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PSDE Green Power ENERGY EFFICIENCY

Special Report - White Goods Part II

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Power Systems Design EUROPE

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PSDE Green Power ENERGY EFFICIENCY

Revive to Survive

This issue of Power Systems Design Europe carries the editorial theme of White Goods –always a popular topic - covering the products, new topologies and trends in this competitive market where energy efficiency, silent operation and eco friendly designs are destined to be the winners.

Our power industry contributes significantly to the success of the new generation of white goods with a myriad of sensors, controllers, motor drives, power management products and solutions. For you, our technical audience of power electronic engineers and management, I have tried to bring up-to-date, in-depth reporting on these themes.

With energy efficiency (I'll call it EE here) being the 'next big thing' we are uniquely poised to show the world what we can really do. We have all been bombarded with the news of the financial crisis where governments are scrambling to plug the holes in the leaking financial bucket. It seems strange that this all comes as a big surprise to these experts but I strongly believe that the reaction will be firm and thorough; there is simply too much for too many 'top dogs' to lose, apart from the rest of us who just need to pay the bills. I also believe that this will result in significantly more investment to revive the vital EE sector of the power industry simply because common sense tells me that this sector must be high on the investor's priority list. We cannot depend on oil, the current prime energy source, both in terms of medium term availability and the political instability of its location.

Design engineers involved in wind, solar and alternatives sectors as well as those in white goods and equipment suppliers will certainly have yet another added responsibility to shoulder. No big surprises here, but wouldn't it be nice if the guys that really earn the rewards could see that only by investing significantly in engineering talent and creativity, which includes education, training and remuneration, can we make progress. It's no use fighting the desperate energy battle with a workforce that is qualified in anything other than engineering.

We'll need insightful and qualified leadership with clout, not just to generate this (for sure, more expensive) energy, but also to move it from where the sun shines or wind blows or waves roll to where it is actually needed. It's not often found to be in the same geographic location! This raises a whole new chapter in the area of work for our power transmission community.

The flipside of this is that it brings a wonderful 'opportunity' for engineering expertise to flourish and grow. Whatever views any of us have on the result of the election in the US, one fact is very clear. We will have an even stronger focus on EE. Whether it is for reasons of popularity, career enhancement or genuine belief, it is born out of necessity. The fact is, this 'opportunity' - call it what you like – will certainly be focused to tackle the world EE issue. Even a politician's promise is accountable and we, the human race, cannot afford to let them go soft on us on this.

So, in the 'here and now' of the industry and with it, PSDE magazine, I hope you enjoy the issue, please keep your feedback coming in and don't forget to check out our standing 'tongue-in-cheek' fun-strip, Dilbert, at the back of this issue.

All the best!

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

New Design and Manufacturing Services Centre

ACAL Technology announces the enhancement of its Design and Manufacturing Services Centre. Located in Wokingham, UK, the centre provides customers with specialist technical support and a full range of in-house design and assembly resources for end-to-end product development and systems integration.

ACAL Technology's Sales and Marketing Director, Steve Carr, explained, "We believe that the Centre provides customers with distribution's most comprehensive in-house range of design and assembly services. By providing immediate access to every service required to take products from development to complete system integration, ACAL strips away unnecessary delays between multiple suppliers to achieve the most concentrated design cycle."

The extensive range of in-house equipment and services includes a 3-metre EMC chamber for pre-compliance testing, extensive CAD and specialist test equipment, and a device programming centre as well as connector and fibre-optic cable assembly.

The ACAL Design and Manufacturing Services Centre can also assemble physical contact and expanded beam (lens) fibre-optic cables and copper cabling. Other assembly services include PCB layout, power-supply construction, and rack and enclosure fabrication, as well as software installation, documentation, and functional or soak testing.

In addition to providing a major resource for customers, the ACAL Design and Manufacturing Services Centre will provide additional support for ACAL Technology's specialist design and application engineers throughout Europe.

www.acaltechnology.com

Digi-Key Stocks Tyco PolyZen Devices

Digi-Key Corporation has expanded its line of Tyco Electronics Raychem Circuit Protection Products to include the PolyZen family of polymer-protected Zener diodes. PolyZen devices are polymer-enhanced precision Zener diode micro-assemblies that help protect sensitive electronics from damage caused by inductive voltage spikes, voltage transients, incorrect power supplies and reverse bias. Applications include portable media players, global positioning systems, hard disk drive 5V and 12V bus protection, automotive peripheral input power protection, DC power port protection, and industrial handheld POS.The PolyZen devices are featured in Digi-Key's print and online catalogs and are available for purchase directly from Digi-Key. To date, billions of Tyco Electronics Raychem Circuit Protection products have been used to protect a wide range of electronic products in the computer, battery and portable electronics, consumer, automotive, industrial appliance & HVAC, and telecommunications markets. Digi-Key Corporation focuses on providing customers with superior service in product selection and availability, on-time delivery, and responsiveness.

www.digikey.com

Dietmar Hilgers Appointed VP of Operations for Vincotech

Vincotech has announced that Dietmar Hilgers has been appointed vice president of operations. In this newly created position, Hilgers reports to Rainer Sendrowski, General Manager Vincotech Group, and is based in Unterhaching, Germany.

A 15-year veteran of the automotive industry and a functional expert in Toyota Production System principles, Hilgers manages Vincotech's global operations, including its manufacturing plants in Bicske, Hungary, and Shenzhen, China. He also oversees global quality, supply chain and strategic purchasing.

Hilgers refined his logistics and supply chain expertise at various automotive companies where he improved procurement practices, streamlined operations and improved overall profitability. He most recently served as plant manager at Faurecia Innenraum Systeme GmbH, Peine, Germany.

Hilgers received a bachelor's degree in business administration and operations as well as a Diploma in Sociology and Psychology from the University of German Federal Armed Forces in Neubiberg/Munich.

www.vincotech.com

Elke Eckstein Leads Osram's Worldwide Opto-Semiconductor Production

Elke Eckstein has been appointed Chief Operating Officer (COO) at OSRAM Opto Semiconductors GmbH in Regensburg, Germany.

Eckstein's career has been closely associated with the semiconductor sector. She brings more than 25 years of experience in the semiconductor sector to her new position as well as extensive specialist knowledge. Most recently she was Vice President Manufacturing at AMD in Dresden where she was responsible for day-to-day operations at the world's most efficient semiconductor factory, F30/38. In her new function, Eckstein assumes responsibility for worldwide production – a crucial key position in the rapidly growing semiconductor sector.

She had already shown her strengths in technology development and product engineering at ProMOS Technology, an earlier joint venture between Infineon and Mosel Vitelic based in Taiwan.

www.osram-os.com

Precision in Fine PCB Structures

Christian Enzmann GmbH, independent supplier of printed circuit board prototypes, professional quick-turns and volume production for the automotive, industrial, medical and aerospace markets, has made a mass production start of its new Stripping, Etching and Stripping (SES)-line. The process-optimized SES-line by Occleppo allowed Enzmann to improve etching quality significantly. Enzmann will be able to achieve a track gap width of 100µm in 70µm base copper and only 50µm in 18 µm base copper.

Precision fine-pitch PCB technology allows designers to meet controlled-impedance routing demands, increasing the company's ability to support RF, medical, and other applications that require an accurately defined signal.

www.enzmann.de

Ericsson Receives Chinese Top 10 DC/DC Award

The award recognizes those DC/DC products manufacturers who, through innovative features in new products, help the continuous development and improvement of power-supply technology for the industry. The award ceremony took place on September 18th in Beijing at the seventh annual Power Technology conference.

In an industry first, Ericsson's BMR453 series of DC/DC converters uses a digital control platform contained within the modules themselves. By integrating more into the control circuitry, the concept frees up real estate for greatly improving the power density, simultaneously offering unprecedented levels of control.

With 96% efficiency, the BMR453 offers up to 400W output power or up to 33A with ±2% accuracy. At that level of accuracy, the best module commercially available offers just 300W output power. Ericsson's BMR453 offers 33% more power in the same package size.

Patrick Le Fèvre, Ericsson Power Modules Marketing Director, said: "It is with great pride that Ericsson Power Modules receives this award for the third time. It is also very satisfying to be recognized by the Chinese Power Community as a technology leader driving innovation in board mounted products that contribute to lower energy consumption, resulting in lower CO_2 emissions."

Jianping Zheng, Head of Power Modules Sales and Marketing for the Market Region Asia Pacific added, "In a very competitive market, winning this prestigious award for the third time is not only a real honor for all of us, but a very encouraging sign of recognition to all of our employees working hard to develop such advanced products offering significant benefits to our customers and the environment."

Once again, the award reflects the maturity of Ericsson Power Modules in the Asia-Pacific region. This is contributing greatly to an increase in local support to customers in China, as well as international customers who are outsourcing parts of their projects and activities in the region.

www.ericsson.com/powermodules

Indium Promotes McKee to Support European Sales

INDIUM CORPORATION®

Indium Corporation announces the promotion of David McKee to the position of Key and Direct Accounts Manager for Indium Corporation in Europe.

David is responsible for providing direction and support to Indium's network of direct and key accounts in Europe, the Middle East, and Africa, with a focus on the company's solder products. He also works with the global sales team to support Indium's multi-national customers.

David joined the Indium Corporation sales team in 2000. He has experience as a mechanical engineer in the automotive market, as well as the electronics industry. He has held positions in production and process engineering, sales, and management.

David is based at Indium Corporation's facility in Milton Keynes, UK and reports to Guido Lanoye, European Sales Manager.

Indium Corporation is a premiere materials supplier to the global electronics assembly, semiconductor fabrication and packaging, solar photovoltaic, and thermal management markets.

www.indium.com

NXP Appoints Senior VP Global Sales & Marketing

NXP Semiconductors has announced Michael Noonen is appointed as Senior Vice President, Global Sales & Marketing. Joining NXP from a global sales position at National Semiconductor, Noonen's role will focus on leading NXP's worldwide sales & marketing teams to strengthen the go-to-market strategy and execution in order to achieve both revenue growth and value creation at new and current customers.

"Mike has a proven track record as a global sales leader, and a wealth of experience in growing revenue profitably, by aligning semiconductor technologies, application insights, to the distinct business requirements of customers. I am sure that Mike's experience in value based selling will be a big boost to NXP's revenue growth and margin extension," said Frans van Houten, President and Chief Executive Office, NXP Semiconductors. "This announcement is further demonstration of our customer-centric approach to all operations, and we are delighted Mike's appointment provides additional expertise in leading our worldwide customer teams to become best-in-class."

Noonen will be part of NXP's Executive Management Team and based in San Jose, California. He will report directly into Frans van Houten, CEO.

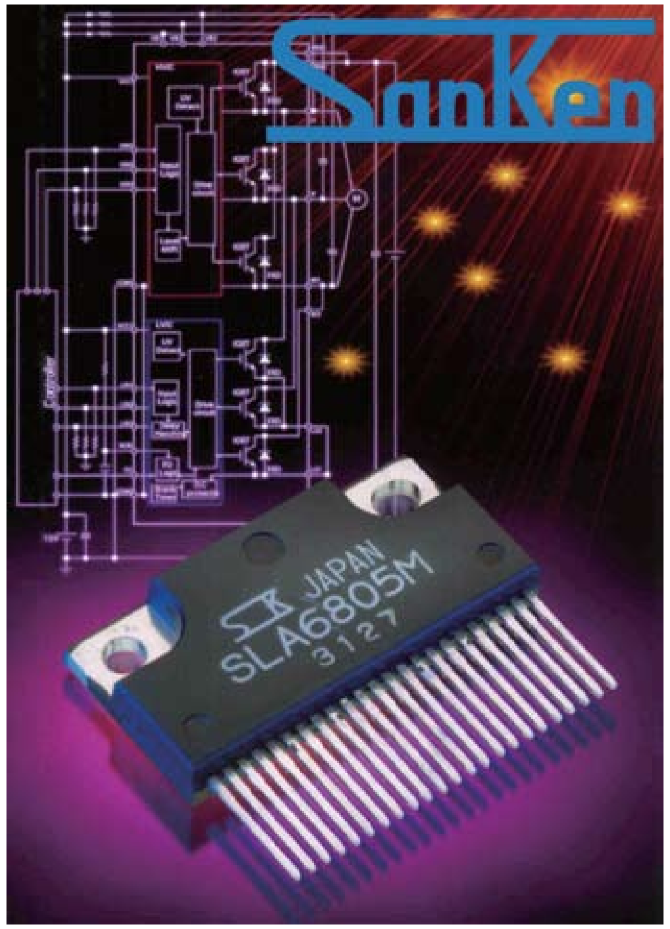
www.nxp.com

Power Events

- ***electronicAsia 2008,***
  October 13-16, Hong Kong, China,
  www.electronicasia.net
- ***electronica 2008,***
  November 11-14, Munich, Germany,
  www.electronica.de
- ***SPS/IPC/Drives 2008,***
  November 25-27, Nürnberg, Germany,
  www.mesago.de/en/SPS/main.htm

New Series of Intelligent Power Modules for White Goods

Sanken are expanding their SLA6800M and SMA6800M Series of Intelligent Power Modules (IPM) range. Highlighting a broad variety of high voltage, three-phase motor driver ICs targeted at the residential white goods (home appliance) and commercial three-phase motor market segments, such as air conditioners, refrigerators, and washing machines. Sanken IPM devices are particularly well-suited to applications in variable speed control systems and power inverter systems.



With the global need for energy saving, home electric appliances in Japan are now required to indicate their energy saving levels on product labeling but are only now beginning to emerge in other countries. This movement has lead to technological changes; for example, AC motors are increasingly being replaced by higher efficiency brushless DC motors (BLDC).

To drive these motors, a 3-phase full bridge inverter and driver IC are required. For low-capacity fan motors in room air conditioners, a commonly-used product has been a combination of drive IC and protection functions with the 3-phase full bridge circuit, integrated on a single chip. However, these single-chip solutions have the disadvantages of large switching losses and limited allowable power dissipation.

Conventional single-chip IGBT-based driver ICs for low capacity motors, have drawbacks such as large switching losses and limited allowable power dissipation. An alternative, described in this note, is the inverter power module (IPM) SMA6800M Series, which is designed for use in low-capacity motors such as air conditioner fans.

The SMA6800M Series uses power MOSFET chips to achieve low loss levels. Highly integrated multichip technology is used to combine the driving circuitry with a high voltage monolithic IC, allowing packaging in a small SIP. This package is ideally suited for equipment requiring compact size and high efficiency.

Demand for these applications is expected to increase rapidly in the near future, due to commercial economic pressures and governmental regulations mandating the use of energy-conserving technologies.

IPM type ICs are gradually becoming prevalent for controlling motors in residential and commercial laundry washing machines, where they replace several discrete components, thus saving application space and design effort. In many instances, IPM devices yield the lowest overall cost solution, especially in the current regulatory environment, which is forcing manufacturers to redesign their power management systems. Traditional discrete-device topologies are proving difficult to adapt to these applications, and manufacturers are turning to more rapid design solutions using the highly integrated topologies offered by IPM types of devices.

The SLA6800M and SMA6800M Series, operates from 85 to 265 VAC input voltage, and 1.5A to 3.0A output current. These ICs can withstand voltages of up to 500 V (MOSFET breakdown voltage) and 600 V (IGBT breakdown voltage).

www.sankenpower.co.uk

Saving Energy Equals Power

By Peter Oaklander, Intersil's Senior Vice President, Power Management Products Group

For years, power management designers in handheld portable devices have been trying to squeeze every last bit of power efficiency from their devices in order to preserve their precious little batteries. Extended battery life was a value point that every consumer recognized as paramount to the functionality of their information/entertainment devices. During that same period, there was far less attention paid to the efficiency of our "plugged-in" devices. They would always work, as long as they had an energy source.

Soaring energy costs have drastically changed that mindset, and energy efficiency in almost everything we use is becoming the most important value a power management company can deliver, eclipsing or at least equaling "designability" and form factors. A market leading device must deliver in all three of these areas.

All consumers are looking to save cost. Power-hungry appliances such as air-conditioners, washing machines, and refrigerators, along with the insatiable growth in information/entertainment technologies in the home, are now impacting most home budgets.

The same companies that have been leaders in driving energy efficiency in handheld consumer products will also be the leaders in solving the energy consumption issues within the home appliance/white goods market. The shift will come as consumers begin to base their purchases on the cost to run, versus the cost to acquire: a mindset that major computing infrastructure companies have dealt with for more than a decade now.

This push for energy efficiency is increasing the demand for semiconductor content for controlling, monitoring and sensing, which makes white goods one of the fastest-growing market segments for power management through the next

five years ending in 2013.

The increased power management semiconductor content within each device will grow faster than the market rate, with shipments of dishwashers, microwaves, washing machines and dryers expected to grow to 112 million units in 2013; a 34.9% increase from the 83 million units in 2005. During that same period, Intersil expects the value of power management ICs in those devices to grow from $32.5 billion to 51.5 billion; a 58.6% increase.

Microwaves will continue to grow in demand, but the power management demand for those devices, which are already quite energy efficient, will grow roughly at about the same rate. The appliances that will see the largest power management growth will be washing machines, dryers, and refrigerators.

To increase efficiency, appliance manufactures will be using more intelligent circuitry to drive their motors including power modules, high-voltage regulators, discrete Insulated Gate Bipolar Transistors (IGBTs), Pulse Width Modulators (PWMs), diodes and MOSFETs.

In addition to improving efficiency, there is increasing market demand to integrate more "intelligence" into household appliances. Everything from high-powered LED lighting, display panels, I^2C interfaces for control, and even internet connectivity for everything from refrigerators to washing machines, will drive increased IC demand.

Integration of these products to support the increased power efficiency and improved functionality will have a big impact on design of these devices. Appliance designers will look for power efficient solutions that are easy to implement or design in. Because of this, power modules, where most of the necessary circuitry is co-packaged within a single IC, will see increased penetration in these markets.

Beyond white goods, there will be increasing pressure for greater efficiency in home computers where Intersil is uniquely positioned within the Climate Savers initiative, a non-profit organization dedicated to reducing power consumption of computers by 50% by year 2012. Intersil recently unveiled a phase shifting power management IC for computing motherboards that can drop or add phases based on the power demands at any given time during operation which helps the device run 70% more energy efficient.

So whether it is in the refrigerator, washing machine, dryer, or home computer, consumers will be placing a higher demand on efficiency. IC manufacturers who can provide the most energy efficient power management solutions will be the biggest winners.

www.intersil.com

Power Supply Ringing Waveforms

PWM power supplies are plagued with ringing waveforms that can degrade performance, impact EMI measurements, and even cause failure. This article explores some of these ringing waveforms, and gives a laboratory technique to measure them easily and safely.

By Dr. Ray Ridley, Ridley Engineering

Simple Flyback Converter

The flyback converter is widely used in industry, but many designs do not provide the needed the safety margins needed for modern products. A major cause of this is the ringing waveforms that exist in the converters.

Figure 1 shows a basic flyback converter. Ideally, this converter has square-wave waveforms across the power semiconductors. In reality, there are numerous parasitic elements that cause ringing in the circuit when the semiconductors are turned off.

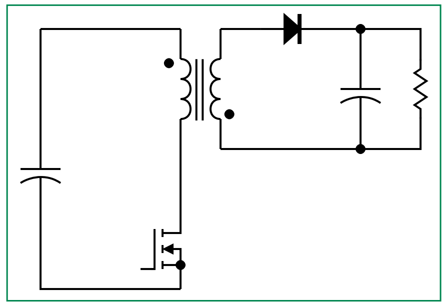


Figure 1: Simple flyback converter with main power stage components.

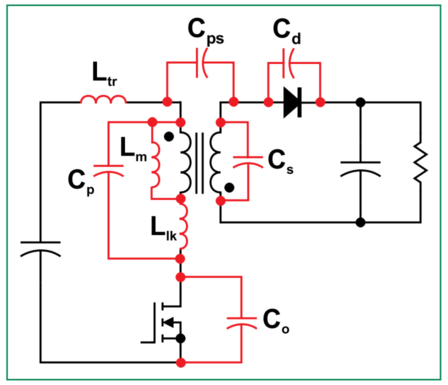


Figure 2: Flyback converter including major parasitic components, shown in red.

Figure 2 shows the dominant converter parasitics. These include:

- Board trace inductance L_{tr}
- Transformer leakage inductance L_{lk}
- Transformer magnetizing inductance L_m
- Transformer primary capacitance C_p
- Transformer primary-to-secondary capacitance C_{ps}
- Transformer secondary capacitance C_s
- FET output capacitance C_o
- Diode junction capacitance C_d

This complicated circuit is actually a simplification of the real circuit. The capacitances shown are bulk capacitances which are actually made up of many distributed capacitances. Furthermore, elements can be voltage dependent, in the case of the semiconductor junction capacitances, and frequency dependent, like the transformer leakage inductance. The simplified circuit is used to give us some hope of trying to understand and control the waveforms that we see on our breadboards.

Figure 3 shows the FET voltage for a typical flyback converter. It is often a surprise to new designers to see how severe the converter ringing is, and how much extra stress is applied to the semiconductors relative to the ideal square-wave waveforms.

Almost all flyback converters apply a clamp circuit, or snubber circuit to the FET to prevent the ringing waveforms from destroying the device. Before this is done, however, it is a useful experiment to look at the ringing waveforms closely to learn more about them.

Figure 4 shows the same FET voltage waveform, zoomed in on the first two ringing cycles. The period of ringing is 110 ns, corresponding to 9 MHz. There is a general rule that this ringing frequency should be about two orders of magnitude (100 times) the switching frequency of the converter, or else the subsequent snubber dissipation of the ringing will be very lossy.

Notice that this waveform has an interesting characteristic distortion. At the top of the waveform, the peak is very sharp, corresponding to a high-frequency resonance. At the bottom of the waveform, the trough is very shallow, corresponding to a lower frequency resonance. The resonant frequency of the waveform is actually voltage dependent.

This particular waveform is a reso-

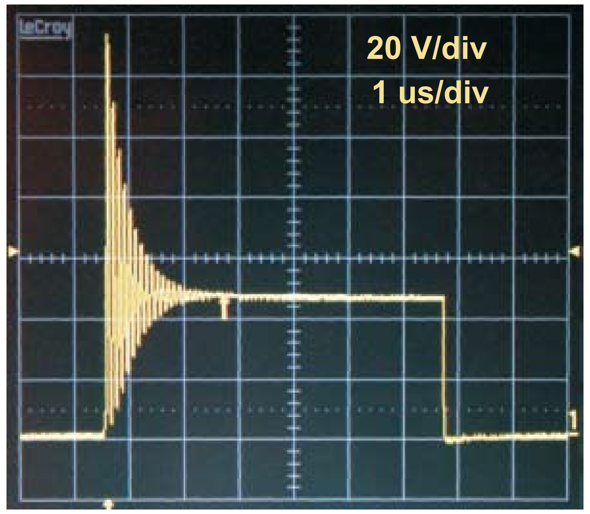


Figure 3: Flyback converter FET voltage waveform.

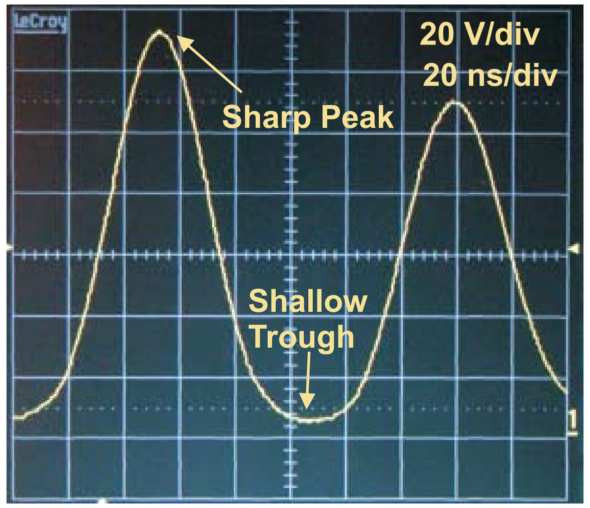


Figure 4: Flyback converter FET voltage waveform detail.

nance between the leakage inductance of the transformer, board trace inductance, transformer capacitance, and the output capacitance of the FET. (Since the diode is on during this ringing, its capacitance is not involved in determining this waveform.) The voltage-dependent output capacitance of the FET is responsible for the distortion on the waveform.

If ever you see this kind of waveform in any of your power circuits, it means that the ringing is strongly dependent upon a semiconductor junction capacitance, rather than on a physical capacitive structure such as transformer windings or heatsink capacitance. This knowledge can help you troubleshoot your power supply, targeting the right component to reduce capacitance.

Measuring Waveforms without Touching the Circuit

The waveforms shown so far are produced by capacitances on the primary side of the converter, in the orders of tens of picofarads. As frequencies climb, and part sizes shrink, these capacitances can also reduce. We have to be very careful that any instrumentation connected to the converter does not materially affect the waveforms themselves. For many converter waveforms, attaching a scope probe affects the waveforms of the circuit, and in some cases, can cause converter failure. (It can also lead to the opposite effect – masking destructive waveforms that, without the instrumentation, would lead to failure.)

A technique to make sure we are not disturbing the circuit is to remove the probe tip and ground lead from the scope voltage probe, change the scale on the oscilloscope, and just hold the voltage probe near the component node we are trying to measure. For a FET drain voltage, the large area of the tab of power component will couple its signal to the scope probe very effectively. Figure 7 shows this test setup.

