5006	60	4.1	100	67	PQFN 5x6 mm
IRF7749L2	60	1.3	108	220	DirectFET-L8
IRFB3077	75	3.3	210	160	TO-220
IRFH5007	75	5.9	100	65	PQFN 5x6 mm
IRF7759L2	75	2.2	83	220	DirectFET-L8
IRFP4468	100	2.6	195	360	TO-247
IRFH5010	100	9	100	65	PQFN 5x6 mm
IRF7769L3	100	3.5	124	200	DirectFET-L8
IRFP4568	150	5.9	171	151	D²PAK
IRFH5015	150	31	56	33	PQFN 5x6 mm
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IRFH5020	200	59	41	36	PQFN 5x6 mm
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