Figure 5 shows the FET drain waveform measured this way. Notice that voltage scale is now just 100 mV/divi-

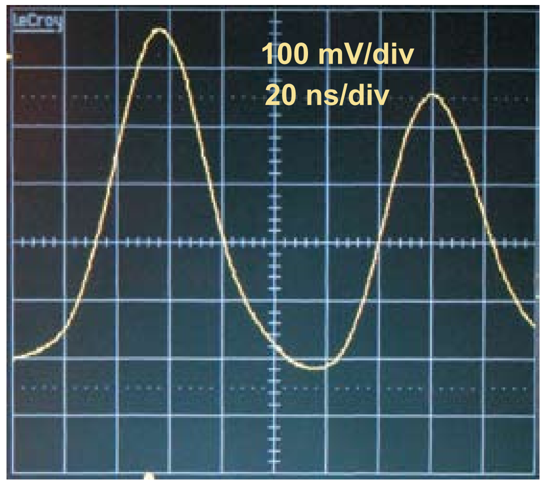


Figure 5: Expanded FET voltage measured without touching the circuit.

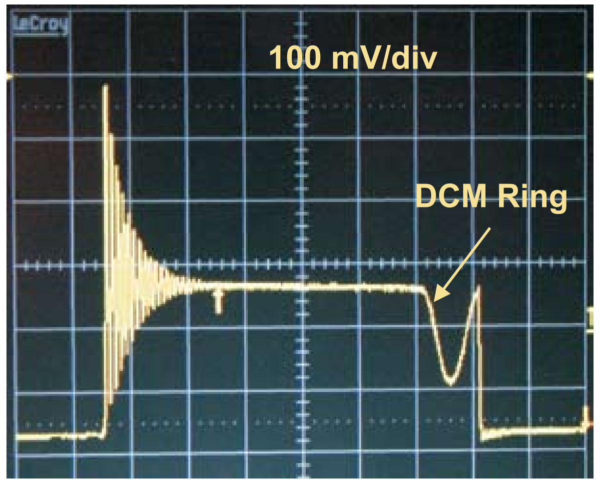


Figure 6: Flyback FET voltage in DCM, measured without touching the circuit.

Figure 7: Measurement technique for voltage waveforms.

sion rather than the 20 V/division for Figure 4. You cannot use this technique to measure exact amplitudes, but you can see the waveshapes and frequencies involved.

In this case, the waveforms of Figures 4 and 5 are almost indistinguishable. There is just a slight shift in the ringing period to 105 ns due to the removal of the scope probe capacitance. After making this measurement, we can now rest assured that the instrumentation does not significantly affect our measurements in this case.

Figure 6 shows the same circuit operating at lighter load. This waveform is again measured without touching the circuit with the instrumentation. There is an additional ringing period shown which corresponds to the converter entering discontinuous conduction mode (DCM). This is a much lower frequency, since it is caused by the magnetizing inductance of the transformer ringing with circuit capacitances.

Figure 6 is a very characteristic signature of a DCM flyback. As you become more experienced in power supply design and their characteristic waveforms, the contactless measurement becomes a very powerful and rapid diagnosis tool. You can look at the waveforms of a hardware sample for which you may have no circuit diagrams, and quickly and safely be able to identify the type of converter involved, its mode of operation, and any potential problems in the waveforms.

Summary

Ringing waveforms contain much information about the design of a converter. Before you completely suppress them with snubbers and clamp circuits, they should be recorded and studied carefully. This will help you in the design of snubbers, in identifying dominant parasitic, and in protecting your circuit in all modes of operation.

Transient events can give rise to additional circuit resonances, and you should always try to capture worst-case waveforms during test conditions other than steady state. Many circuit failure events occur during transients due to these additional stresses.

Always be careful when trying to measure very high frequency waveforms. The instrumentation itself can change the circuit. The contactless measurement technique described is a very useful diagnostic tool for switching power supplies, and you should practice this with your circuits.

www.ridleyengineering.com

On the Road

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

Infineon Technologies

I had the pleasure of meeting with Arunjai Mittal, Infineon's President of the Industrial and Multimarket division at the company's impressive facility in Munich, Germany. The Q&A session based on Infineon's position in the vital area of energy efficiency is reported below.

Efficient Energy Utilization

Our greatest energy resource in the future

The global demand for electricity is growing annually by 2.4 %. The Energy Information Administration is expecting energy demand to double to 30.1 million GWh from 2004 to 2030. What are the opportunities and challenges presented by this development for power semiconductor manufacturers?

Arunjai Mittal: The figures are particularly striking when one considers where the demand is growing above average rates. China with 4.4% and India with 3.9% are well out in front. Electricity that we do not use will therefore become our largest resource for the future. Infineon offers the very powerful and efficient solutions in the IGBT and MOSFET sector for applications both in the industrial as well as in the consumer and home appliance areas. Of special significance is that, according to the UN, last year was the first time in history that more people lived in cities and urban areas than in rural areas around the globe. This development is set to continue and will affect where and how electricity is obtained, transported and consumed.

Where do you see the greatest potential for savings and what are the areas Infineon will focus on in the future?

Our chips and modules minimize pow-

er dissipation and maximize energy savings throughout the entire value chain from energy generation to energy transfer and consumption. Let us consider the example of power supply. According to various market research institutes, about 9.5 million servers were operating in 2006. This figure is to grow to about 30 million by 2011. A server consumes an average of 1200W – that means global consumption of 36,000MW. Greater efficiency, for example, through deployment of our CoolMOS MOSFETs, could make a decisive contribution in this regard.

Even a reduction in demand by 1 per cent, corresponding to 360 MW, would be practically equivalent to the capacity of a hydroelectric power station. Do not forget that more efficient power supplies also have reduced cooling demands.

You are one of the leading providers of power semiconductors for industrial applications. Are even greater potential savings not possible in the area of traction and drive systems?

The demand for electrical energy can be considerably reduced by the use of chips. Electronic controllers in electrical drive systems and motors can yield large savings, namely 20% to 30%, between 30% and 40% in air-conditioning systems and about 20% in illumination systems. Domestic induction cookers consume 25% less power than electrical cookers. From our point of view there are two principal approaches for drive and motor systems. On the one hand, there is the energy optimization of traction drive systems in combination with braking power recovery. Studies carried out by the Deutsche Bahn and the Berliner Verkehrsgesellschaft have discovered savings potential of 300 GWh. This roughly corresponds to the yearly electricity consumption of a small city with 30,000 inhabitants. In the area

Four-Day

Power Supply Design Workshop

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

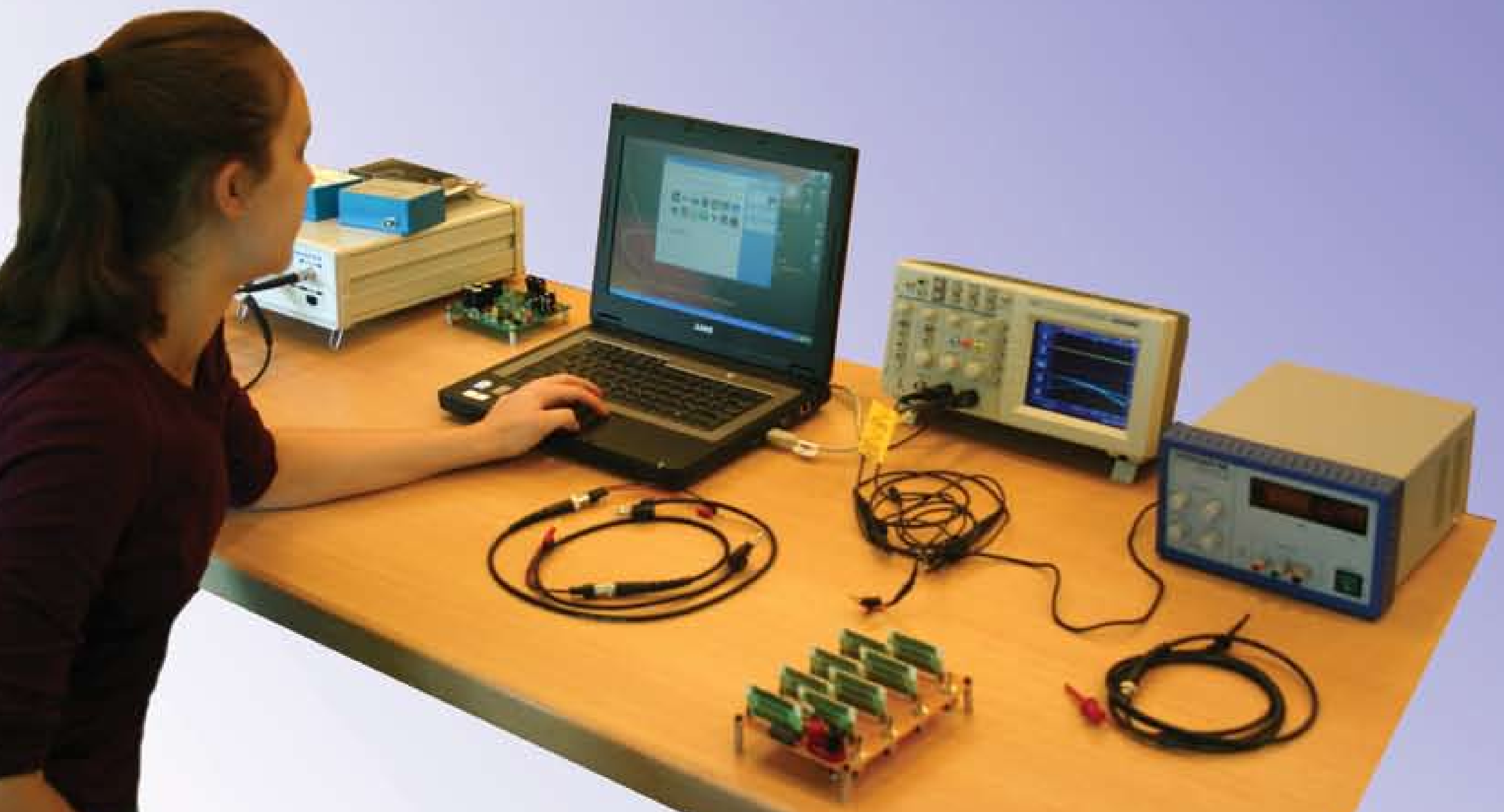
Learn first-hand from Dr. Ray Ridley, a leading power electronics industry consultant and researcher. During his 28 years in the industry, he has taught advanced design to thousands of engineers worldwide. The world's leading engineering companies in aerospace, semiconductors and commercial applications send their engineers to the Workshop to take their designs to the next level.

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

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

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

Download a registration form at www.ridleyengineering.com



Agenda

Monday

Morning Lecture 8:30 - 12:00

Power Stage Topologies
Inductor Design
Saturation
Core Loss
Proximity Loss
Practical Design Procedures

Afternoon Laboratory 13:00 - 17:00

Design of Flyback Inductor/Transformer
Construction, Winding, Gapping Transformer
Impedance and Leakage Measurement
In-Circuit Testing
Snubber Design
Full Power Testing
Efficiency Measurements

Tuesday

Morning Lecture 8:30 - 12:00

Transformer Design
Saturation
Leakage Inductance
Planar Magnetics
Proximity Loss
Multiple Output Cross-Regulation
Winding Capacitance
Practical Design Procedures
Gate Drive and Current-Sense Transformers

Afternoon Laboratory 13:00 - 17:00

Design of Forward Inductor
Design of Forward Transformer
Construction, Winding, Gapping Forward Mag.
Impedance and Leakage Measurement
In-Circuit Testing
Snubber Design
Full Power Testing and Efficiency Measurements

Wednesday

Morning Lecture 8:30 - 12:00

Simulation of Power Supplies
Small-Signal Analysis for Voltage-Mode Control
PWM Switch Model
CCM and DCM Operation
Right-Half-Plane Zeros
Loop Gain Criteria
Compensation Design

Afternoon Laboratory 13:00 - 17:00

Measurement of Forward Control Characteristics
Output Impedance Measurement
Control Loop Compensation
Loop Gain Measurement
Stability Optimization
Step-Load Response Measurement

Thursday

Morning Lecture 8:00 - 11:00

Current-Mode Control
Current-Mode Circuit Implementation
Current-Mode Problems
Current-Mode Advantages
Small-signal Analysis of Current-Mode Control
Subharmonic Oscillation
Current-Mode Feedback Design

Afternoon Laboratory 12:00 - 15:30

Measurement of Flyback with Current-Mode
Compensating Ramp Addition
Control Loop Compensation
Loop Gain Measurement
Stability Optimization
Second-Stage Filter Design

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of conventional electrical drives, inverter technology and power electronics are the main sectors that can reduce the individual consumption of such drives by up to 40%. If, according to ZVEI (Zentralverband Elektrotechnik- und Elektronikindustrie e.V., the German Electrical and Electronic Manufacturers' Association), the German industry would convert to electronically controlled drives to a level of 50%, electricity savings of 20% could be achieved. In numerical terms, this would amount to 22 TWh annually or nine coal-fired power stations in the 400-MW class that could be saved. The potential that this improvement would allow at global level can be seen from the fact that currently only about 10% of electrical drives are electronically controlled.

In the consumer sector nearly everything recently concerned the subject of standby. How do you view the savings potential here?

With 90% this offers the highest level of savings potential. If you accept that in Europe alone almost 200 million TV sets run for about 20 hours every day in standby, then about 2 GW of power are wasted by this situation alone. By implementing the demands of the International Energy Agency, which would allow a reduction in the annual standby consumption by up to 90 %, two 900-MW class power stations could be replaced. The best way of saving energy is not to use the standby mode. However, if this is not possible, our chips help to achieve the lowest standby values.

For fast implementation of these objectives, the appropriate components must be readily available however. Has the situation regarding delivery complications last year settled down in the meantime?

In the last few weeks and months we are seeing increasing consolidation of the warehouse stock in all regions. My impression is that deliveries are now running more smoothly for energy supplies up to 100KW. We are expecting the situation to be satisfactorily resolved for energy supplies above 100 KW in the coming weeks and months. The main market drivers continue to be the areas of energy efficiency and energy supply.

In the meantime, the automotive sector has also become more involved in finding hybrid drive solutions for the future. How do you view the importance of this technology today for power semiconductor manufacturers?

Environmental awareness is growing, and not only because one feels the pinch at the gas station. But it is not hybrid drives alone that help to reduce fuel consumption and emission. Sensors, microcontrollers and power electronics – for example, with perfect tire pressure, with an ideal fuel/air mixture in the engine that is independent of the air pressure, with optimum power transfer from cam and crank shafts, reduced idle current in control units, PWM control of fuel pumps and air-conditioning fans, more energy-efficient alternators, electrically-assisted power steering or on-demand electrical primary water pumps, are also contributing in ever greater measure. Infineon offers semiconductors for all of these applications. Applying all measures to vehicles is worthwhile: 100 Watts of saved electrical power corresponds to 0.1 litres less fuel consumed in 100 km.

Electric engines in drive trains certainly enhance their efficiency and also reduce emissions. The growth forecasts for hybrid vehicles are currently assessed contrastingly. Along with the economic and political conditions, the requirements for successful market launching of hybrid vehicles include the development of cost-efficient, reliable and compact hybrid drives. The automotive market is on the right path in this respect. However, the hybrid market is more widespread and offers further openings. It includes drive technology for other kinds of electric vehicles and vehicles with fuel cells, as well as commercial vehicles like municipal buses, taxis, inner-city delivery vehicles and airport vehicles. Industrial drives and construction vehicles whose hydraulic systems could be replaced by more energy-efficient electric engines are also of interest.

After Infineon has long concentrated on IGBT modules, you have now presented your first IPMs with your MIPAQ series at the PCIM. What caused you to adjust your strategy in this direction?

Actually, I don't see any change in strategy here, but rather a consistent evolution of our power integration strategy what we have been pursuing for many years now. After the integration of the rectifier diodes into the IGBT module, our PIM modules, we are now offering products containing current shunts (MIPAQ™base, MIPAQ™sense). These current shunts have power dissipation and are therefore mounted in a module.

We have also been continuously developing ever more compact solutions with our technologies to offer our customers greater functionality with ever smaller dimensions. In keeping with this trend, I also view the introduction of the MIPAQ™ family as a steady continued realization of our product policy. MIPAQ™sense, for example, has a standard Econo3 housing and offers, along with 100A IGBTs, current shunts and digital evaluation electronics with functional electrical isolation. You will not find such compressed functionality in any other IPM in the world.

Let's take a look into the future: when will Infineon enter the market with the IGBT5 and what performance of these components can users expect?

In step with our earlier rhythm, we are planning to launch the next IGBT generation on the market in 2011. In a period of five to six years we will achieve a significant increase in the performance density of our components. In this way we will offer our customers a notable performance gain that justifies the use of new technologies. Along with the markedly higher performance density, the new generation will in particular be characterized by lower losses, higher junction temperatures of up to +200°C and a new connection and packaging technology adapted to the performance of the components.

Electrical energy is becoming more and more precious. We need to learn to best utilize this ever diminishing resource, both in existing and in new applications. Infineon will contribute to this endeavor and continue to develop power semiconductors that help to use the electrical energy as efficiently as possible.

www.infineon.com

Linear Technology

On my recent visit to Linear Technology Corp. in California, US, I talked with Tony Armstrong, Director of Product Marketing for Linear's Power Products. He walked me through the very latest power offerings from Linear.

LT3509 Dual 36V, 700mA Step-Down Regulator

The LT3509 is a new dual, current mode, step-down switching converter, with internal power switches each capable of providing 700mA output current. This regulator provides a compact and robust solution for multi-rail systems in harsh environments. It incorporates several protection features including over-voltage lockout and importantly, a cycle-by-cycle current limit. The device is short circuit robust with thermal shutdown providing additional protection. The LT3509 has a wide 3.6V to 36V operating range and its over-voltage lockout protects the circuit through 60V supply transients.

Tony Armstrong, Director of Product Marketing for Linear's Power Products.

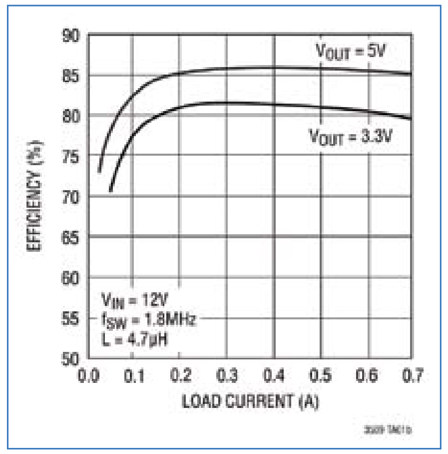


Figure2: Efficiency curve.

The LT3509 features a low drop-out voltage with 95% maximum duty cycle And the adjustable 300kHz to 2.2MHz switching frequency, which is set by a single external resistor, can be synchronized over the full range. The high frequency enables the use small Inductors and ceramic capacitors for low ripple and to minimize footprint, further enhanced by the integrated boost diodes and internal compensation.

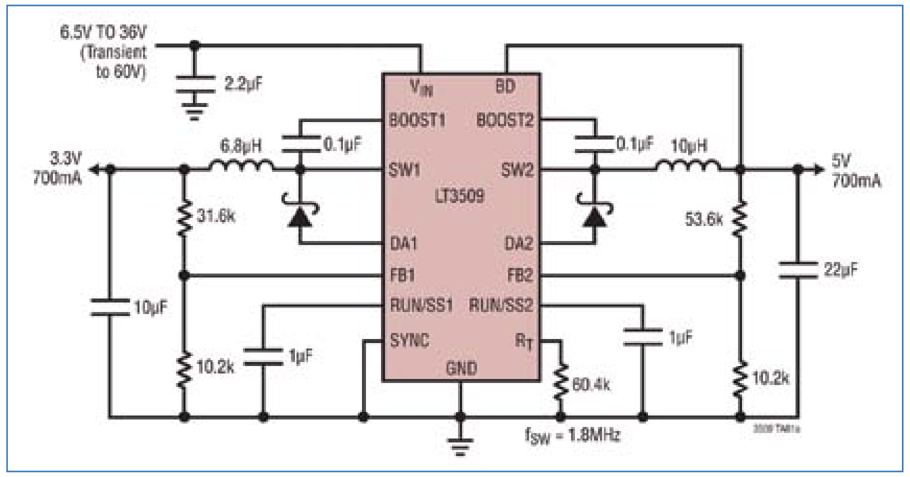


Figure1: Typical application for Dual Output Step-Down Converter 3.3V to 5.0V.

Constant frequency operation above the broadcast radio AM band avoids interference with radio reception, making the LT3509 particularly suited for automotive applications. Other applications include industrial controls, wall transformer regulation, networking devices and CPU, DSP or FPGA power supplies.

Each regulator has an independent shutdown and soft-start control pin and when both converters are powered down, the common circuitry enters a low current shutdown state.

The LT3509 is supplied in thermally enhanced 14 lead (4mm × 3mm) DFN and 16 lead MSOP Packages.

LTC3642 High Efficiency, High Voltage, 50mA Synchronous Step-Down Converter

The LTC3642 is a high efficiency step-down DC/DC converter with internal high side and synchronous power switches that draws only 12µA typical DC supply current at no load while maintaining output voltage regulation. The low dropout

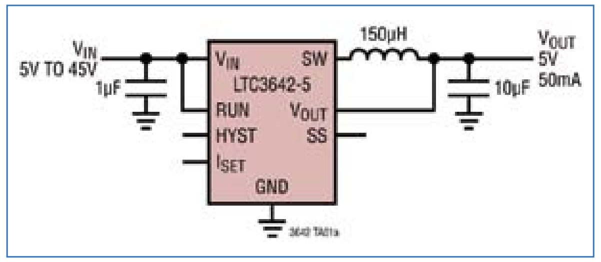


Figure1: Typical Application for 5VOUT Step-Down Converter.

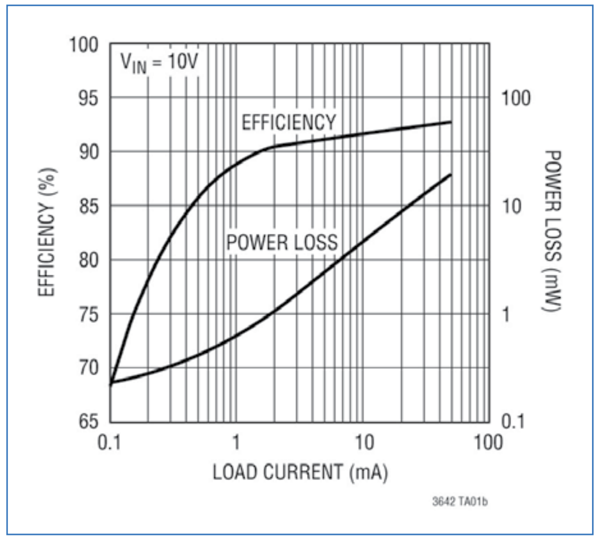


Figure2: Efficiency and Power Loss vs Load Current.

operation features 100% duty cycle.

The LTC3642 which is available in 3.3V, 5V and adjustable output versions (note: only three external components required for fixed output versions) can supply up to 50mA load current and features a programmable peak current limit that provides a simple method for optimizing efficiency in lower current applications.

The LTC3642's combination of Burst Mode® operation, integrated power switches, low (12µA) quiescent current and programmable peak current limit provides high efficiency over a broad range of load currents.

With its wide 4.5V to 45V input range and internal overvoltage monitor capable of protecting the part through 60V surges and transients, the LTC3642 is a robust converter suited for regulating a wide variety of power sources. Additionally, the device includes a precise run threshold and soft-start feature to guarantee that the power system start-up is well-controlled in any environment.

Typical applications for the LTC3642 include 4mA to 20mA current loops, Industrial control supplies, distributed power systems, portable instruments, battery-operated devices and automotive power systems.

The LTC3642 is available in Low Profile (0.75mm), thermally enhanced 3mm x 3mm DFN and MS8E packages.

www.linear.com

National Semiconductor

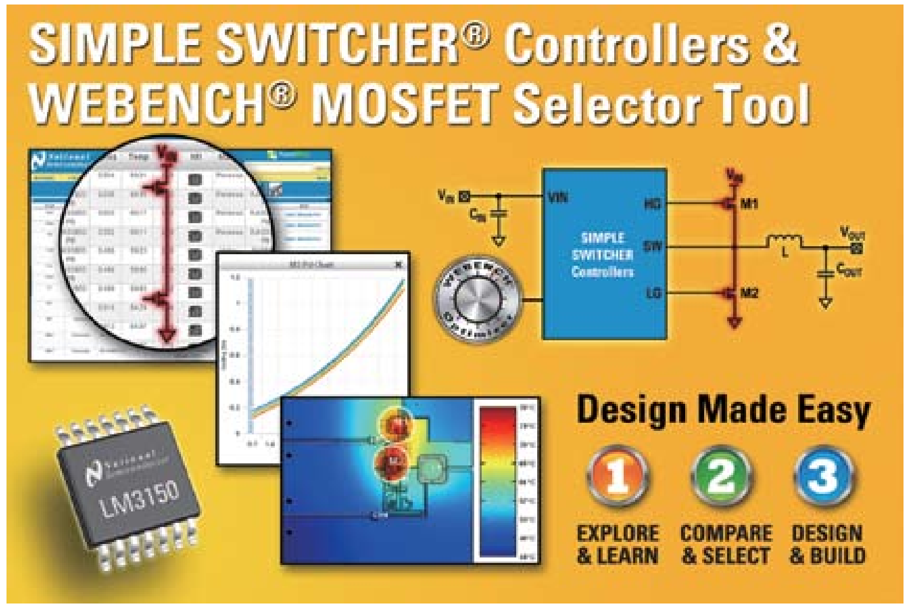
At its press conference recently at its HQ in Santa Clara California, US, National Semiconductor Corp. introduced a powerful new family of SIMPLE SWITCHER® synchronous buck controllers and the industry's first end-to-end MOSFET selection tool to simplify switching controller designs. All this, together with the enhancements to WEBENCH, National's online design environment, make a very powerful toolkit for the designer.

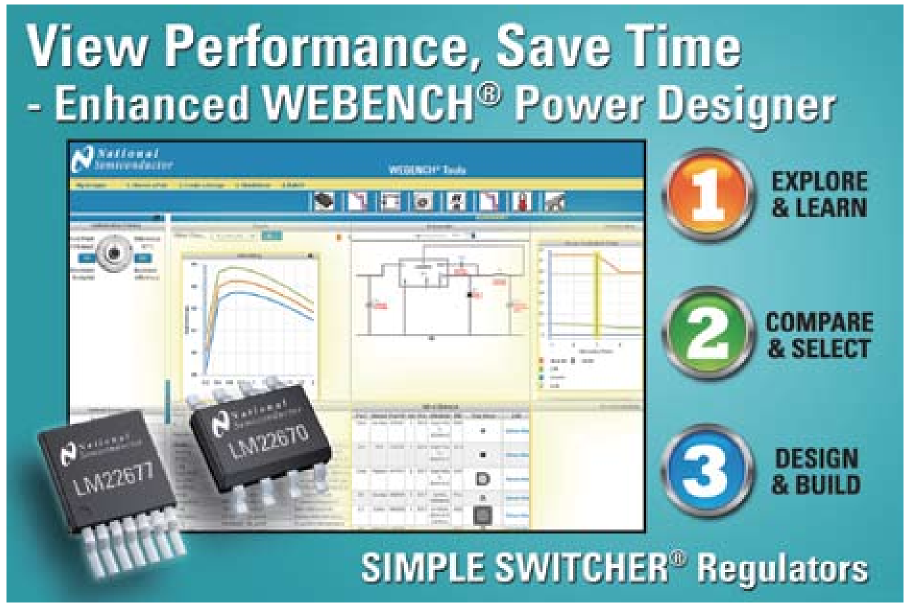
National Launches SIMPLE SWITCHER Families – A Designer's Toolkit

tages for the SIMPLE SWITCHER controllers range from 6V to 42V with output current capability up to 12A. The controllers require minimal external components, which simplifies the design process and reduces the overall solution size. The new SIMPLE SWITCHER controllers feature 93 percent peak efficiency at load, positioning them among National's PowerWise® family of energy-efficient products.

Controller designs are more complex than integrated switching solution designs due to the complexity associated with selecting external MOSFETs. National's WEBENCH® suite of online tools has been expanded to include MOSFET selection and analysis for a quick and easy controller design.

Part #	V_{OUT} Range	Frequency
LM3150	Adj. down to 0.6V	Adj. to 1 MHz
LM3151-3.3	Fixed 3.3V	250 kHz
LM3152-3.3	Fixed 3.3V	500 kHz
LM3153-3.3	Fixed 3.3V	750 kHz





Technical Features

The four new SIMPLE SWITCHER controllers are easy-to-use components to design an efficient, medium-current, step-down power controller. The LM3150, 51, 52 and LM3153 employ a constant-on-time (COT) control topology that eliminates the need for an external compensation network, which reduces external component count and design complexity.

The emulated ripple-mode technology allows for the use of low equivalent-series-resistance (ESR) output capacitors which further reduces system size, complexity and output voltage ripple, providing enhanced electrical performance.

The LM3150 controller features an adjustable output voltage down to 0.6V and programmable operating frequency up to 1 MHz.

The LM3151, 52 and LM3153 controllers feature fixed-frequencies of 250 kHz, 500 kHz and 750 kHz, respectively, and include output currents up to 12A. Each offer a fixed 3.3V output voltage with varying input voltages from 6V to 42V and require just 11 external components for easy design and small system size.

More information is available at www.national.com/switcher.

MOSFET Selection Tool

National's industry-renowned WEBENCH design environment enables power supply designers to easily "dial-in" their size and efficiency requirements while also realizing fast time to market.

The new MOSFET selection tool is the first to provide end-to-end support for switching controller designs, including MOSFET selection, optimization and design simulation. The tool includes technical data on a variety of vendors' devices, allowing the designer to sort and select by thermal parameters, power dissipation and price.

Optimization graphs and charts offer views of the impact of optimizing the design for efficiency or footprint over various operating ranges. The designer can analyze power dissipation of the MOSFETs at different frequencies, efficiencies and footprints as well as over the load current and input voltage operating ranges.

Once MOSFETs are selected and optimized, National's WEBENCH provides electrical simulation of the complete circuit's dynamic behavior in both frequency and time domains. The designer can then run thermal simulations of the complete solution, including the MOSFETs, to analyze thermal characteristics of the design. When complete, a report summary is created and a custom prototype power supply kit can be ordered.

Available now and offered in a 14-pin thermally enhanced TSSOP package, the LM3150, 51 and LM3152 are priced at $2.30 each and the LM3153 is $2.22 each in 1,000-unit quantities.

Input Range	Frequency	Output Current 0.5A	1.0A	2.0A	3.0A	5.0A
4.5V to 42V	Adjustable up to 1MHz	LM22671	LM22672	LM22680	LM22670	LM22677
4.5V to 42V	Fixed 500 KHz	LM22674	LM22675		LM22673 LM22676	LM22678 LM22679

New SIMPLE SWITCHER Regulators

National also announced 11 new SIMPLE SWITCHER® step-down voltage regulators. The voltage regulators are well-suited for a wide variety of applications including automotive, industrial and communication.

This new family offers a wide input voltage range from 4.5V to 42V, which allows for wide-voltage transients from 12V and 24V input rails. Internal compensation and small, low pin-count packages simplify the design process and reduce overall system size.

Technical Features

The 11 new SIMPLE SWITCHER step-down voltage regulators support a variety of load currents from 0.5A to 5A. Designed with voltage mode control, the family comprises the LM22670 through to LM22680. Each provides a fixed switching frequency at 500 kHz and adjustable switching frequency or frequency synchronization up to 1 MHz which allows for electromagnetic interference (EMI) reduction in noise-sensitive automotive, industrial and communication applications. Available in an industry-standard 8-pin PSOP package and new 7-pin TO-263 thin package, the step-down voltage regulators also feature adjustable frequency, precision enable, external soft-start and adjustable current limits.

These 11 new SIMPLE SWITCHER devices are pin-to-pin compatible with National's LM267X series of regulators. Additional information is available at www.national.com/switcher.

New TO-263 Thin Packaging

National's new TO-263 thin package is manufactured from lead-free solder and halogen-free mold compounds. The TO-263 thin package is footprint and PCB drop-in compatible with that of the standard TO-263 package. Overall package thickness is 50% thinner than standard TO-263 packaging (2.00 mm vs. 4.57 mm). It features improved moisture sensitivity levels and comparable thermal performance to the standard TO-263 packaging. Available in standard tape-and-reel, the package received industry approval from the JEDEC JC-11 committee in May 2008 under registration number 10-447.

Availability and Pricing

Available now, the 11 new SIMPLE SWITCHER regulators range in price from $1.30 to $3.25 in 1,000-unit quantities. www.national.com.

Enhanced Power WEBENCH Design Environment

WEBENCH has now been expanded to include enhanced optimization tools including bill-of-material components charts, efficiency and footprint graphs and the ability to output a fully formatted report summarizing the design.

Real-time electrical simulations now feature enhanced waveform processing that enables designers to see the electrical behavior of the circuit under dynamic conditions such as load transient, line transient or start up. Bode plots are also provided to evaluate and optimize loop stability. Thermal simulation enables engineers to track and solve thermal challenges in a design through the use of copper heat sinking, air flow and copper thickness.

National has added optimization graphs and charts to the WEBENCH design environment, which allow designers to view the impact of optimizing the design for efficiency or footprint. The tool graphically shows the efficiency, footprint, component power dissipation and frequency for different design scenarios.

These charts offer views of the electrical properties such as efficiency, output voltage ripple, duty-cycle and power dissipation over a range of output currents and input voltages. This feature lets designers quickly view design tradeoffs and select the best design optimized for their needs.

When the design is complete, a report summary is created and a custom prototype power supply kit can be ordered.

www.national.com

Saving Precious Energy

One milliwatt at a time

I asked Paul Lones, VP, Worldwide Information Technology of Fairchild Semiconductor about the huge amount of energy consumed by datacenters. It seems a strange situation where we demand more processing power on one hand and demand less power consumption with the other. Not only this, but as processors run faster and dissipate more heat, air conditioning needs to be increased to keep the temperature within safe operating limits. Paul explains how it all started at Fairchild.

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

The need for energy efficiency is a global reality, driven by both consumer and business demand. Cost is only one factor. Increasingly, awareness of the environmental impact of our activities fuels this demand as well. The semiconductor industry plays a key role in increasing the energy efficiency of many products from cell phones to appliances to industrial equipment. Semiconductor suppliers can leverage this technical activity to develop a workable economic model for fostering green practices in the workplace. Nowhere is this more evident than in information technology.

At Fairchild Semiconductor, we first came to this realization while pursuing other business objectives. In looking to reduce maintenance and support costs in our own data centers, we assessed the best way to utilize our servers and have adopted virtualization technology that allows more than one application to operate on a server. Virtualization allows the sharing of systems among multiple applications and this ability in combination with the advances in servers leads to the conservation of energy. Today's computer hardware was originally designed to run only a single operating system and a single application, but virtualization makes it possible to run multiple operating systems and multiple applications on the same computer at the same time.

Coupled with the relentless march of technical advances in IT hardware

capability, Fairchild was able to reduce the number of servers and the types of servers in our data centers even though we were nearing capacity before our changes. Semiconductor solutions that have been adopted by server hardware designers, such as Fairchild's Green FPS™ and Power-SPM™, have improved the energy efficiency in servers in all modes of operation (active, standby, sleep, etc.).

In our quest to upgrade and make better use of our servers, we have not only reduced maintenance and support costs, but found we were also able to reduce energy consumption by 45 percent and realize a significant space savings as well. While initially this was an unexpected bonus, we recognized that leveraging some of the same technical advancements we see in our own products, our systems selection and installation approach could further increase the value to Fairchild through reduced energy costs and environmental impact.

Sometimes the decision has to be taken to retire older servers and equipment that will not make the grade, in terms of performance and efficiency. Our whole industry has moved forward at such a pace in terms of low power consumption, higher efficiencies with better cooling and air-flow techniques. Manufacturers of modules and ancillary equipment that make up today's systems are under huge pressure to design and develop for high performance, low power, and high efficiency. Software developers are under similar pressure, and so collectively we move ahead. The market is highly competitive.

As a result of our quest to upgrade, the entire IT team at Fairchild has assumed the mantle of environmental stewardship. In the review of hardware and software acquisitions, we have incorporated energy efficiency into our formal assessment process. We also have initiated an internal program where we recognize and reward documented increases in energy efficiency and reductions in environmental impact. This elevated awareness has helped spread best practices that are being implemented across our IT groups worldwide.

We have found that many individuals are inherently attracted to energy conservation and enjoy the engineering challenge of combining energy savings with meeting other technical objectives. By pooling our collective knowledge and looking at business practices in a more holistic fashion, we can make tremendous in-roads into reducing costs and our environmental impact. Our business practices have demonstrated that it is economically sensible and profitable to care about the environment.

This paradigm shift in 'greening' our IT requires a change in mindset and behavior. It is our individual and collective responsibility as a business to incorporate energy conservation into business decisions. We continue to show our IT team that even small changes in business behavior can make a tremendous difference. As renowned anthropologist Margaret Mead once said, "Never doubt that a small group of thoughtful, committed citizens can change the world; indeed, it's the only thing that ever has."

Paul's final comment: "As semiconductor suppliers, we all need to consider how we can help save our world, one milliwatt at a time."

Paul aptly calls this the 'virtuous cycle' where one good thing leads to another and then another. At Fairchild it looks like a very positive power avalanche is already in progress.

www.fairchildsemi.com

Cabinet Reduces Power Consumption, Boosts Reliability

I met recently with Mike Kania, Director of business development for Eltek Valere, a leading power system provider for telecommunication and industrial applications, about their most recently launched and upcoming products.

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

Eltek Valere has announced the 3030 cabinet family, a line of outdoor telecommunications equipment enclosures with a variety of environmental systems that can reduce operating expenses and boost reliability.

The 3030 cabinet family has a tailored thermal system which includes air conditioners, heat exchangers and heaters. Carriers can use this advanced thermal system to choose the most cost-effective means to provide consistent environmental conditions for reliable equipment operation regardless of weather conditions. This is the latest addition to Eltek Valere's existing Site Support line of outdoor enclosures. Cabinets contain a smoke alarm and a door alarm with temporary defeat. The cabinet family is designed to meet GR-487 CORE environmental standards.

Optional features include air conditioner options, heat exchanger option, DC venting systems, mounting plinth, top and side cable access and modular protection panels.

DC Power System for Central Offices with Unique Pyramid Bus Structure

The company also announced Powerpack Scalable, a new fully integrated DC power system for central offices, mobile telephone switching offices (MTSOs), data centers and other high-capacity computing/networking centers.

The new system can scale up to 10,000 amps and is optimized for facilities where high power needs and easy expandability are important.

Powerpack Scalable is a brand new system based on Eltek Valere's three-phase, 48V Powerpack rectifiers which are rated at 200A and offer 93.5 percent efficient (max.) power conversion with available 208VAC or 480VAC AC input options. Using three-phase power, the Powerpack rectifiers provide more reliable and evenly distributed power.

The rectifier bay is a compact and easily upgradeable system that can accommodate up to 15 Powerpack rectifiers and provide up to 3,000 amps in a single bay. The design of the rectifier bays is also optimized with easy rear access and flexible load distribution to make expanding the number of rectifiers in the bay easy.

For larger power implementations, the Powerpack Scalable plant has a unique pyramid busbar structure that enables multiple rectifier bays to be joined to offer up to 10,000 amps of power for growing telecom or enterprise power applications. The pyramid busbar was developed by Eltek Valere in response to challenges its customers were having with interleaved busbars that required special equipment to expand, making them difficult to upgrade in the field.

With the XC2100 controller, the system can be monitored and configured remotely over an IP network. Each rectifier also has an LCD screen for local configuration and monitoring.

High Efficiency "Green" Version of Leading DC Power System

The V-Series HE is a series of rectifiers offering more than 95% efficient power conversion. The V-Series HE debuts as Eltek Valere's second product line to adopt high-efficiency technology. This is a standalone, 48-volt AC-to-DC power rectifier and battery charger that provides up to 1,000 Watts of power for telecom applications. It features a voltage input range of 90-264 VAC and a power output of 20.8 Amps. The rectifier provides full digital control, with a simplified structure and more intelligent monitoring.

The family is fully compliant with Eltek Valere's Compact DC Power System, Integrated DC Power System and Modular DC Power Systems. They are installed in thousands of wireless and remote terminal locations worldwide.

The V-Series HE also features the BC controller for complete remote and onsite monitoring of the rectifier and other system elements. In addition, the rectifier includes a self-protective feature that allows for adjustment to output power depending on temperature and input voltages.

The V-Series HE Rectifier Module V1000A-HE will be available in February 2009 from Eltek Valere and its resellers worldwide. All V-Series rectifiers have a CE mark, are UL recognized and are NEBS compliant.

www.eltekvalere.com

New 3030 cabinet.

Eltek ValereV1000A1HE.

Powerpack Scalable.

Simulation for Easy Power Supply Designs

ADIsimPower^{TM} helps designers build optimized power supplies

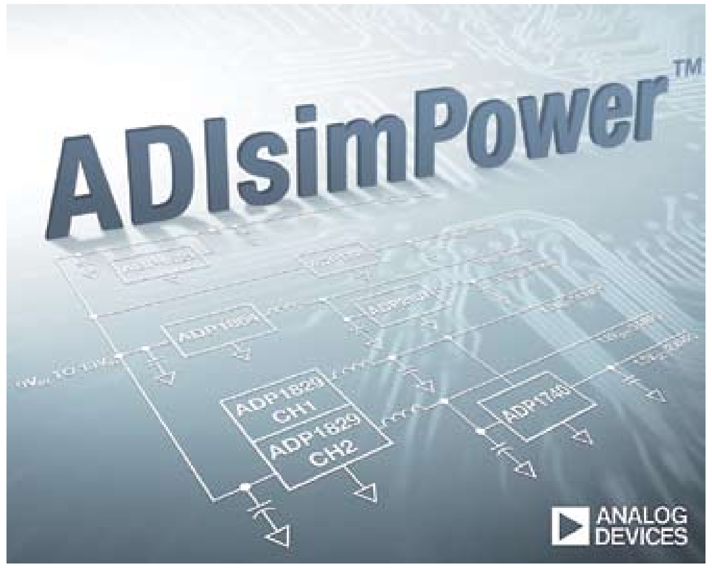
For several decades, sophisticated power electronics is being designed into equipment that we use in our day-to-day lives and white goods are no exception. More and more electronics is embedded in consumer appliances and the trend is growing. In the past, the main purpose of embedded electronic power circuitry was simply to drive the power element such as the motor in a washing machine or to control the temperature of a heating element. Now it is a vital performance and environmental issue.

By Bertrand Campagnie, Field Application Manager, Analog Devices, France

Today, sophisticated electronics is already heavily entrenched in the man-machine interface, using for instance capacitive keyboards or LCD displays. In the future, to make these compliant with home automation requirements, the white goods sector will exhibit a huge growth in electronics dedicated to "smart" features such as diagnostics, programmability, remote control and for sure, communications. The designers of white goods will have to deal not only with relays or IGBTs, but also with memories, processors, FPGAs and possibly hard or solid state disks, all having their own power management requirements and constraints.

Insert ADIsimPower-Theme-Graphic

To serve these new needs in terms of power management, the simplest solution is to use power modules. Many of them are available on the market, offering a wide variety of output currents and voltages. But in many cases, these modules will not be the optimal candidates, mainly due to cost reasons. They are usually more expensive than "pseudo-discreet" solutions, and for high volume applications, it is worth spending a little time to develop a "hand-made" power supply with standard regulators or controller ICs. In addition of cost savings, it will not only give the flexibility to "tune" the power supply and exactly match the system's needs in terms of output voltage, output current, voltage sequencing but also in term of efficiency which is a more and more important parameter of today's designs.



Nevertheless, the design of a high efficiency and cost effective power supply is not an easy task and requires a great deal of expertise and creativity. With the constant race for productivity and today's resource constraints, the design team usually has the huge task of dealing with all sections of the signal chain, but often the designer of the power supply is not necessarily a power management expert.

A new design tool

To help the engineer to design new power supplies, Analog Devices now offers a web based tool which requires no registration and no login, called ADIsimPowerTM. This tool guides the user through a four-step process that will result in providing the key elements of the design including schematic, bill of materials, efficiency data and associated performance data. It is available on Analog Devices' web site, at the link www.analog.com/power.

As mentioned by an Analog Device employee, "This tool is so accurate that it is used internally". This software is not only for inexperienced engineers, but also a reliable tool that even seasoned designers can use to make their life easier. Analog Devices' Engineers have effectively observed close correlation with hardware they build. The predicted efficiency is generally within 1% of the measured value.

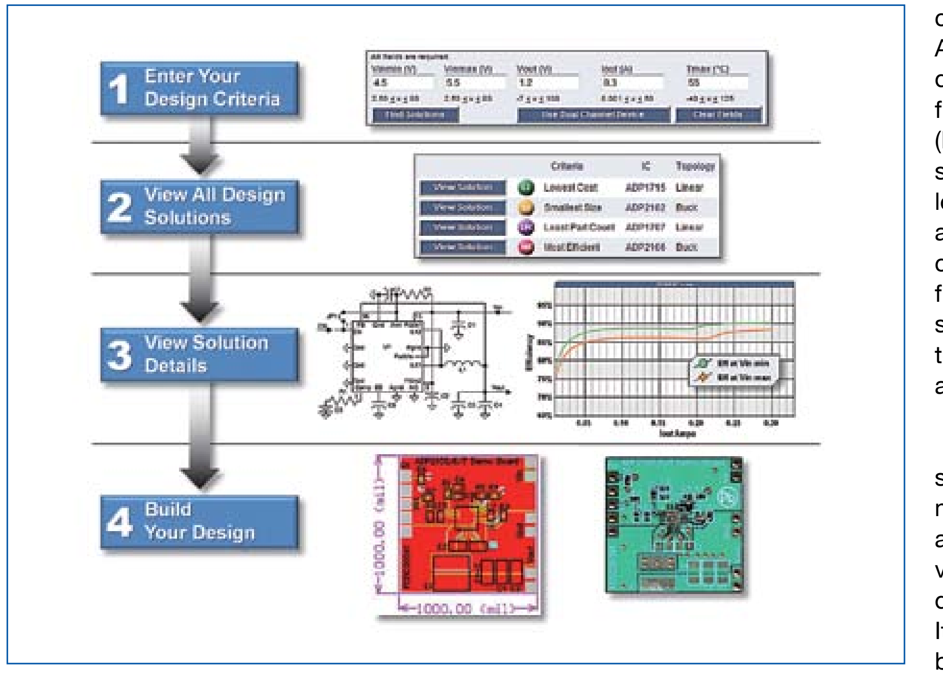


Figure 1 : Four-step simulation process.

In a first example, let's use the default configuration and let's assume the designer wants to build a power supply that can generate 1.2V with a current of 0.3A from a source voltage between 4.5V and 5.5V. For such a requirement, several solutions are available on the market, but the designer certainly has no time to test them all. Depending upon whether efficiency, cost or board space is the key factor, the choice would have to be different. Of course, it is obvious to tell that a solution based on switching regulators will be more efficient than a solution based on LDO's, but among the myriad of switching regulators on the market the choice is not at all straightforward. This is where a simulation tool like this becomes so valuable.

With ADIsimPower^{TM}, after having filled in the design criteria, several choices are suggested by the software: two of them are based on LDO's (ADP1715 and ADP1707 in this case) and the two others are based on switching regulators with integrated FETs (ADP2102 and ADP2106). These suggestions are stamped with labels representing four characteristics: Lowest cost, Smallest size, Least parts count and Most efficient. So, depending on what are the most important criteria, the user can select the solution which is found to best match his or her requirements.

Let's assume the efficiency is the key parameter here. By selecting the corresponding option, we get a schematic based on the switching regulator ADP2106. This device is a low quiescent current, synchronous, step-down dc-to-dc converter with integrated FET, which is suitable for an output current of up to 1.5A. It is packaged in a compact 4mm x 4mm LFCSP package. At medium to high load currents, these devices use a current-mode, constant-frequency pulse-width modulation (PWM) control scheme for excellent stability and transient response. At light loads conditions, the ADP2106 uses a pulse frequency modulation (PFM) control scheme that reduces switching frequency to save power. The power switch and synchronous rectifier are integrated for minimal external part count and high efficiency.

In addition to the schematic, the software provides parameters such as maximum ripple voltage at the output, and also gives the "actual versus target" values for voltage, current and power. A detailed bill of materials is also provided. It includes not only the active devices, but also all the passive parts, with the required space on the PCB and approximated cost estimation.

Among the most useful data provided by this software there are two graphs: the first curve gives the efficiency versus the output current (see an example at figure 3), and the other shows the power losses. With the help of these simulations and graphs, the designer can see immediately that with a solution based on the ADP2106 requiring 71mm^2 on the board, the efficiency will be in the range 88% to 90% for an output current of 0.3A. If we compare with the simulation results of the solution based on the ADP2102, best candidate regarding the size, the efficiency would be about 87% in the same conditions, but the board space would be much smaller: only 17mm^2 (versus 71mm^2 for

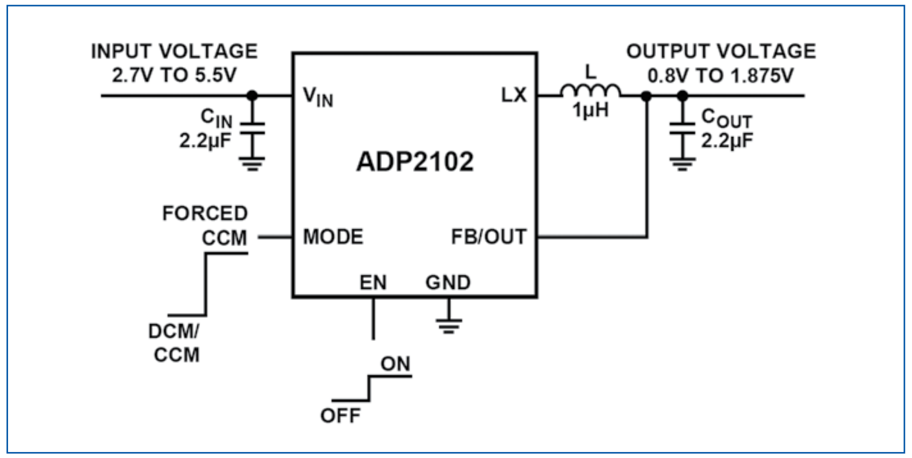


Figure 2: Example of tiny circuit based on the ADP2102.

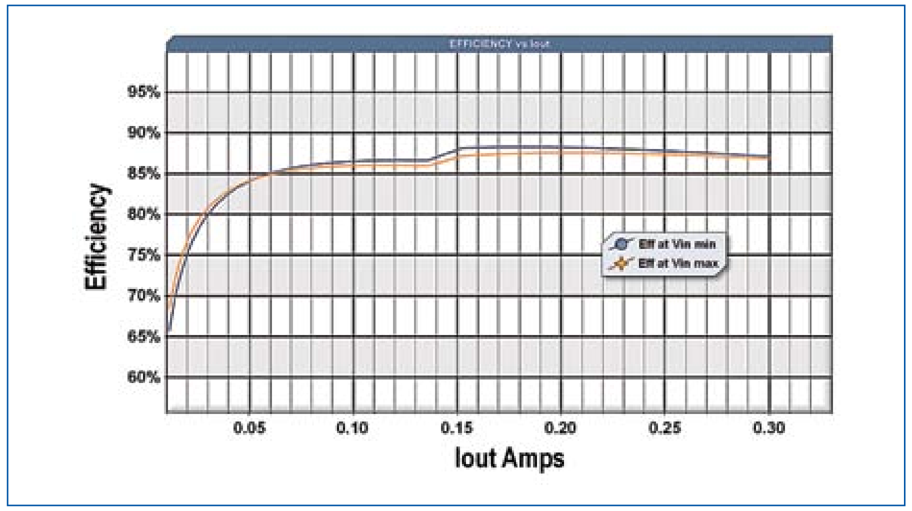


Figure 3: Example of efficiency curve provided by ADIsimPowerTM.

the ADP2106). This difference can be explained by the 3MHz switching frequency of the ADP2102 which results in using smaller values for inductance and capacitance.

As a conclusion, the user may end up in choosing to lose a few percent of efficiency in order to achieve a solution at least 4 times smaller!

Cost can be a decisive element too, and for that the software provides cost information based on 1K prices. With higher required volumes it is simply a process of contacting the local Analog Devices representative or a distributor.

Even though this simulation software gives highly accurate and reliable data, it is always good practise to validate the design by a "real" experiment on an evaluation board. That is why in the last step of this design tool, the user can either order an evaluation board that exactly matched his design, or use the provided layout schematics to build it.

For higher output current

For applications that require a higher output current, the proposed candidate is the ADP1864, at least for power supplies up to 5A. The ADP1864 is a constant-frequency current-mode step-down dc-to-dc controller that is available in a 6-lead TSOT package. It drives an external P-channel MOSFET that regulates an output voltage as low as 0.8V for up to 5 A load current, from input voltages as high as 14V.

The ADP1864 provides system flexibility by allowing accurate setting of the current limit with an external resistor. It includes an internal soft start to allow fast power-up while preventing input inrush current. Additional safety-features include short-circuit protection, output over-voltage protection, and input under-voltage protection. Current-mode control provides fast and stable load transient performance, while the 580 kHz operating frequency allows a relatively small inductor to be used in the system.

As with over 30 LDOs and several other switching regulators and controllers, the ADP1864 is fully described by its model in the simulation tool, allowing the user to fully simulate power supplies using this part.

If a still higher current is needed, let say in the range of 4A to 20A, the software recommends candidates that belong to the ADP182x family: the ADP1821/ADP1828 are recommended for single output supplies and ADP1822/ADP1829 for dual output supplies. At the time of writing, the simulation tool does not fully support these versions. It suggests the product as a possible option but the full simulation is not yet possible. Nevertheless, the corresponding models will be implemented very soon.

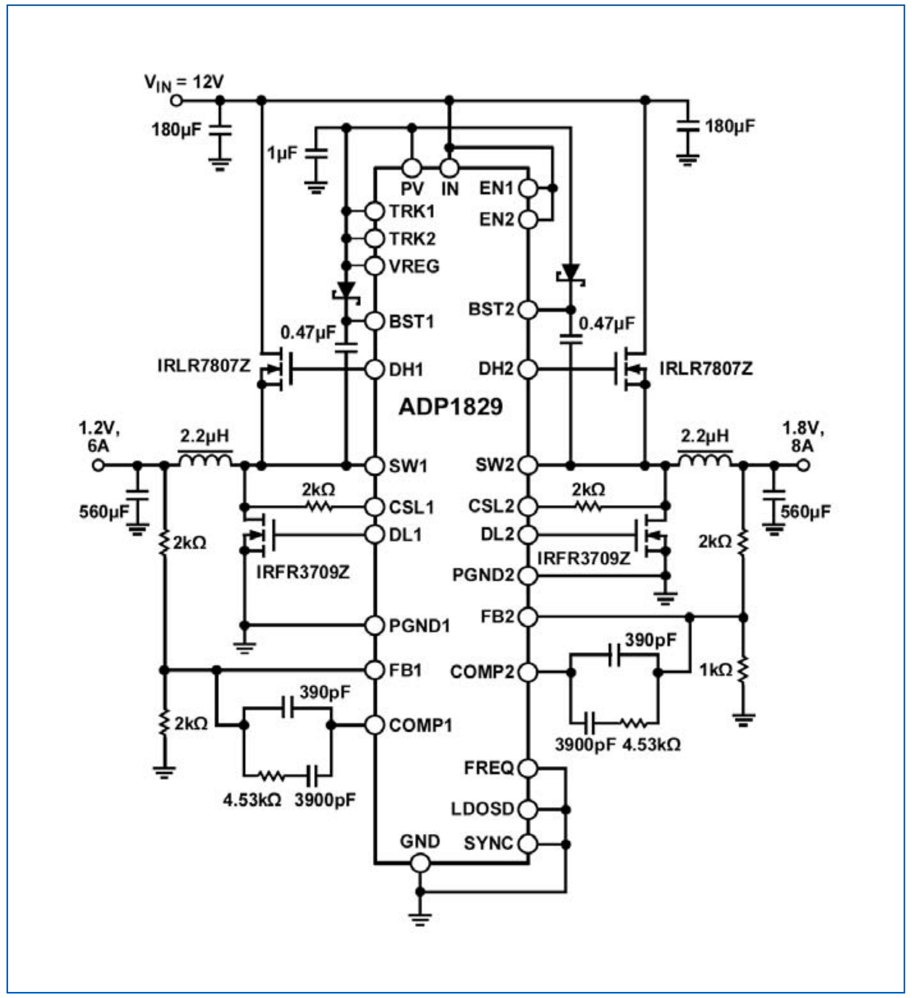


Figure 4: Dual, high output current solution based on the ADP1829, soon to be supported by the simulation software.

For a single output, the ADP1828 is similar as the ADP1821 but it supports a wider chip voltage range (to bias the IC), eliminating some external circuitry. The package has also more pins, and thus it is more feature rich and owns for instance Power Tracking pins, so convenient for adequate sequencing when multiple power supplies have to simultaneously rise at power up, and stay within a given limit of voltage difference.

As an example, let's look at the ADP1829. This product is a versatile, dual output, interleaved, synchronous PWM buck controller that generates two independent output voltages from an input voltage between 3.0V and 18V. Each channel can be configured to provide output voltage from 0.6V to 85% of the input voltage. The two channels operate 180° out of phase, which reduces the current stress on the input capacitor and allows the use of a smaller and lower cost input capacitor.

The ADP1829 operates at a pin-selectable fixed switching frequency of either 300 kHz or 600 kHz. It can also be synchronized to an external clock to achieve switching frequency between 300 kHz and 1 MHz.

The ADP1829 includes an adjustable soft start to limit input inrush current, voltage tracking for sequencing or DDR termination, independent power-good output, and a power enable pin. It also provides current-limit and short circuit protection by sensing the voltage on the synchronous MOSFET.

About voltage tracking

One of the nice features of the ADP1829 is it capability to manage the voltage tracking. This is not part of the targeted features of ADIsimPower™ but it worth to mention it as it is especially important when the part is generating supply voltages applied on a single integrated circuit, such as the core and I/O voltages of a DSP, a microcontroller or FPGAs. Improper voltage tracking or sequencing may result in generating latch-up condition that usually ends up by the destruction of the powered device.

Two types of voltage tracking are possible with this part: the coincidence tracking and ratio-metric tracking. Coincident tracking is the most commonly used. It limits the slave output voltage to be the same as the master voltage until it reaches regulation while ratio-metric tracking limits the slave output voltage to a fraction of the master voltage. The ADP1829 supports these two modes by simply changing resistance values. It allows the cost-saving of external tracking circuitry… and with the incessant price constraints on equipment these days, even a small saving is worthwhile.

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Regulated Power from a Vehicle's 12/24V Auxiliary Power Port

Powering handheld equipment on the go

Handheld devices powered off a battery are quickly becoming integral to our fast-paced lifestyles. Many of these products can now be conveniently charged within the automobile to increase their versatility. Constructing a power supply that can withstand the harsh conditions within a vehicle is a challenging task. The designer must consider requirements such as size, overload protection, transients, noise and cost. This article will examine issues confronted when providing auxiliary power from a vehicle and TI's straightforward design examples and solutions to safely overcome these obstacles.

By Rich Nowakowski, Product Marketing Manager, Texas Instruments Incorporated

Most battery-powered handheld devices require 5V to charge the Lithium-Ion (Li-Ion) battery with a current less that 1-A. In delivery trucks equipped with portable notepads that capture a customer's signature, the voltage needed may be 12V or higher and at a higher level of current. Although the typical voltage is 12V for automobiles and 24V for trucks, the voltage range from a vehicle's auxiliary power port ranges from 8V to 60V or higher, due to transients. These transients are the result of ignition noise, relays switching, jump starting, and load dump. This sudden release of energy results from the battery's rapid disconnect while the alternator provides charging current to a load. A DC/DC converter that receives power from a vehicle's electrical system must tolerate these transients to prevent component overstress.

Clamping Transients

First, the designer must decide at what level to clamp the voltage and how to implement a protection scheme. The purpose of a clamp is to prevent components such as semiconductors and capacitors from operating in or near their respective breakdown regions. A transient voltage suppresser (TVS) circuit absorbs transient spikes and surges, but the energy absorbed may not be enough to protect the system. A Zener diode that uses a resistor in the current path to limit the current may work at small current levels, but will not be able to withstand transients on the order of hundreds of milliseconds. However, reverse polarity diodes in series with the battery rail are very effective at blocking the negative voltage spikes. To protect the system from damaging transients, a voltage transient clamping circuit along with a wide input DC/DC converter provides an effective solution.

Figure 1 shows a circuit that can tolerate 60V transient and safely clamp the output voltage to 27V, which is then applied to a DC/DC converter to derive 5V. The clamping circuit can be easily tailored by setting the output clamp voltage and capacitance for any load, and then adjusting the control loop [1]. At typical input voltages, the pass element's forward voltage drop is low, which provides a higher efficiency than a linear regulator. The advantages of the clamping circuit approach are its low cost and an abundance of lower input voltage DC/DC converters available.

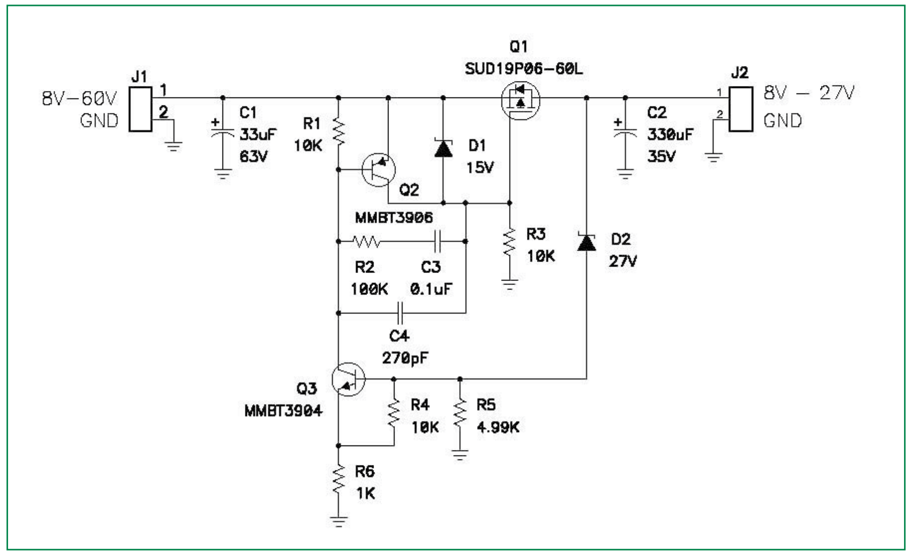

Figure 1: Voltage clamping circuit limits output voltage to 27V.

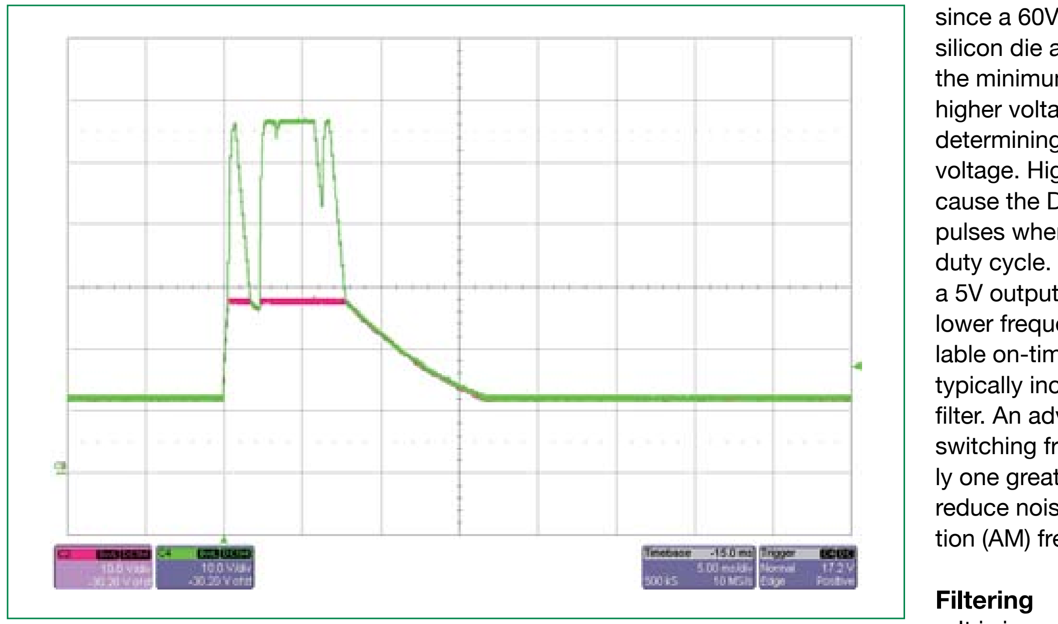

Figure 2. Output voltage is clamped to 27V.

Figure 2 shows the response to a large irregular input voltage transient implemented with the circuit in Figure 1. When the input voltage exceeds the 27V Zener rating of D2, the output voltage is clamped to approximately 27V, rejecting further changes in the input. Care must be taken not to overstress Q1 with excessive voltage, current, and thermal conditions.

Another available option is to use a DC/DC converter that can tolerate a high 60V input and provide a 5V output, such as the TPS54160 from Texas Instruments. The advantage of implementing a higher voltage DC/DC converter is the board space savings by eliminating the clamping circuit to reduce the power adapter size. However, from a cost standpoint, a 60V DC/DC converter is typically more expensive than a 28V or 36V converter at the same current level since a 60V MOSFET requires more silicon die area. It is wise to consider the minimum controllable on-time of a higher voltage DC/DC converter when determining the lowest possible output voltage. High voltage transients may cause the DC/DC converter to skip pulses when it drops below its minimum duty cycle. A 60V DC/DC converter with a 5V output may need to switch at a lower frequency if the minimum controllable on-time is not long enough. This typically increases the size of the output filter. An advantage to using a high switching frequency converter, especially one greater than 1.7MHz, is that it will reduce noise in the Amplitude Modulation (AM) frequency band.

Filtering

It is important to consider conducted EMI (electromagnetic interference) noise in the design of a power supply, especially when placed in a vehicle where AM and FM reception can be hampered. Filtering the power supply is the best defense for reducing the generation of noise. In general, Frequency Modulation (FM) noise is easier to filter due to its use of higher frequencies (80-110MHz). On the other hand, AM noise is more difficult to filter since the frequencies are around the 500 kHz to 1.7MHz range. The AM band poses a problem with many DC/DC converters since the frequencies overlap, as well as the switching frequency harmonics. Newer DC/DC converters switching near 2MHz can alleviate this problem, as long as

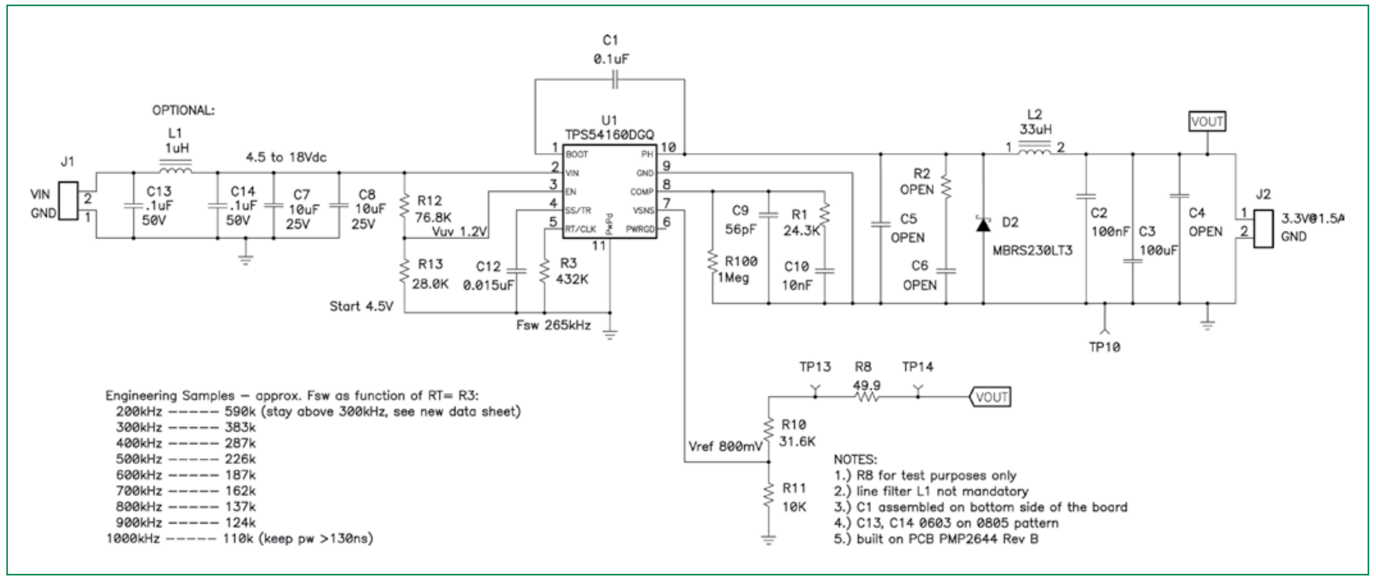

Figure 3. TPS54160 with noise filtering circuitry.

the controllable minimum on-time can support the required duty cycle. Filter design techniques for reducing conducted and radiated EMI can be viewed in SEM1500 Topic 1 [2].

Figure 3 shows an example of a low pass π (PI) filter, a capacitor, inductor and capacitor combination, placed on the input side of the TPS54160 DC/DC converter to help reduce EMI. Inductors are useful for filtering lower-frequency noise, and ferrites are useful for filtering higher-frequency noise. On the input side of the DC/DC converter, the PI filter is implemented with components C13, L1, and C14 in conjunction with additional input capacitors C7 and C8. The switching frequency is easily modified by adjusting the value of R3. By setting the resistor R3 to 56K, the TPS54160 can operate at 1.8MHz and avoid noise sensitive frequency ranges in transportation applications. With consideration of the minimum controllable on-time, a switching frequency of 2.5MHz is possible.

Other Noise Reducing Techniques

Snubber circuits enhance EMI performance of the switching converters by reducing the amplitude of a voltage spike as well as decreasing their rate of change (dV/dt). While some amount of power is dissipated in a typical RC snubber, it does serve the purpose of reducing switching loss in a MOSFET. In Figure 3, provisions have been made for R2 and C6 to allow the implementation of a snubber circuit if needed to reduce switching noise spikes. The techniques of snubber design can be viewed in SEM900 Topic 2 [3].

To help further reduce noise, a bootstrap resistor can be used. Although not shown in Figure 3, a small resistor of several Ohms placed in series with the bootstrap capacitor C1 will reduce the turn-on time of the internal MOSFET, thereby reducing the rising edge ringing of the SW node. However, the trade off is the increased switching loss of the MOSFET which slightly lowers the overall efficiency.

Finally, there is no substitute for a careful board layout when designing a power supply for use inside a vehicle. Good layout techniques can decrease EMI.

Summary

A circuit powered from an automotive electrical system must survive in a harsh environment. There are many obstacles to overcome in the design and construction of what seems to be a simple power supply that charges a battery operated device. This article provides insight to these challenges and provides resources for further study.

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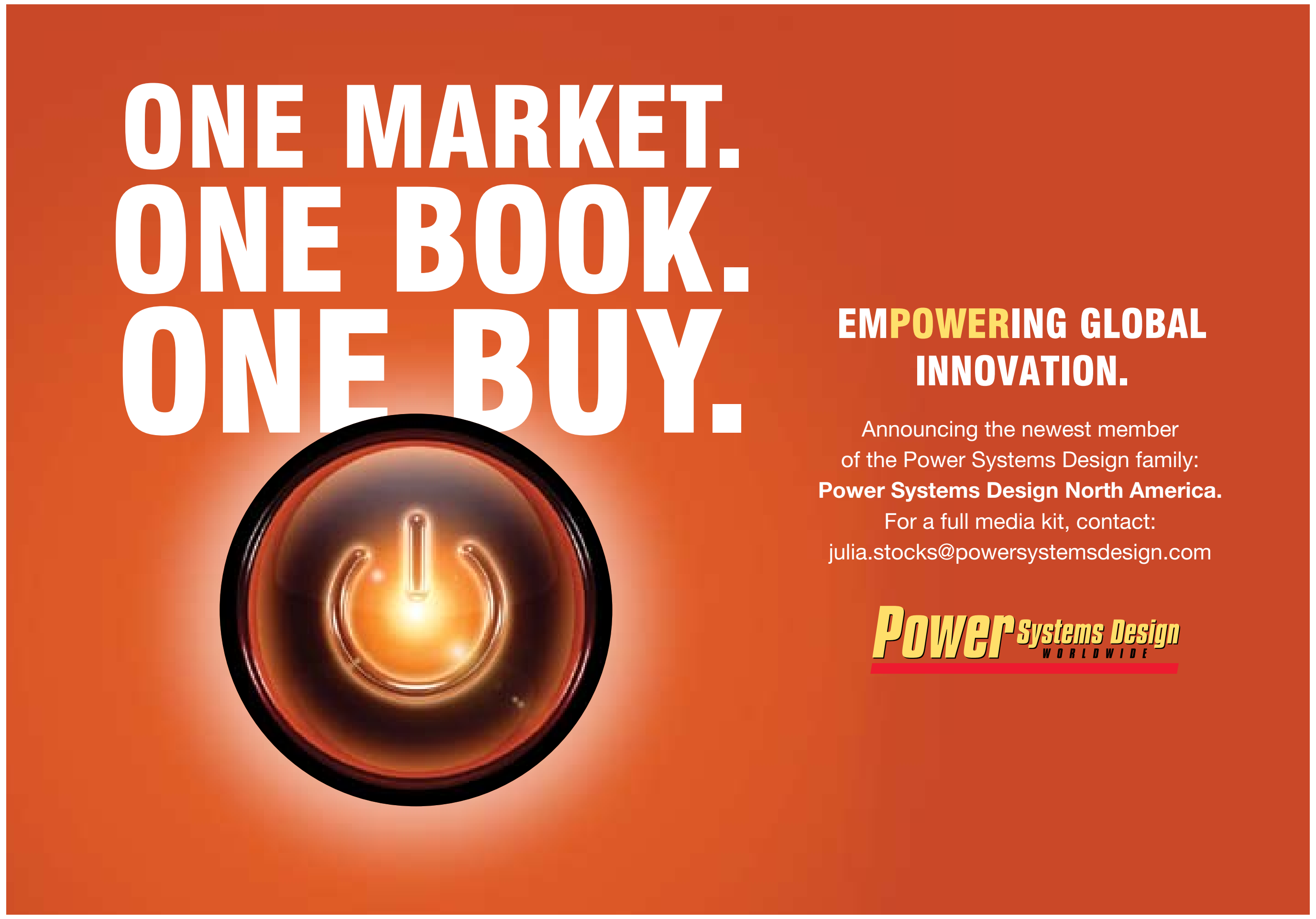

Resonant Power Conversion

Ideal for meeting latest Energy Star v2.0 regulations

Energy Star v2.0 targets single-voltage external ac-ac and ac-dc supplies up to 250 W. Qualifying products must meet criteria for standby mode, active mode, and in some cases, power factor too. It divides supplies into three power levels - $\leq$1 W; >1 W to $\leq$49 W; and >49 W to $\leq$250 W. Recognising that conversion efficiency tends to fall at low output voltages, the specifications further differentiate between supplies such as mobile phone chargers that provide 6 V or less at 550 mA or more.

By John Miller, VP of Business Development, CamSemi, United Kingdom

As beleaguered power-supply designers everywhere recognise, regulatory agencies across the world from Australia and China to Europe and the US have been steadily tightening the energy-efficiency requirements for the external supplies that sustain consumer electronics. The process started with mandatory limits for the standby-mode consumption of wall-adapters and chargers, which the European Commission estimates wasted 8 TW in 1996 within Europe alone - or the output of eight average-sized nuclear power stations - rising to a colossal 14 TW in 2006. Meanwhile, 2003's rolling blackouts in the US elevated electricity consumption to the top of the nation's agenda, with one result being the widespread adoption of its Environmental Protection Agency's Energy Star efficiency requirements. Now we have Energy Star v2.0 to meet, which becomes effective in November 2008 and sets demanding new targets for operating efficiency and no-load power. The broadly similar European Commission's Code of Conduct v3 follows in January 2009.

These requirements almost certainly spell the end of external linear power supplies for consumer electronics, driving designers to find energy-efficient alternatives at the lowest possible implementation cost. And as if the regulators were insufficient drivers for change, the exponentially rising cost of the steel and copper that the large iron-cored transformers needed by linear supplies will finally seal that technology's fate in all but a handful of applications. In the consumer market, such applications have almost invariably included audio equipment and AM-band radios, where switching noise often generates audible interference.

To overcome such issues, a new topology - the Resonant Discontinuous Forward Converter (RDFC) - promises to slash implementation costs while comfortably meeting the new legislative requirements for supplies from 1W to 60W.

Traditional solutions for high-volume, low-power, isolated off-line power supplies use a ringing-choke converter (RCC) or the flyback switch-mode topology. Of these, the RCC is the oldest - see figure 1.

The circuit dates back to the mid-1950s and is very often used in low-cost phone chargers for some of the emerging, less well-known brands. Here, rectified ac line stimulates a transformer-coupled relaxation oscillator. The feedback loop from the top transformer winding controls the transistor's conduction to provide elementary regulation, with the output coming from a separate, isolated winding. The circuit is unable to adapt to efficiently handle light output loads, as its frequency increases as the load level falls to consume more energy relative to the output load.

Off-line flyback converters use a single coupling inductor that stores energy and provides isolation - see figure 2. In this example, a voltage reference and optocoupler provide feedback to a MOSFET gate-driver that controls switch Q1. When Q1 closes, current builds linearly in T1's primary, which appears as an inductor because the transformer's inverse coupling reverse-biases D5. When the control circuit opens Q1, the energy in T1 transfers to the secondary and forward-biases D5. Despite the simplicity of its on-off control loop, with proper design the circuit provides good efficiency across its operating range. Its major disadvantage stems from the hard switching action that creates EMI problems, typically requiring considerable input filtering to quash conducted

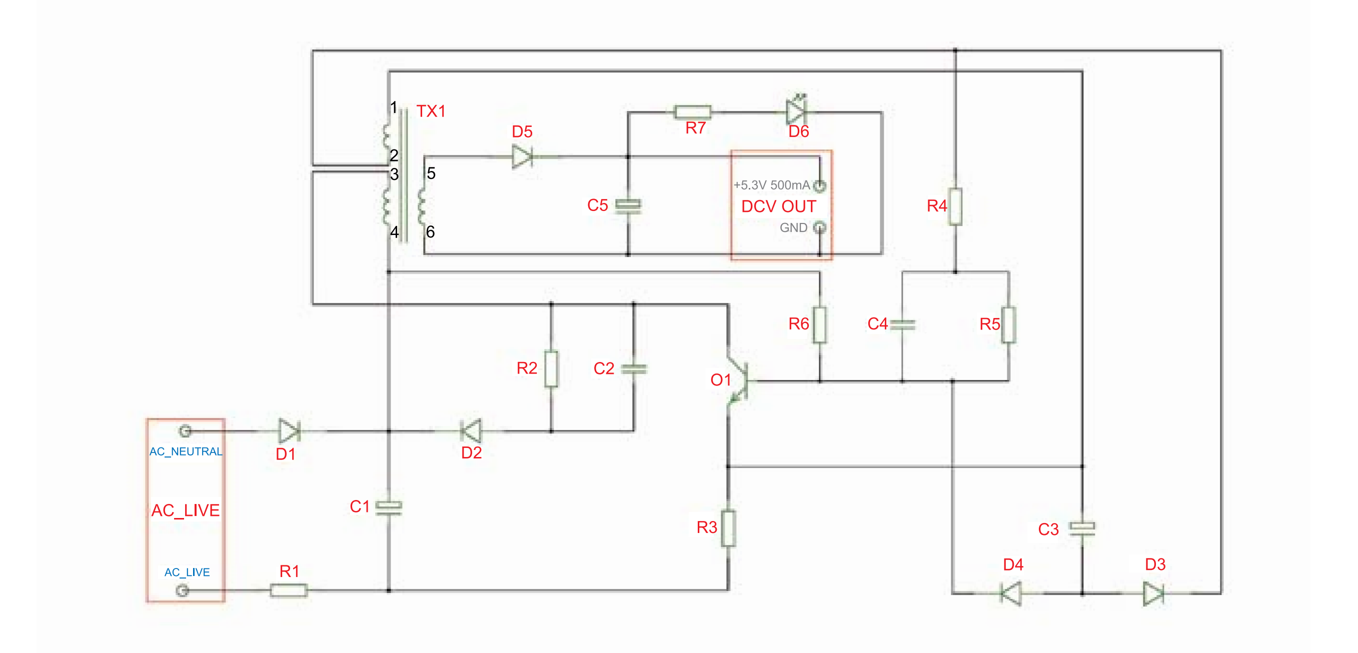

Figure 1. Traditional solutions for high-volume, low-power, isolated off-line power supplies use a ringing-choke converter (RCC) or the flyback switch-mode topology.

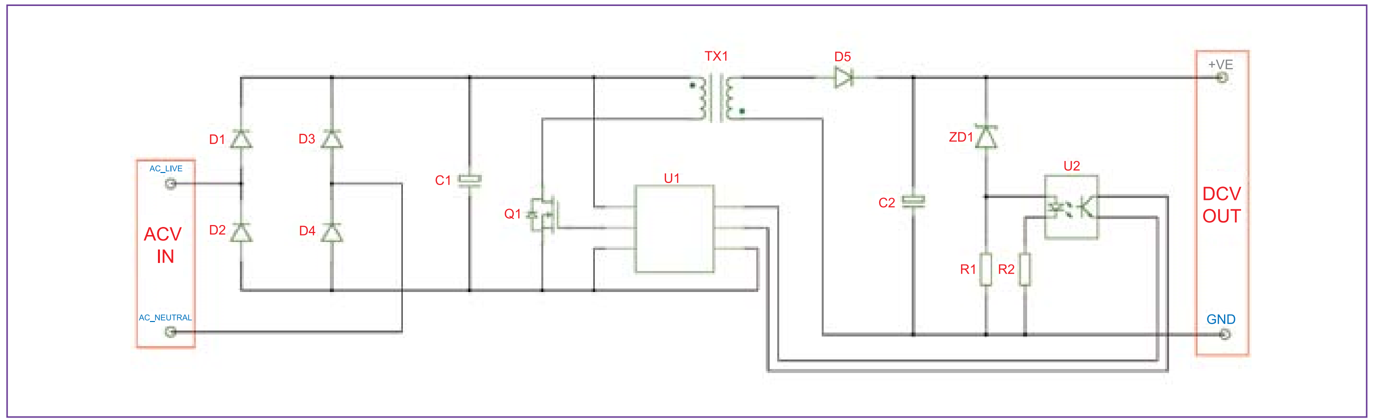

Figure 2: Off-line flyback converters use a single coupling inductor that stores energy and provides isolation.

emissions and careful layout to minimise radiation.

Resonant Converter Basics

By switching sinusoidal waveforms at near-zero levels of voltage and current, CamSemi's RDFC topology avoids hard switching and the attendant EMI issues, yet offers highly efficient operation over the entire load range. Offering comprehensive overload protection, the topology also minimises circuitry to offer a highly cost-effective solution for volume consumer products. Figure 3 shows the circuit elements.

Unlike the flyback converter, the RDFC circuit's transformer operates in forward mode, transferring energy to the secondary when the primary transistor switch closes in the same conduction phase. Because the core is no longer required to store energy, this arrangement allows a reduction in core size compared with flyback for a given power output and efficiency level to help cut BOM cost and save space. At the same time, it also dispenses with the need for a secondary free-wheeling diode and choke.

The transformer is the key component in a resonant circuit that results from its magnetizing and leakage inductances reacting with the sum (C_{RES}) of the input capacitance, the transformer's winding capacitance, and the driver transistor's output capacitance.

When the bipolar transistor primary switch Q1 in figure 3 closes, the current in the transformer charges C_{RES}. The different magnetizing and leakage inductance values (L_X) result in two resonant frequencies according to the formula:

$$F_{RES} = \frac{1}{2\pi\sqrt{L_X C_{RES}}}$$

As the magnetizing inductance is much larger than the leakage inductance, its resonant frequency is much lower than that due to the leakage inductance; 40 - 60 kHz is the typical operating range.

The C2470 controller series controls the charge/discharge cycles to

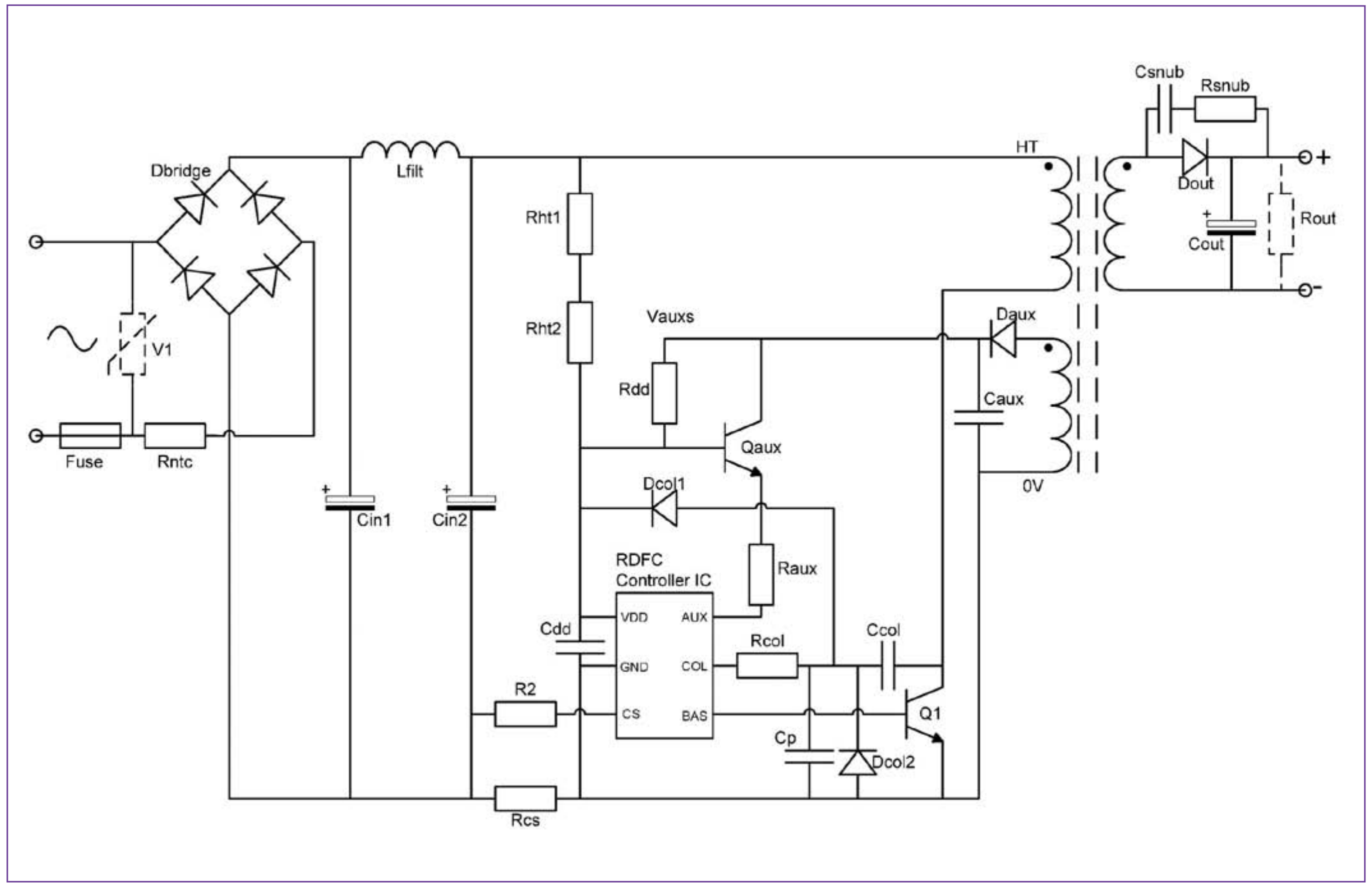

Figure 3: Offering comprehensive overload protection, the topology also minimises circuitry to offer a highly cost-effective solution for volume consumer products.

maintain the RDFC circuit's efficiency across the full range of line and load variations without needing the flyback converter's relatively costly opto-isolator and voltage reference in the feedback loop. An optocoupler and its support components together typically account for around 10% of the BOM cost in a conventional flyback or RCC design so this is a significant saving. However, dispensing with these components also improves reliability as these components cannot then fail – which can cause the flyback converter's output voltage to rise uncontrollably and damage the load circuit.

Available in 6-pin SOT-23 and 8-pin DIP/SOP packages, the C2470 controllers embed six functional blocks - see figure 4.

The V_{DD} shunt regulator supplies the CMOS chip's 3.3 V internal circuits. At system power-on, two high-value resistors (R_{HT1} and R_{HT2} in figure 3) bleed start-up current into this regulator to initiate power conversion. When the system is running, a subsidiary transformer winding generates the auxiliary supply AUX that sustains the chip and provides the base-current drive for the primary switch, Q1. Resistor R_{AUX} sets Q1's maximum base current.

The controller monitors the current flowing in the circuit using shunt resistor R_{CS} and Q1's collector voltage via coupling capacitor C_{COL}. The current-sense loop provides overload protection while the collector voltage waveform

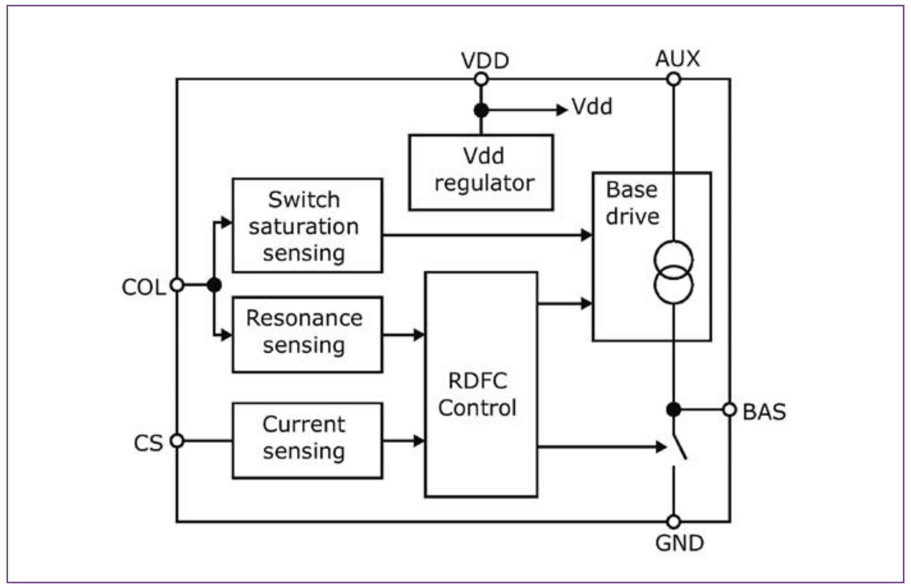

Figure 4: Available in 6-pin SOT-23 and 8-pin DIP/SOP packages, the C2470 controllers embed six functional blocks.

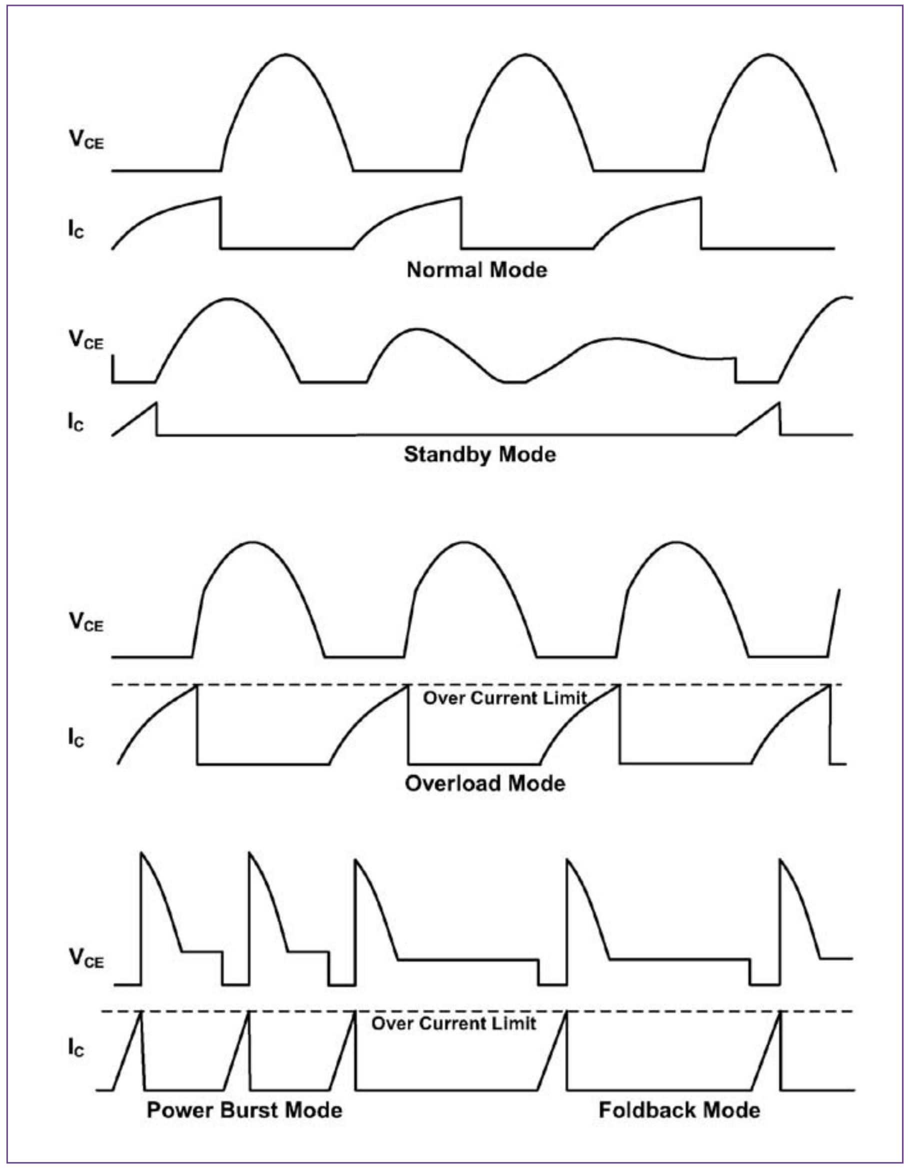

Figure 5: Examples of Q1's collector-emitter voltage and collector current waveforms that accompany the different operating modes.

controls the timing and current levels of the signal on base-driver pin BAS. This driver turns Q1 on and off, with the chip controlling the base-drive current to minimize switching losses. This elegant architecture supports five operating modes, all of which guarantee fully resonant operation:

• Standby - saves power at low loads by progressively reducing Q1's on-time and increasing its off-time as the load falls from about 20% of rated output current.

• Normal - delivers steady-state power from about 20% to 100% of load current rating. The transformer's resonance determines Q1's off-time; the on-time is 75% of the off-time.

• Overload - cuts in at >100% of load current rating to prematurely terminate Q1's on-time, so the output voltage falls. Heavy overloads invoke foldback mode.

• Foldback - entered from overload mode when the output voltage falls to about 70% of nominal level. Q1 switches in a low-duty cycle mode that maintains the AUX supply.

• Power Burst - entered periodically from foldback mode to deliver maximum power for a set number of cycles, permitting the controller to attempt to restart normal mode.

The control algorithm moves seamlessly between these states in response to load conditions, which it senses cycle-by-cycle from the voltage at the chip's CS pin. Figure 5 shows examples of Q1's collector-emitter voltage and collector current waveforms that accompany the different operating modes.

RDFC Slashes Quiescent Power Consumption

Apart from cutting conducted noise, the sinusoidal-waveform, near-zero-voltage switching technique that RDFC uses significantly increases the technique's efficiency compared with either flyback or RCC topologies. Both flyback and RCC converters store energy in the coupling transformer in one cycle and transfer this energy to the secondary in the next cycle. This action creates unavoidable losses in the transformer's core. By contrast, the RDFC topology's forward conversion mode transfers energy in one cycle.

Because RCC and flyback converters transfer energy by discharging the transformer's primary - which acts as an inductor - these designs demand fast switching while significant current is flowing. This hard-switched turn-off causes the output voltage at the converter's primary switch to rise sharply while the power device is conducting a significant amount of current, inherently leading to power losses.

The RDFC converter's near-zero-voltage switching minimises losses as the primary switch turns both on and off. At turn-on, virtually no current is flowing in the transformer's primary when the transistor changes state; and when the transistor turns off, its collector voltage

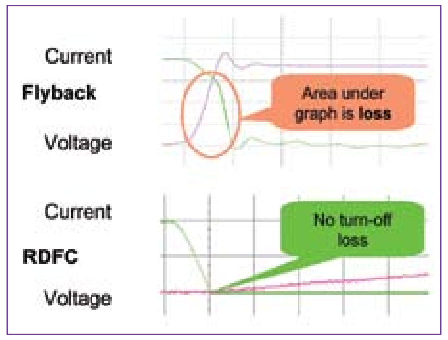

Figure 6: Both state transitions are gradual, allowing the power level to rise and fall smoothly on a cycle-by-cycle basis.

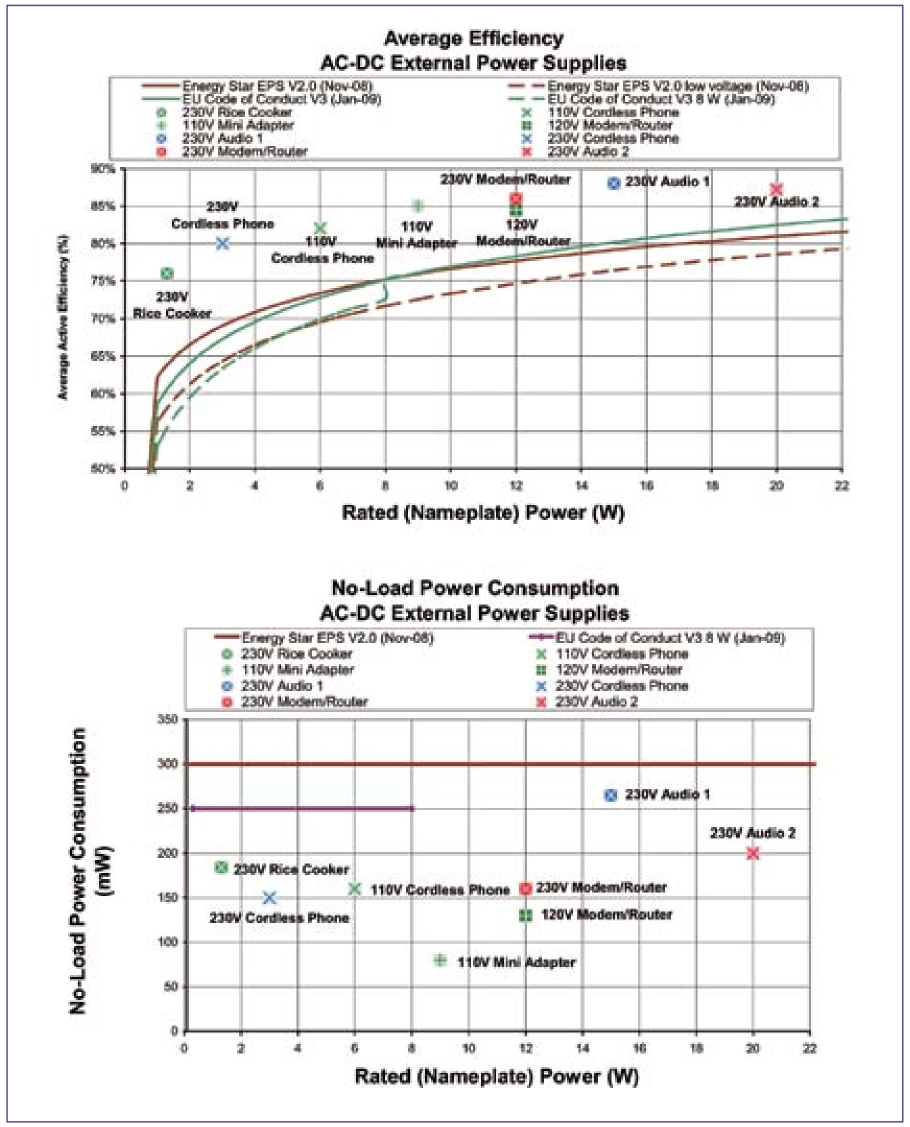

Figure 7:A range of reference designs that provide solutions for representative applications clearly demonstrates the efficiency advantage that CamSemi's RDFC implementation makes possible.

Sample	Nameplate Output Power(P_{no})	Nameplate Output Voltage	Nameplate Output Current	Average Efficiency in Active Mode (expressed as a decimal)
PS 1	0.75 watts	1V	750 mA	0.497 * 0.75 + 0.067 = 0.4398 or 0.44
PS 2	0.75 watts	10V	75 mA	0.480 * 0.75 + 0.140 = 0.5000 or 0.50
PS 3	20 watts	5V	4000 mA	【0.0750 * Ln (20)】 + 0.561 = 0.7857 or 0.79
PS 4	20 watts	10V	2000 mA	【0.0626 * Ln (20)】 + 0.622 = 0.8095 or 0.81
PS 5	75 watts	5V	15000 mA	0.86
PS 6	75 watts	10V	7500 mA	0.87

Table 3: Example of Minimum Average Efficiency in Active Mode.

Nameplate Output Power (Pno)	Maximum Powr in No-Load	
	Ac-Ac EPS	**Ac-Dc EPS**
0 to < 50 watts	≤ 0.5 watts	≤ 0.3 watts
≥ 50 to ≤ 250watts	≤ 0.5 watts	≤ 0.5 watts

Table 4: Energy Consumption Criteria for No-Load.

rises slowly and the collector current level falls, creating a soft-switching action. Both state transitions are gradual, allowing the power level to rise and fall smoothly on a cycle-by-cycle basis. Figure 6 graphically illustrates these effects.

Furthermore, as the load on the RDFC circuit falls to zero, the controller progressively reduces the switch's on-time and increases its off-time. This load-adaptive strategy is a major contributor to the topology's ability to so easily meet the standby-mode power consumption demands that the new specifications impose. Implementing the controller in a 3.3V CMOS process minimizes its own power consumption, allowing a simple auxiliary transformer winding and few components to derive its power supply.

A range of reference designs that provide solutions for representative applications clearly demonstrates the efficiency advantage that CamSemi's RDFC implementation makes possible. Figure 7 shows the margin that these designs achieve when plotted against the efficiency levels that the new standards demand.

In general, the active-mode efficiency figures are easy to meet, as the specification's Table 3 shows:

The examples in this table span a mere 44% for a 1 V/0.75 W supply to a more typical 87% level for a 10 V/75 W supply. However, the maximum standby-mode levels that the specification's Table 4 demands are typically far harder to achieve:

The European Commission's Code of Conduct v3 has several detail differences, notably not discriminating between ac-ac and ac-dc supplies to adopt the ac-dc limits from Energy Star's Table 4. Also, the EC specification subdivides supplies of 8 W and less into a separate group that has standby-mode requirements of 0.25 W to the end of 2010 and 0.15 W after that time.

Interestingly, neither specification targets supplies that are internal to the equipment or multiple-output external supplies, although devices such as set-top boxes and audio equipment already have standby-mode requirements of 1 W. The duration of this situation is currently a matter of conjecture, but industry wisdom suggests it will not be for long.

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Design Considerations for System Management Implementations

Power and thermal management can no longer be an afterthought

As smaller process geometries drive multi-volt devices and increase voltage and temperature fluctuation susceptibility, system management continues to gain importance in the design of all electronic systems -- from advanced mezzanine cards (AMC) for ATCA or MicroTCA racks to motion control systems for industrial automation. A collection of seemingly unrelated tasks with the goal of ensuring the proper operation of the system, system management tasks focus on maximizing system uptime, identifying and communicating alert conditions, and logging data and alarm conditions. In markets driven by standards, reliability and uptime are key metrics by which OEMs can differentiate themselves. Among all system management tasks, power and thermal management are the most recognizable.

By Ravi Pragasam, Senior Product Marketing Manager, Actel Corporation

Current system management implementations require a large number of discrete components (sometimes numbering in the hundreds). Occupying large amounts of board space, this collection of fixed-function chips (Figure 1) and discrete components, such as a CPLD, real-time clock, power sequencer, temperature monitor, fan controller, nonvolatile memory, PWM, and configuration memory, must work in concert to create a cohesive solution. In addition to consuming board space, the large number of components adds to both direct (unit cost, assembly cost, and inventory cost) and indirect (design time, procurement, and discontinuation) costs. Furthermore, these hardware-implemented discrete solutions often require component changes and/or board re-spins even for incremental design changes, requiring costly and time-consuming requalification and making it impossible to create platform solutions. With reduced component count, failure rates are dramatically decreased.

The Alternative Approach to System Management

Because system management is not the primary purpose of the typical board, its implementation is often an after thought. Taking a reactive approach to system management (addressing each task individually) will ensure high cost / component count implementation. However, with some forethought, a designer can easily develop a system management solution utilizing programmable system chip (PSC) technology.

Programmable architectures, such as field-programmable gate arrays (FPGAs), continue to outpace market growth, replacing application-specific integrated circuits (ASICs) in many applications. However, careful consideration of the programmable architecture is required.

Despite the flexibility and reprogrammability they can offer, SRAM-based FPGAs require a great deal of hand holding to keep them operational. At power-on, SRAM devices must be configured with their designs and often require voltage sequencing to avoid programming errors or other problems on-chip. Brownout detection is another burden associated with using SRAM-based solutions. Since SRAM FPGAs are inherently volatile, the user must ensure the configuration memory is not upset by voltage dips. For many SRAM-based FPGAs, a voltage variation as little as 60mV is enough to put the device in an unknown state, thereby requiring reset.

These challenges can be avoided by using a nonvolatile flash-based PSC technology. A flash-based mixed-signal PSC, such as the Actel Fusion Programmable System Chip, can perform a host of system management tasks and offer a single-chip implementation, replacing multiple discrete components at less than 50 percent of the cost and board space while maintaining system reliability. Just one of these platforms can integrate and perform all system management functions, removing the 'pain' and burden currently associated with system management. Further, the integrated flash memory of the mixed-signal solutions allows designers to store design files for many different types of FPGAs, eliminating a separate configuration PROM from the board. Further, much like other reprogrammable solutions, a configurable and flexible mixed-signal PSC device enables design changes to be easily implemented whether during development or even after the unit is deployed.

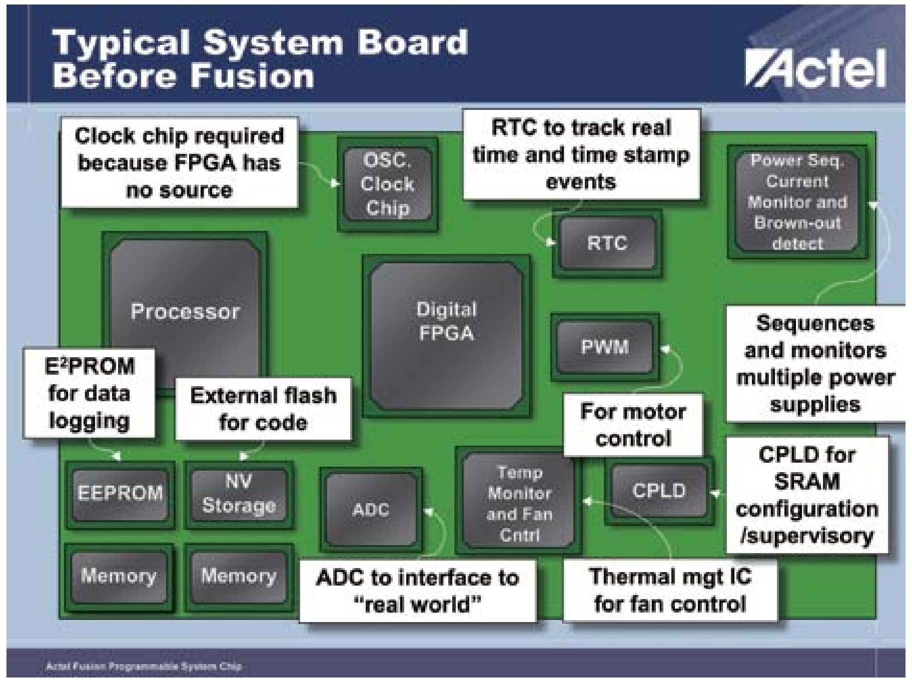


Figure 1. Typical System Management Solution.

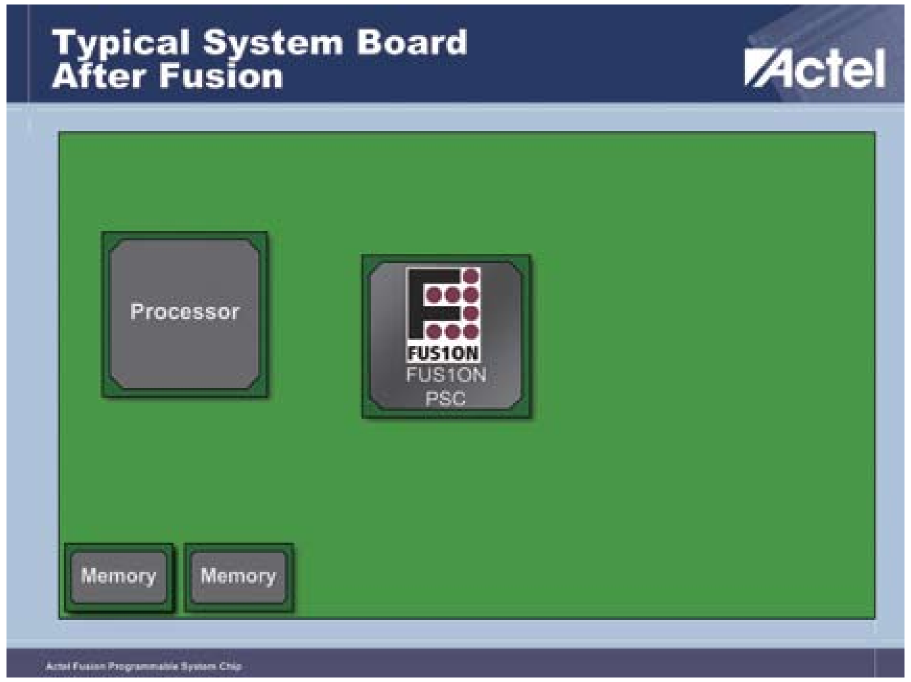


Figure 2. System Management with flash-based, mixed-signal PSC.

Power Management

Power management is one of the most recognized system management functions. Within power management, the tasks include power-on detection and reset, power sequencing, voltage monitoring and trimming and current monitoring. Since none of the power rails have been initialized within the system, a power management solution must be live at power up, flexible, and support single high-voltage sources. As each unique board design has its own set of power management requirements, the power manager must also be configurable to adapt to a board's unique and changing needs.

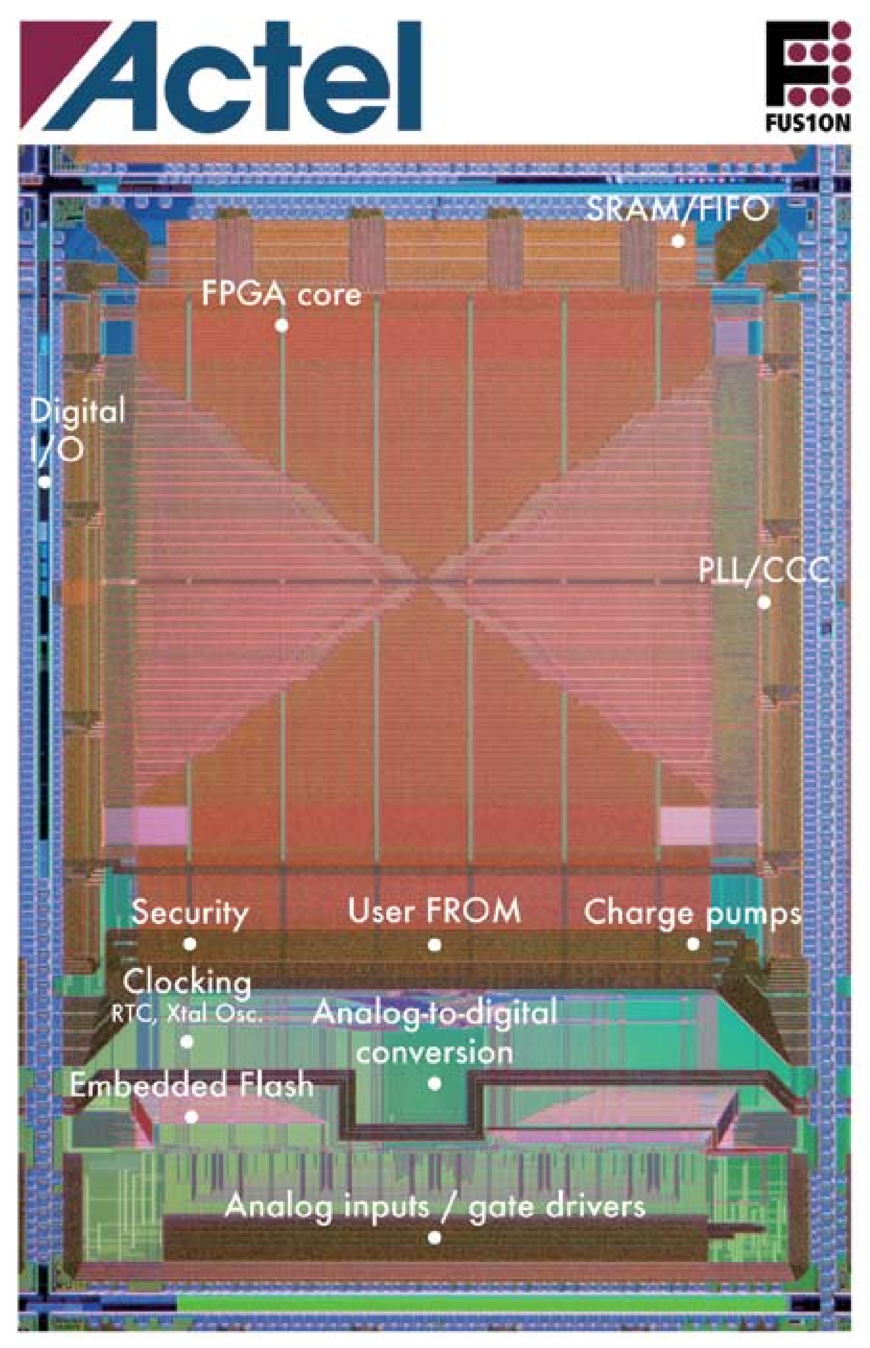
Many systems derive their power from a single high-voltage source. As an example, the advanced mezzanine cards (AMC), common to Advanced Telecommunications Computer Architecture (ATCA) and MicroTCA racks, specify a single 12V power rail from which they derive their needed lower voltages (i.e. 3.3V, 18.V, and 0.9V). The optimal power manager can connect directly to and monitor high-voltage supplies without external support circuitry. The high-voltage process allows for a higher reference voltages to be used in the analog to digital converter (ADC), enabling higher dynamic range.

The specific power sequence and ramp rate can be programmed into a PSC. A flash-based PSC with an analog front end is live at power-up, flexible and reprogrammable and supports direct connection to high voltage signals. Also, because a mixed-signal PSC can easily support multiple functions for the same package pins, current monitoring can be enabled on certain pins or configured as voltage monitors, depending upon system requirements.

Thermal Management

Maintaining the proper environmental operating conditions is a key component to system management. Today's intelligent systems not only monitor and manage thermal conditions, but also distribute system traffic and loading to better balance the system and maximize performance.

With integrated temperature monitoring capabilities, mixed-signal FPGAs allow designers to easily and effectively maintain optimal system conditions, leading to increased uptime and performance with fewer components and reduced cost. Today's mixed-signal PSC solutions are also able to easily monitor up to 10 remote temperatures, reinforc-



Actel Fusion Die Layout.

ing the position that these devices are excellent thermal management solutions. Remote temperature monitoring enables designers to track the temperature of not only power converters and inlet or outlet air, but also processors and power-hungry SRAM-based FPGAs. Additionally, PSCs can handle fan control to enable closed-loop thermal management.

Diagnostics and Prognostics

Despite some of the costs and risks involved, today's typical system can often simply maintain the system. However, historical performance or failures often need to be tracked without adding additional components. Diagnostics and prognostics, or the ability to determine failure modes and predict them, are quickly gaining momentum in system management implementations. Certainly, the ability to read back time-stamped system parameters about board operation or review post-production failure analysis is invaluable to system development. Similarly, the ability to put together a 'black box' for the board would save valuable time and effort when trying to identify failure modes and design weak spots.

The on-chip flash memory of a mixed-signal PSC offers the designer the ability to save and time stamp key system parameters, such as current consumption of power rails, device temperatures, and voltage rail fluctuations. Not only can this data be analyzed post-failure to identify the root cause of failure, but innovative designers are looking to analyze system trends during operation. By analyzing how a particular parameter varies over the life of the board, it is possible to predict a failure before it occurs, thereby increasing system up time.

For example, in a sample motor control application, a designer might measure the current to the windings as well as motor vibration (as a voltage input) to determine when to bring the equipment down in a planned fashion. In industrial applications, a planned shutdown is dramatically less expensive than an unplanned one due to the cost to fix the problem as well as the possibility of lost profit from equipment shutdown. Thus, flash-based mixed-signal PSCs enable designers to send in the repairman before the board fails.

System management functionality, such as power and thermal management, can no longer be an afterthought to board design. Today's discrete and fixed-function implementations incur high design costs, often requiring different components and board-level changes with each minor design iteration. A single-chip, configurable PSC implementation is the ideal system management solution. Nonvolatile flash-based mixed-signal PSCs, like the Actel Fusion family, offer an unprecedented level of integration, reducing component count, board space, and total system cost and thereby increasing reliability and uptime.

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White Goods Part II

PSDE Green Power ENERGY EFFICIENCY

Premium Cooker Hood Lighting Features Power LEDs

Faber uses Luxeon Rebel power LEDs for sleek cooker hood design statement

Power LEDs are now pushing the frontiers of design for living today. When Faber made the strategic decision to design power LEDs into their new premium range of cooker hoods, they found that, by replacing traditional halogen lamps with Luxeon Rebel LEDs from Philips Lumileds, they were able to offer lower energy consumption, a much longer lifetime, a more modern white colour temperature, and a slimmer, sleeker design.

By Steve Landau, Director of Communications, Philips Lumileds.

White goods manufacturer, Faber, is Italy's top manufacturer of cooker hoods for the residential market, and is a global leader in its field with a large export trade through international distribution channels.

In 2007, Faber began intensive development work on a new generation of ultra-slim cooker hoods. The new range was to target the premium segment of the market, for which the key drivers are a distinctive, 'designer' aesthetic and non-standard features. The premium customer wants to own a product that reflects their good taste in design and that sets their home apart.

The specification for the lighting unit inset in the new range of hoods reflected the overall marketing objective. Key features of the specification included:

• A maximum 20mm profile (height). The new range of cooker hoods was to be dramatically thinner than any previously introduced to the market. The unprecedented thinness was to give a sense of elegance and weightlessness, embodied in different product domains by devices such as ultra thin laptops or new generation LCD televisions

• Long operating lifetime for the light source itself. The frequent failure-and-replacement cycle experienced with typical incandescent light sources was incompatible with the high-quality positioning of the new range

• Color temperature which would complement the high-technology, contemporary feel of the overall design.

Special Report – White Goods Part II

Faber invited a long-term luminaire supplier, Hikari of Italy, to provide prototype designs that fitted the specification.

Luminaire design: fundamental considerations

Cooker hoods today use halogen lamps as their light source. Halogen has been favored because it can meet high targets for light output in a smaller form factor than other incandescent sources such as fluorescent tubes or GLS bulbs. The typical color temperature is in the warm-white region, which consumers have in the past preferred to the cool-white typically available from fluorescent light sources.

The new Faber specifications, however, clearly ruled out the use of halogen - a fixture with a tight 20mm headroom would not be able to accommodate standard halogen lamps. This was not the only factor that counted against the typical cooker hood light source, though. Halogen also offers a severely constrained operating lifetime in kitchen applications – a mean time before failure of fewer than 1,000 hours is common.

Faber also wanted a neutral white color temperature to complement the contemporary positioning of this new range of cooker hoods. Warm-white is suitable for traditional kitchen appliances, as it matches the homely, comfortable feel of kitchens in the mass market.

The upmarket consumer targeted by the premium Faber cooker hood, however, typically favors a contemporary kitchen design which emphasises high technology, bright surfaces and neutral tones. While cool-white is too harsh for most tastes, neutral-white complements well the contemporary kitchen aesthetic.

It was therefore clear at the outset to Sergio Macchioni, Technical Director of Hikari, that halogen was unsuitable, and that no other incandescent light source would be able to meet the tight dimensional constraints. He says: 'I knew straight away that only one technology – power LEDs – was going to be able to meet the design specifications. Power LEDs offer the combination of features that we needed – small size, long operating lifetime and the potential to get a neutral-white color temperature.'

If this much was clear, however, the main issue for the design team was to configure the design for optimal performance – and that meant making a choice between a wide variety of LEDs.

Balancing choices to find the right power LED

The factors which drove the component choices of Mr Macchioni's designers arose from the particular nature of the application itself. First, the tight dimensional constraints put a premium on the physical size of the LED. Mr Macchioni says: 'Faber had set themselves a really difficult technical challenge: to accommodate the hood's large components, such as fan motors and blades, filters and housings, inside an incredibly thin casing. That meant that every square millimeter of space that we could free up with our luminaire design would be valuable to Faber. One objective for us, then, was to find the smallest possible LED that could meet the light output requirements.'

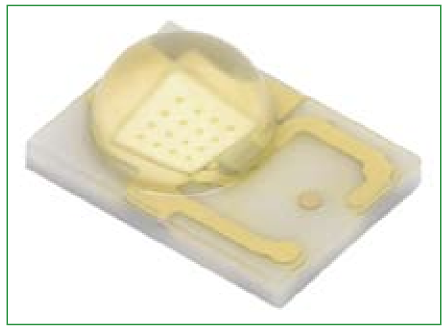
Another challenge was that cooker hood lighting units operate in a very hot, steamy environment. There are wide variations in the performance of different LEDs as operating temperature varies: high temperature reduces both operating lifetimes and light output at different rates with different LEDs. Hikari required a device that offered high performance and high reliability in high temperatures.

Finally, whichever device was chosen, it needed to be available in sufficient volumes. Mr Macchioni says that Hikari wanted to be able to 'trust the manufacturing and distribution capabilities' of its chosen supplier.

The device which best fitted the constraints of the design specification for Faber's premium cooker hood was the LUXEON Rebel LED in Neutral-White from Philips Lumileds. On the basis of lumens/mm^2, LUXEON Rebel LEDs are the best on the market. In addition, multiple LUXEON Rebel LEDs can be safely placed very close together, resulting in the highest light density from an LED system. The small size of the LUXEON Rebel helped Hikari to design a luminaire that occupies both a small footprint and a low profile, thus making it easier for Faber to accommodate the other elements of the cooker hood.

Further, datasheet comparisons showed Hikari that the LUXEON Rebel LED offered excellent performance at high temperatures, both in terms of operating lifetime and light output. This had a crucial impact on one important aspect of Hikari's design: the luminaire's housing, made of cast aluminum, also operates as its heatsink to draw heat from the LED and maintain a safe and efficient operating temperature.

The high tolerance of the LUXEON Rebel for extreme temperatures enabled Hikari to limit the size of this heatsink/housing, and to meet the maximum profile specification of 20mm. In other words, an LED with a lower tolerance for heat would have required a larger heatsink in order to hit the design's targets for light output and operating lifetime. By making use of the high safe operating temperatures that the LUXEON Rebel can withstand, the Hikari team was able to offer Faber greater space savings.



The Hikari luminaire uses Neutral-White versions of the LUXEON Rebel, which answers Faber's requirement for a more contemporary aesthetic than the warm-white of halogen, without reaching the cool-white color temperature of a fluorescent tube.

Mr Macchioni also places a lot of importance on the ability of suppliers to meet the needs of his production department. In particular, the binning arrangements which Philips Lumileds makes for its LUXEON Rebel devices help provide for repeatability and security of supply in manufacturing. Mr Macchioni says: 'We can use Philips Lumileds' binning information to reliably sort shipments of LEDs, and ensure that matching parts - in terms of flux and color temperature - are grouped together in a luminaire.'

Design and reality: the outcome for Faber

The luminaire in the Faber cooker hood is a brilliant engineering and optical solution to an extremely tough design challenge. Thanks to the high light density of the LUXEON Rebel devices and the small heatsink/housing, the luminaire fits the target 20mm profile and occupies a small footprint.

Each luminaire uses two LUXEON Rebel LEDs which produce 80lm/Watt (typical). In the Faber cooker hood, these LEDs driven at 500mA consume a total of 3W per luminaire, while producing the same lux as a 20W halogen lamp.

The expected operating lifetime of the luminaire is 30,000 hours, compared to less than 1,000 hours for the halogen alternative. Furthermore, the LED luminaire will not have failed completely after 30,000 hours, but will simply be expected to have dimmed to below a desired threshold.

A borosilicate glass light diffuser built into the housing/heatsink ensures that the neutral-white light from the LEDs is cast evenly over the whole cooking area, avoiding the 'spotlight and shadow' effect common with halogen systems.

By providing a contemporary light from a source that could easily outlast the product itself, the Hikari luminaire fully supports the premium positioning that Faber is aiming for with its groundbreaking new range of ultra-slim cooker hoods.

These hoods are on sale to the general public as of September 2008. Depending on the success of the range, Faber will next consider introducing LED lighting into its mid-priced range of products.

Hikari is now enjoying a great deal of interest in its luminaire from other manufacturers of kitchen equipment and kitchen furniture, as its suitability for kitchen use is readily apparent.

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Sensorless FOC Makes Sense for Motor Control

FOC helps washing-machine manufacturers achieve up to 95% efficiency

Efficient motor control lies at the heart of the drive to reducing energy consumption and noise in washing machines where the motor is the major power guzzler, drawing as much as 85% of the total power.

By Padmaraja Yedamale, Principal Applications Engineer, Home Appliance Solutions Group, Microchip Technology Inc.

Boosting the energy-efficiency of appliances and reducing audible noise are the top priorities for most appliance manufacturers. Often, this need for efficiency is driven by stringent government regulations, as well as by consumers who are willing to pay a premium for more eco-friendly machines. The challenge for appliance manufacturers is to find a way to increase efficiency and reduce audible noise without adding significantly to their overall system costs.

Advanced motor control techniques, such as Field-Oriented Control (FOC) or vector control can help to achieve these objectives.

Washing-machine control

Most washing machines are based on a drum unit with a BLDC or PMSM motor, a motor controller board, and a user-interface board with a keypad and a display unit, as shown in Figure 1. The commands for controlling the wash load, rinse speed and other actions are sent from the user-interface board to the motor-control board via a serial link, such as UART, SPI or proprietary serial protocols. The motor controller board then makes the relevant adjustments to the motor speed and torque.

Efficient motor control is therefore the key to making appliances more energy-efficient.

DSCs take control

Previously, appliances have been held hostage by a few custom hardware and control techniques, but the development of Digital Signal Controllers (DSCs) and power electronic switches makes variable-speed drives a viable alternative. In particular, the latest generation of dsPIC® DSCs offer peripherals which are optimized for motor-control applications, allowing systems to achieve significant savings in energy consumption and cost. These specialized peripherals include Motor-Control Pulse-Width modulation (MCPWM), a high-speed analogue-to-digital converter (ADC) and scaleable Flash program memory. The dsPIC's DSP engine also supports the fast mathematical operations which are essential for executing computationally intensive control loops.

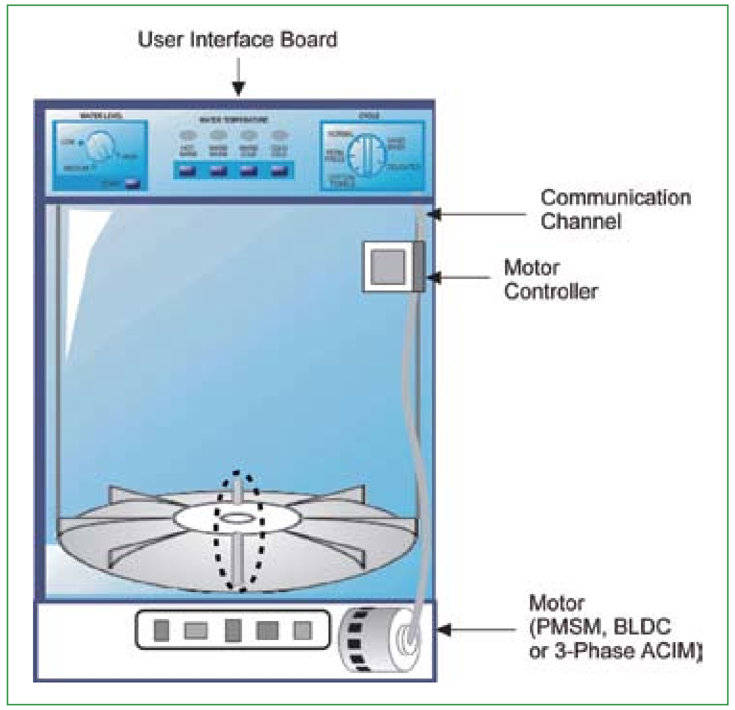


Figure 1: Advanced motor-control algorithms make washing machines quieter and more energy-efficient.

dsPIC DSCs can be used as the signal controller on the motor-control board, whilst the user-interface can be managed by an 8-bit microcontroller (MCU), such as Microchip's PIC16 or PIC18 families. The FOC algorithm can be implemented for either a three-phase AC Induction Motor (ACIM), a three-phase Brushless DC (BLDC) motor or for a Permanent Magnet Synchronous Motor (PMSM).

The construction of PMSM motors makes them inherently more efficient than ACIM. The following example, therefore, demonstrates how to implement the sensorless FOC algorithm for a PMSM motor in a washing machine.

But why use the FOC algorithm? Traditional BLDC motor control uses a six-step method to drive the stator, generating oscillations in the torque. In six-step, or trapezoidal control, a pair of windings is energized until the rotor reaches the next position, then the motor is commutated to the next step. Hall sensors are used to determine the rotor position in order to electronically commutate the motor. The dynamic response of the six-step control is unsuitable for controlling a washing machine, because the load changes dynamically within a wash cycle, and varies with different loads and wash cycles. Also, in a front-loading washing machine, the gravitational power works against the motor load when the load is on the top side of the drum. Only advanced algorithms, such as FOC, can handle these dynamic load changes.

Theory of FOC

The FOC algorithm generates a three-phase voltage as a vector to control the three-phase stator current. By transforming the physical current into a rotational vector using the Clarke and Park transforms shown in Figures 2 and 3, the torque and flux components

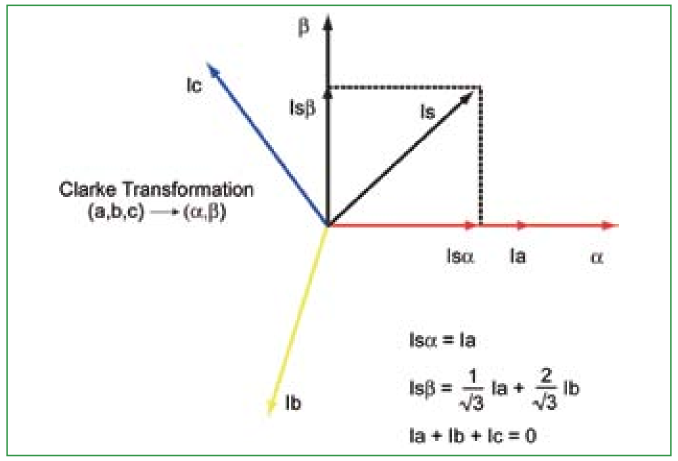


Figure 2. Clarke Transform.

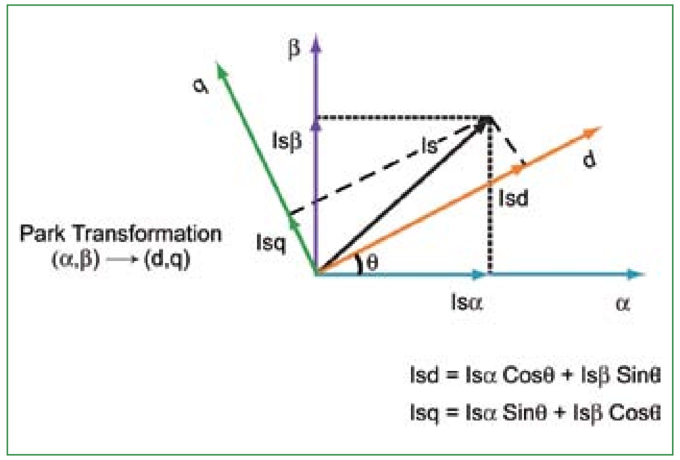


Figure 3. Park Transform.

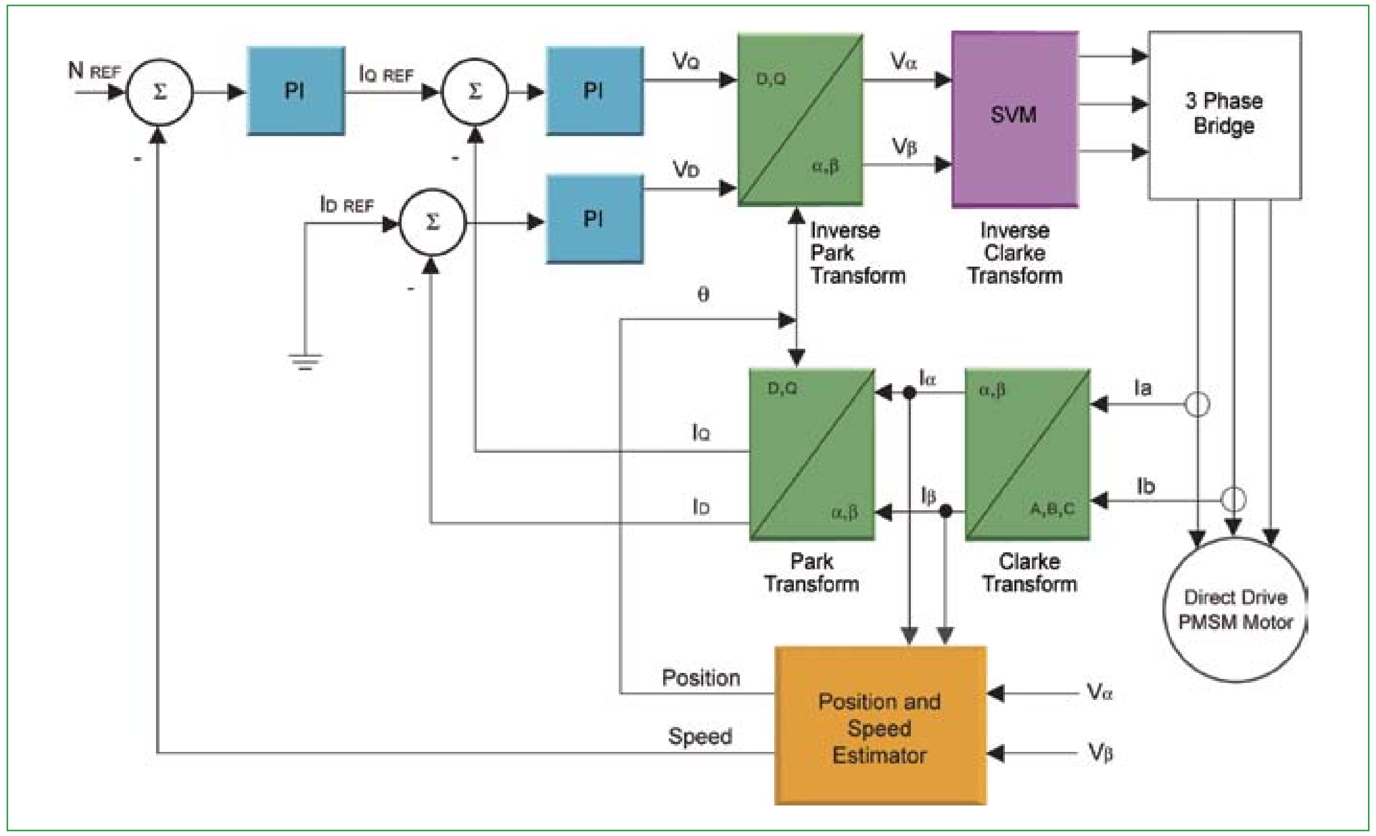


Figure 4: Sensorless FOC control of a PMSM motor in a direct-drive washing-machine.

Special Report – White Goods Part II

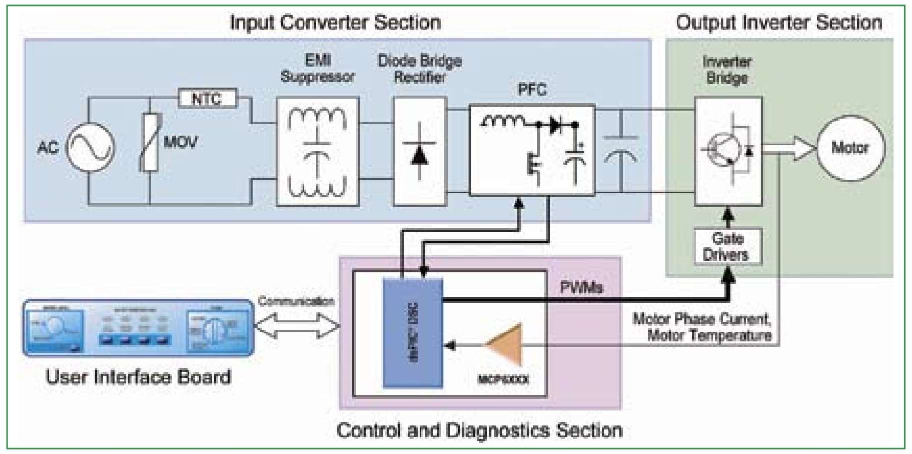


Figure 5. Block diagram of a washing machine based on a dsPIC® DSC.

become time-invariant, allowing control with conventional techniques such as the Proportional & Integral (PI) controllers used with DC motors. Brushed DC motors are constructed so that the stator flux and rotor flux are kept at 90 degrees to each other, therefore generating maximum possible torque from the motor. Using the FOC technique, the motor currents are transformed into two-axis vectors comparable to those in a DC motor.

The process begins by measuring the three-phase motor currents. In practice, since the instantaneous sum of the three current values will be zero, only two of the three currents need to be measured and the value of the third current calculated from the resulting measurements. This delivers an immediate reduction in hardware costs because only two current sensors are required.

Clarke Transform

The first transform to be implemented is the Clarke Transform. This moves a three-axis, two-dimensional coordinate system referenced to the stator, onto a two-axis system based on the same reference. In Figure 2, I_a, I_b and I_c are the individual phase currents in the Clarke Transform.

At this point, the stator current phasor can be represented on a two-axis orthogonal system with the axis called α-β. The next step is to transform to another two-axis system called the d-q axis that is rotating with the rotor flux. This is accomplished by the Park Transform illustrated in Figure 3.

When a sinusoidal input current is applied to the stator, it causes a rotating magnetic flux to be generated. The speed of the rotor is directly related to the rotating flux vector. The flux vector must be kept in alignment with the rotor magnetic poles at all times, so that the motor can produce the maximum torque.

The entire process, including coordinate transformations, PI iteration, transforming back, and generating PWM, is shown in Figure 4, which also describes the functions required for FOC control. Error signals are formed using I_d, I_q and reference values for each. The I_d reference controls rotor-magnetizing flux.

It is important to remember that I_d and I_q (representing torque and flux) are only time-invariant under steady-state load conditions. The I_q reference controls the torque output of the motor, whilst the outputs of the PI controllers provide V_d and V_q, which is the voltage vector that is sent to the motor. A new transformation angle is estimated based on voltages generated by the inverse Park transform and currents generated by the Park transform.

The FOC algorithm uses the new angle to place the next voltage vector. The V_d and V_q output values from the PI controllers are rotated back to the stationary reference frame, using the new angle. This calculation provides the quadrature voltage values, v_a and v_b. Next, the v_a and v_b values are transformed back to three-phase values: v_a, v_b and v_c. The three-phase voltage values are used to calculate new PWM duty-cycle values that generate the required voltage vector.

In the FOC algorithm method, three-phase-separated PWM signals are sine-wave modulated, using Space Vector Modulation (SVM), and applied to the motor's three-phase windings. Shunt resistors are used to monitor the current in each winding and compare it to an electrical model that is based on the motor's characteristics. These characteristics are usually supplied by the motor vendor, although they can be measured by using the inductance and resistance values of the windings. The calculation to determine the position of the rotor is performed by indirectly measuring Back Electromotive Force (EMF), based on a motor model. Back EMF is extracted from the motor's model by inferring the estimated currents that equal the measured current.

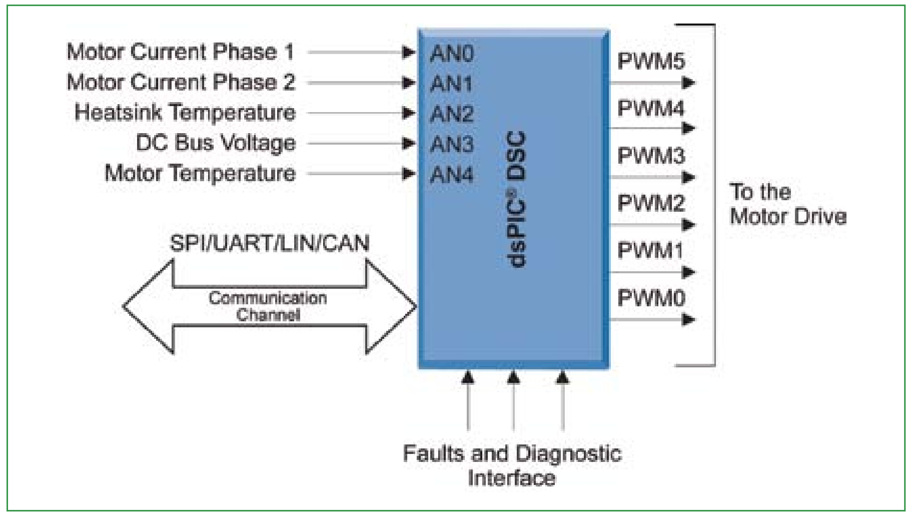


Figure 6: dsPIC® DSC as system controller in a washing machine.

The FOC approach delivers many benefits to PMSM motor power management. For example, FOC improves the dynamic response of PMSM motors, which benefits appliances such as washing machines which need to respond quickly to speed changes involving both the agitation and spin processes. FOC makes this possible by allowing optimal torque production, using less current, by controlling the amplitude and phase of the currents and keeping the stator and rotor magnetic fields at 90 degrees. Also, since FOC allows for controlling the currents of the motor with every PWM cycle, the current is inherently limited.

Motor-Control made easy with dsPIC® DSCs

DSCs such as Microchip Technology's dsPIC® family, are a natural fit for sensorless FOC of the PMSM motor control illustrated in Figure 4. The dsPIC's fast and flexible ADC supports current sensing and offers useful triggering options. For example, ADC conversion triggered by the PWM module enables a cheap current-sensing circuit by sensing inputs at specific times, where switching transistors allow current to flow through sense resistors. Crucially, the dsPIC's ADC has the capability to capture multiple signals simultaneously, which helps to eliminate the delay in motor-current measurements between two phase samples.

Based on the FOC algorithm, the DSC's motor-control algorithm determines the PWM duty cycle and pattern of output. The PWM's most valuable features are complementary channels with programmable dead time. PWMs can be edge-aligned or centre-aligned, with centre-aligned PWMs offering the advantage of reducing the amount of electro-magnetic noise (EMI).

All devices from the dsPIC DSC family provide fault and diagnostics interfaces that include input lines with the ability to shut down the PWMs in case of catastrophic faults. It could, for example, prevent the motor from rotating if a washing machine's agitator locks due to cloth becoming tangled in the drum. This blockage can be detected in the form of over-current in the motor-control system and fault pin can be used to trigger a response to shut down the motor. By deploying the diagnostics feature, faults can be logged, displayed, or transferred to a PC for additional troubleshooting which could help to prevent hard failures and reduce product downtime.

Sensorless FOC design

The block diagram of a washing machine using sensorless FOC motor-control system based on a dsPIC DSC is shown in Figure 5. The variable power supply is produced by converting the AC power to DC using a single-phase diode bridge rectifier and filtering the voltage ripple using a capacitor bank. This DC voltage is inverted into a variable voltage with variable frequency, to feed the motor mains. Using a PWM technique, the DC bus is modulated to output sinusoidal voltage from the inverter bridge.

A rectifier bridge in the input-converter section converts AC voltage from the wall power outlet to DC voltage. Depending on the appliance, there could also be an EMI-suppression block. Normally, an NTC (Negative Temperature Coefficient) resistor is used to protect against the inrush current, whilst high-voltage spikes are suppressed using a Metal-Oxide Varistor (MOV). On the output side of the diode bridge, a capacitor bank filters out the DC ripple.

The input converter section also features an active PFC (Power Factor Correction) block that helps to meet European Energy regulations. This active PFC block comprises an inductor, a power switch and a diode. The DSC's ADCs are used to measure the current and voltage values from the DC bus and, based on these inputs, the DSC controls the power switch using a PWM module. This is achieved by executing a PID loop in the DSC to keep the PF value close to unity.

In the output-inverter section, a voltage-source inverter features two power switches per phase, with freewheeling diodes connected across each switch, and the motor winding connected to the centre of the switches. DC voltage from the input-converter block is synthesized, using this output inverter, to obtain a variable voltage and frequency power supply to control the motor.

Interfacing to the DSC

Access to the DSC's specialized, on-chip peripherals enables easy implementation of the control algorithms. Figure 6 shows an example of a washing mashing machine interface, based on the dsPIC DSC. The DSC's ADC channels can be used to measure the motor current, and the temperature of the motor and the heat-sink connected to the power switches, as shown in Figure 6.

General-purpose inputs and outputs (I/Os) are used for interface switches and for LCD or LED displays. Some applications may choose to use a single dsPIC® to manage motor control as well as other system controls. Serial ports on the dsPIC® can also be used for system calibration and fault diagnostics.

IP protection

With an increase in collaborative design, where different engineering teams may work independently on different aspects of an appliance, there is a greater need to protect Intellectual Property (IP). Microchip's dsPIC DSCs offer CodeGuard™ security (www.microchip.com/codeguard), which protects IP in environments where there is a collaborative design effort.

Conclusion

DSCs, such as the dsPIC family from Microchip, can help to improve the energy-efficiency of washing machines by implementing a sensorless FOC algorithm which can respond to dynamic load changes. Using FOC not only helps washing-machine manufacturers to achieve efficiencies of up to 95 percent in PMSM motor applications, but also minimizes torque ripple to create quieter operation. The common dsPIC® DSC production platform makes it easy and convenient for appliance manufacturers to offer a range of models based on PMSM motors controlled by the FOC algorithm. These software-based motor control designs allow rapid customization of models which can address multiple markets. Achieving the benefits of FOC simply requires manufacturers to make changes to the power section of the appliances.

www.microchip.com

Special Report – White Goods Part II

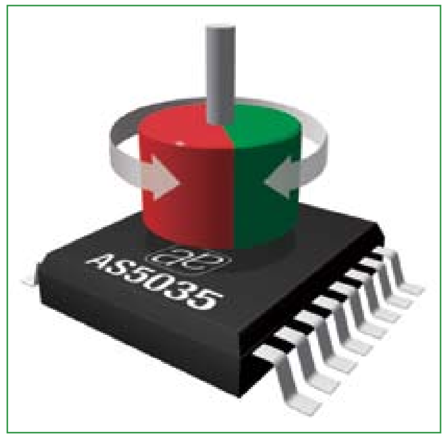
Stabilizing the Washing Machine Drum During Fast Spinning

Magnetic rotary encoders improve position sensing

It is possible to predict and thus reduce drum vibrations in a washing machine when one knows the drum position where a defined current flows in the motor. This allows a further reduction of the static-stabilization-mass usually present in a washing machine system.

By Bernhard Niessen, Field Application Engineer SE, Austriamicrosystems AG, Italy

Washing Machine systems are often based on an electric motor associated with a tachometer which delivers an AC signal with its amplitude proportional to the speed. The resolution of the AC signal (number of pulses per turn) depends on the type of tachometer (number of poles, etc.) and typically is around 16. A classic speed control uses the analog DC signal obtained by rectifying and filtering the AC signal. Another more recent technique is to square the AC signal and use the resulting digital pulses: the time passing between two successive pulses is inversely proportional to the speed divided by the number of pulses per turn (fixed by the selected type of tachometer). These methods are quite simple but practically they can be used only in medium and high speed controls since at low speed they completely lose their accuracy. For this reason they cannot even be used in position controls.



AS5035 Magnetic Rotary Encoder.

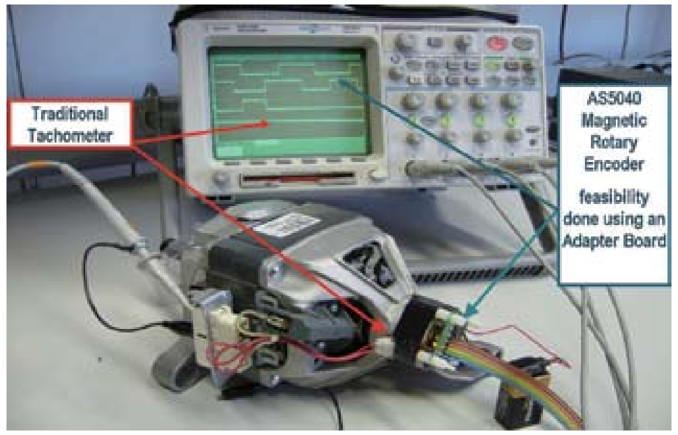
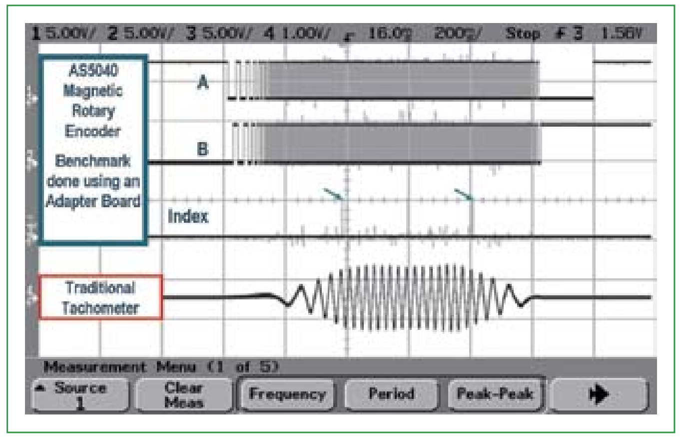


Figure1: Setup of the comparison between Tachometer and Encoder: A brush motor including a 16-pulse tachometer and an adapter board with a Magnetic Rotary Encoder.

A valid, cost effective evolution of the tachometer system is the Magnetic Rotary Encoder which offers: high resolution, stable and accurate output signals from zero to maximum speed (up to 30,000 rpm), contact-less operation, very small size and a variety of possible interface signals, both Absolute (serial interface and PWM) and Incremental (A/B+Index, LSB+Index+Dir, U/V/W) to be chosen from a large family of Encoders. (Fig.1) and (Fig.2) show the setup and waveforms from a comparison between a tachometer and a Magnetic Rotary Encoder supplied by austriamicrosystems.

The higher resolution and extremely small dimensions of the Magnetic Encoder system allow the mounting of the Encoder sensor directly on the Drum shaft end at the back of the washing machine. A practical resolution of a Magnetic Rotary Encoder can be chosen between 8 and 10 bit. By considering a typical ratio of 1:10 in the coupling between drum and its motor, the overall resulting resolution can be typically between 4 and 8 times higher than a usual tachometer with the advantage of a more precise control directly on the drum rather than on the motor/coupling system. For example the encoder AS5035 (Fig.3) has 8 bit resolution, A/B and Index outputs and can work up to 10,000rpm. The Index signal is a position reference pulse which occur every revolution. This allows the control system to keep track of the absolute position and implement an accurate and repetitive stop-to-top-position of the drum for instance in the top-load washing machines.



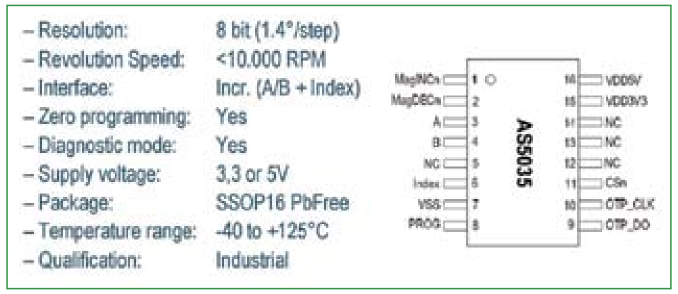


Figure 2(left): Waveforms output from the Tachometer and from the Magnetic Rotary Encoder.

Figure 3(right): Main features and the pin out of AS5035 Magnetic Rotary Encoder.

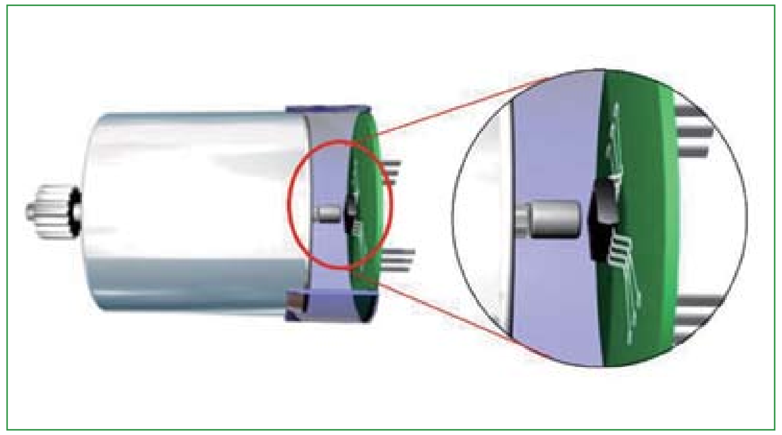


Figure 4: Possible mechanical arrangement of a Magnetic Rotary Encoder chip and its corresponding magnet.

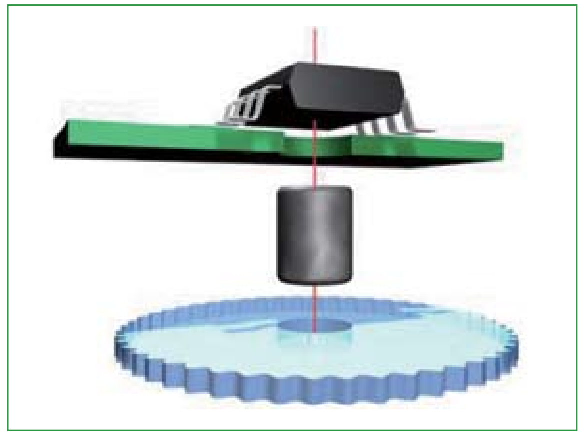


Figure 5: Possibility to place the magnet at the bottom side of the Printed Circuit Board.

Recently new types of Motors were introduced on the Market which allows "sensor-less" solutions with advanced features. Using this type of motors it looks like there is no need anymore for sensors to control the speed. This seems to be only partially true.

The motor-drum system has various asymmetries: position of the motor respect to the drum, residual asymmetries of the clothes in the drum, etc. Typically a washing machine includes some static-stabilization-masses to smooth down the residual vibrations of the motor-drum system at high revolution speed.

There are on-going researches in various directions to further smooth down vibrations and possibly to reduce the static-stabilization-masses. It looks like it is not just a matter of speed control but also torque control. Some studies are evaluating the dynamic misalignment with accelerator-sensors.

A more interesting solution is to combine the information of "current" (torque) with the actual "position" (where the torque is applied) during the rotation of the drum, in addition to a smooth speed control. The amount and frequencies of the vibrations and the delays of the associated effects depend on many factors. One basic factor is the dynamic current variations related to the corresponding positions of the drum during a revolution. Primarily a change in the current is caused by a change of the load which will typically be associated to a dynamic misalignment. In a rotation system, knowing the actual current at each position during a revolution allows the estimation of the coming vibrations and thus the ability to smooth them in advance with an appropriate algorithm.

Specific Magnetic Rotary Encoders from those supplied by austriamicrosystems enable the implementation of such control.

In summary the combination of new types of motors with Magnetic Rotary Encoders and appropriate algorithms should allow proper control of the motor speed as well to smooth vibrations at a very early phase and further reduce the static-stabilization-masses. Furthermore Magnetic Rotary Encoders from austriamicrosystems have intrinsic reference position Index which allows accurate absolute reference positioning.

www.austriamicrosystems.com

Solar Panel Connector Delivers Enhanced Performance

Amphenol Industrial Operations has introduced Helios H4, a low energy loss 4mm connector for photovoltaic systems with a locking design fully compliant with NEC 2008. Improved gasket materials enhance reliability for long-term use in any environment and the new connector has a TUV-compliant touch-proof casing for increased system and user safety.

Helios H4 features a self-cleaning, high efficiency grid contact and has long term UV and ozone resistance to extend its operational life and performance. The combination of Amphenol's advanced contact technology and manufacturing efficiency delivers this enhanced performance at an exceptionally competitive price.

This versatile, low-cost connector, is ideal for connecting multiple solar panels in strings and then to combiner boxes or inverters. It is fully compatible with existing industry standard connectors making it suitable for use in both new and retrofit applications.

RoHS-compliant, Helios H4 is easy to connect on site and has a simple unlocking tool for quick disconnection. It is engineered to meet UL, IEC/CEI, NEC, TUV and DIN V specifications.

www.amphenol-industrial.com

New 1A Output Power Phototriac for White goods

Vishay Intertechnology now broadens its optoelectronics portfolio with the release of an integrated power phototriac that outputs currents up to 1 A to drive resistive and inductive loads. These products are suited for applications in the white goods market.

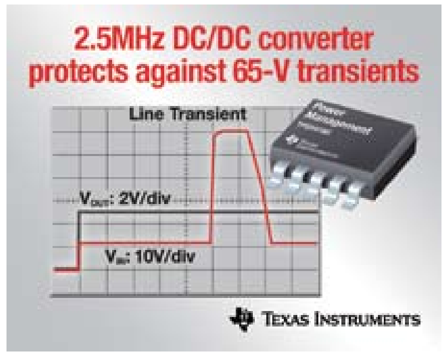
Offered in the 16-pin DIP package, the VO3526 consists of a GaAs infrared LED that is optically coupled to a monolithic photosensitive non-zero-crossing TRIAC detector chip. This in turn powers on an integrated power TRIAC. By eliminating the need for an external power TRIAC and requiring no heat-sink, the device cuts design costs and saves valuable board space.

Rated at 600-V blocking voltage, the power phototriac can provide isolation between DC and AC voltages on 120-V and 240-V AC lines, giving designers a 2X or better safety factor. For additional safety, the device offers an input-to-output isolation voltage of 5300 V. A low 10-mA input trigger current facilitates an easy interface with digital logic.

The VO3526 can also be used as a solid-state relay. Optimized for noisy environments, typical applications for the new device will include home appliances such as air conditioners, refrigerators, dishwashers, washer/dryers, and oven ranges as well as office automation equipment, temperature (HVAC) and lighting controls. These components are manufactured in accordance with RoHS 2002/95/EC and WEEE 2002/96/EC and are certified by key international safety regulatory agencies such as UL, CUL, and VDE.

www.vishay.com

TI's 60-V SWIFTTM DC/DC Converter with Eco-mode™ Technology for Light-Load Efficiency



Expanding on the TI's popular integrated SWIFT™ family of DC/DC converters, the company has introduced a new 60V input, 1.5A output step-down switcher with integrated FET that achieves significant energy savings in light-load efficiency. The wide-input converter helps saves up to 33% of board space compared to competitive wide-input voltage solutions and eases design in industrial and automotive applications.

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

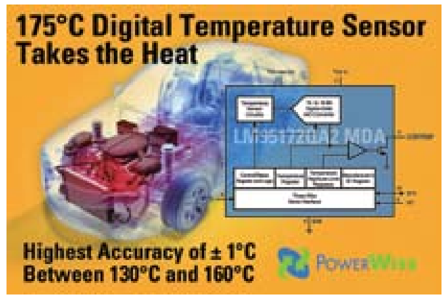
In addition, the converter's high switching frequency range of 300 kHz to 2.5MHz reduces the size of the output inductors to save board space. The TPS54160's frequency fold-back and thermal shutdown features allow the converter to protect itself during an overload condition.

The device also has an integrated track pin that simplifies various sequencing schemes and a clock pin that reduces noise by synchronizing its switching frequency to an external clock.

TI's SWIFT DC/DC converters serve a broad range of applications, such as telecom, computing, industrial and consumer point of load applications with input voltage ranges as wide as 60V and output currents as high as 14A.

www.ti.com

New Thermal Management Sensor for High Accuracy and Extended Temperature



National Semiconductor has introduced a digital temperature sensor to monitor automotive system temperature up to 175°C and delivers +/- 1°C accuracy between 130°C and 160°C.

The LM95172Q's pinpoint accuracy at high temperatures permits lower system guard bands. System engineers now can develop a reliable electronic control unit (ECU) that consistently runs at higher temperatures, allowing for optimal oil viscosity, smaller system form factor and lower weight. These elements enable increased fuel efficiency.

This is the industry's first integrated 175°C digital-output temperature sensor with a serial peripheral interface (SPI) and MICROWIRE® bus interface. The LM95172Q is a member of National's PowerWise® family of products that enable customers to develop more energy-efficient products.

The device is supplied in die form for mounting on hybrid circuit boards and offers temperature monitoring between -40°C and 175°C. The LM95172Q features a 16-bit sigma-delta analog-to-digital converter (ADC), fast conversion rate of 35ms and high resolution of 0.008 degrees C/LSB. The device also includes a temperature switch as well as self diagnosis to ensure safe, continuous operation.

www.national.com/sensors

New High Temperature Relay for White Goods

Omron is extending its popular G2RL power relay with a new, high temperature version, aimed specifically at home appliance cooking application and other heater control applications involving exposure to higher temperature conditions. The new product is available at distributor Rutronik now.

The new Omron G2RL-1A-E-CV is rated for use at temperatures up to 20°C higher than the standard type, tolerating up to 105°C as opposed to 85°C for the standard component. It also offers superior switching performance with longer electrical endurance of up to 100,000 operations switching 16A at 250VAC and 105°C. Initially released in SPST-NO open form, Omron is expecting to release the higher temperature versions in SPDT type, and also to offer normally closed (NC) versions.

Available in 24 different models, Omron's G2RL PCB relay family is ideal for ovens, washing machines, boilers and HVAC equipment. The high sensitivity type, G2RL-H, has a coil sensitivity of 250mW and is available with a UL 1446 Class F Coil Insulation system. The relays conform to VDE (EN 61810-1/EN 60255-23) and UL 508/CSA C22.2 standards and meet VDE0700 regulations for safety of household and similar electrical appliances according to VDE0110.

www.rutronik.com

New Motor Connectors for Wind Power

The HM.16 motor-mount connector from Tyco Electronics simplifies the installation and maintenance of wind power turbines. The connector consists of a cast-aluminium housing that accepts various inserts from the HTS industrial connector family, an interface seal for IP65 protection, and a nickel-plated steel locking lever. The housing is available in several sizes to fit standard motor cutouts so that no motor redesign is required. The mounting footprint can be adjusted to fit the motor's dimensions, up to 140mm x 140mm.The housings can be ordered in a range of colours to allow unique identification of the motor by function or application such as yaw motor or azimuth motor. Options include the standard powder-coated finish, a corrosion-resistant finish, and a shielded version where additional EMI protection is required. The HM.16 motor housing is a compact size 6 form factor within the HTS connector family. By using standard HTS inserts, the HM.16 motor connector allows designers to meet the widest range of application needs. The full range of inserts include typical high-current/voltage circuits covering 150 A/250 A/5000 V, 1 to 25-position power and control signal inserts, coax and Twinax, Ethernet, and many others.

www.tycoelectronics.com

NEW PRODUCTS

First Rosin-Free, No-Clean, Cored Wire Solder

Indium Corporation has introduced CW-501, the First Colophony- (Rosin) Free, No-Clean, Cored Wire Solder for use with Pb-Free alloys.

The company has adapted its industry-leading solder paste technology for use in a cored wire solder to develop this product which contains no rosin, a known allergen. CW-501 comes in a variety of alloys and wire diameters. It provides excellent wetting and solder spread with minimal smoking and low odor. It solders comparably to no-clean or RMA rosin-containing cored wires, and is compatible with Indium Corporation's latest line of no-clean products, including wave fluxes and the award–winning Indium8.9.

All Indium Corporation's bar, wire, and wave flux products are manufactured at its, ISO-9000 certified facility. Established in late 2006, the facility has the latest solder manufacturing equipment and employs solder and flux manufacturing personnel with more than 150 combined years of solder making experience.

Indium Corporation is a premiere materials supplier to the global electronics assembly, semiconductor fabrication and packaging, solar photovoltaic and thermal management markets.

www.indium.com

DC-DC Converters with Regulated Power for High Temperature

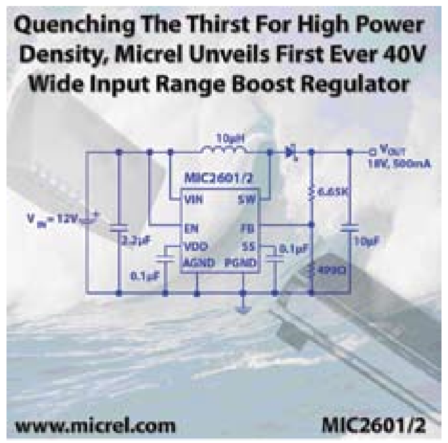
International Rectifier has launched the HTA family of high temperature C-DC converters for high power subsurface and high temperature applications up to 185°C including down-hole drilling, seismic and natural resource exploration, and jet engine control electronics.

The new DC-DC converters are well suited as building blocks and intermediate bus converters for power systems. Available as commercial off-the-shelf (COTS), the new converters significantly reduce design cycle time, size and design costs associated with high temperature applications.

The HTA series is capable of providing up to 20 W of output power over extreme case temperatures of minus 35°C to 185°C. The family of devices has an input voltage range of 150V to 250V and is offered in single and dual output configurations. Input and output are galvanically isolated to protect the output loads from catastrophic system failures at the input side and provide the flexibility of stacking several converters to achieve a higher output voltage.

www.irf.com

High Density 40V Wide-Input-Range Boost Regulators



Micrel has launched a new product line, a family of wide-input range integrated switch boost regulators. The MIC2601 operates at 1.2MHz and the MIC2602 at 2MHz. Both can supply up to 1.2A switch current. The MIC2601/2 are aimed at multimedia STB/antenna/tuners, broadband communications, TFT-LCD bias supplies, bias supplies, positive output regulators, SEPIC converters, DSL applications and local boost regulators.

"Micrel's latest integrated switch boost regulators satisfy designers need for superior power solutions. These high-power-density boost regulators, operating at 1.2 and 2MHz, are ideal for a wide variety of broadband, power supply and multimedia applications," noted John T. Lee, marketing director Non Portable Power, Micrel. "Our customized processes and novel design features enable us to offer best-in-class boost regulators for customers."

These devices, offered by Micrel for the first time, operate over a wide input voltage range (4.5V – 20V) and boost output voltages to as high as 40V. These easy-to-use regulators feature a built-in 1.2A switch, resulting in low external component count as well as low BOM costs. Offering up to 2MHz PWM frequency, these devices are highly efficient and require only the smallest external components. Enhanced stability comes from the use of a small ceramic capacitor. Both MIC2601/2 devices are available in a small footprint, highly reliable, Pb-free 2mm x 2mm MLF®-8 package.

www.micrel.com

Green Business is Great Business

The recent news on the great strides forward in energy efficiency and use of renewables is now resulting in real, tangible success stories in business. Businesses and consumers alike have been fast to learn that this is a win-win-win model.

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

SolFocus has just announced that it has signed the largest CPV (concentrating photovoltaics) deal in Europe, worth over \$100M (€80M). Many have seen CPV and thin film as the two disruptive solar technologies that will bring solar to grid parity. Venture Capitalists have invested heavily in both technologies, but this is the first time CPV is delivering on its promise.

SolFocus recently proved its systems at its first utility-scale installation in Spain and received approval from the California Energy Commission for its flagship product. This new 10 Megawatt project in Southern Spain represents a serious foot-hold in this rapidly growing new market. The CPV systems will be running by the end of 2010, providing enough power for a town of 40,000.

Dr. Kurt-Ludwig Gutberlet, chairman of BSH (Bosch und Siemens Hausgeräte GmbH), called on the audience at the International Consumer Electronics Fair (IFA) in Berlin to work together, in order to encourage consumers to purchase energy efficient appliances. He said that appeals to people's consciences alone are not enough to persuade them to purchase higher efficiency appliances.

Consumers are still not aware, he said, that the money they would save from higher efficiency appliances often cancels out the higher price tag within just a few years.

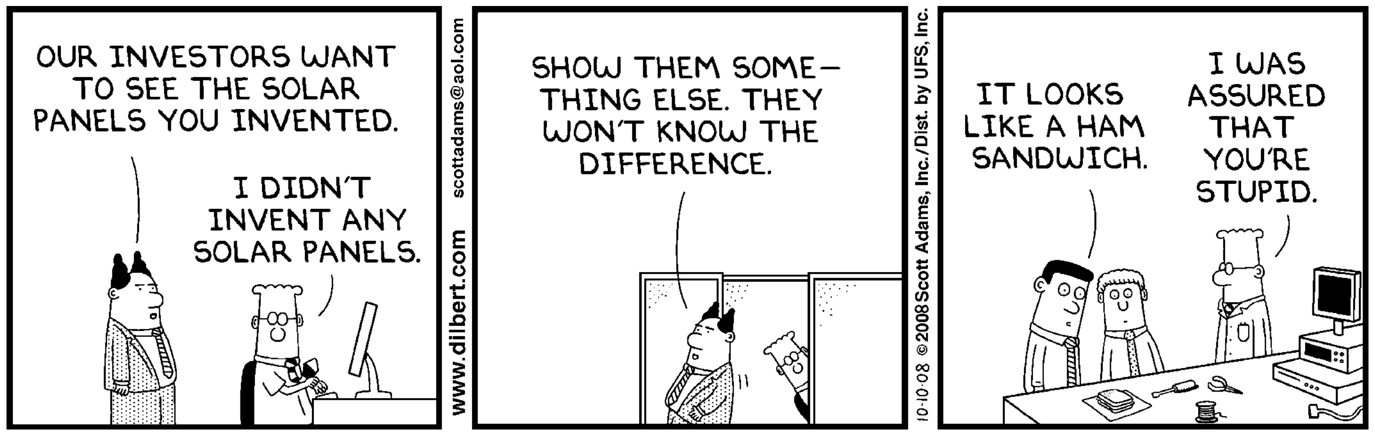
FedEx Express has started work on a new solar-powered hub at Cologne/Bonn airport, the first and largest of its kind for the company, outside the US. The 50,000m^2 hub will be powered by a 1.4 Megawatt solar installation.

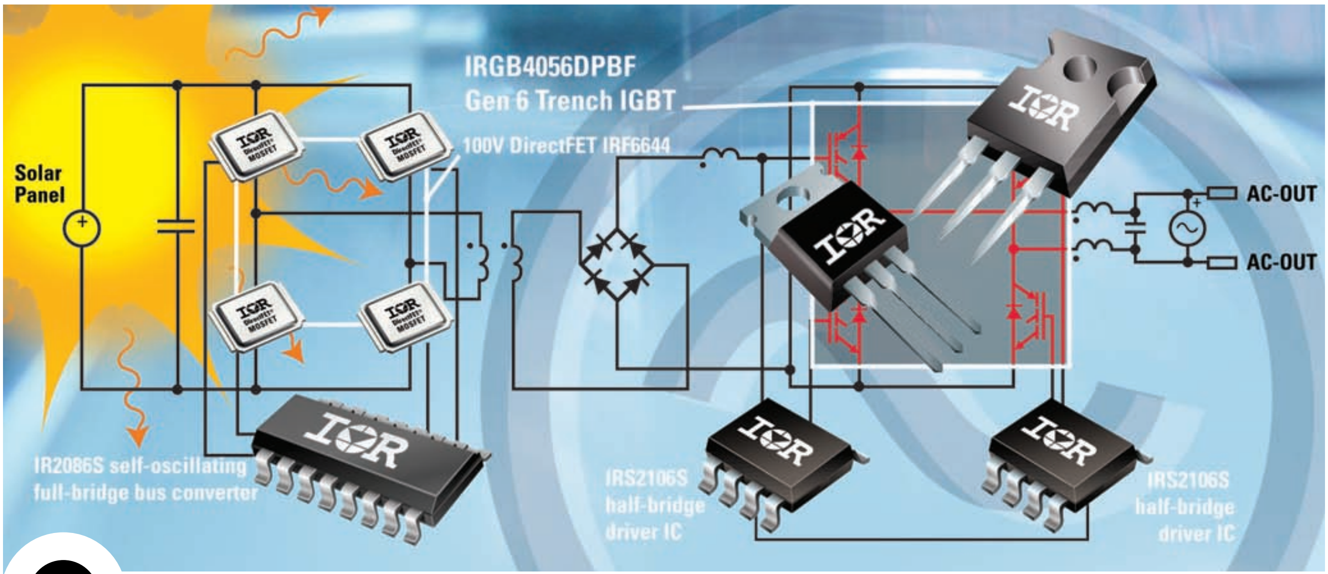
The solar panels will cover a surface area of 16,000m^2, and be able to generate around 1.3 Gigawatt hours of electricity per year – equivalent to the annual consumption of 370 households. The central and eastern European gateway is due for completion in year 2010 and should employ around 450 people.

Last year, Apple's status symbol carried a very high environmental cost. But Apple has now taken these criticisms and cleaned up its environmental status with its new range of MacBook laptops. At the launch, Apple CEO Steve Jobs said, "Apple has invented a whole new way of building notebooks from a single block of aluminium and just as important; they are the industry's greenest notebooks."

The new MacBook uses arsenic-free glass, is PVC-free, brominated flame retardant-free, mercury-free, is made of highly recyclable aluminium and glass enclosures and has 41% smaller packaging. Apple's control over the entire production process has allowed it to create smarter products that use less electricity. The new MacBooks have also now received the US Energy Star certification.

www.powersystemsdesign.com/greenpage.htm





30% Lower Power Loss; 60% Higher RMS Current

With IR's 600V Trench IGBTs for UPS and Solar Inverters

Trench IGBTs

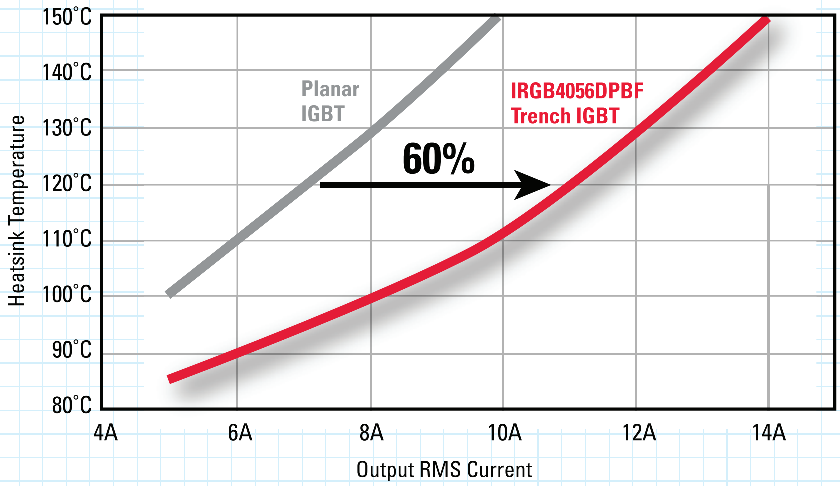
Part Number	Package Type	Voltage	Rated Current T_{CASE} = 100°C V_{GE} = 15V	$V_{CE(on)}$	E_{TS}, at Rated Current, Tj = 175°C
IRGB4059D	TO-220	600V	4.0A	2.20V	210 uJ
IRGB4045D	TO-220	600V	6.0A	2.14V	329 uJ
IRGB4060D	TO-220	600V	8.0A	1.95V	405 uJ
IRGB4064D	TO-220	600V	10.0A	2.00V	415 uJ
IRGP4063D	TO-247	600V	48.0A	2.10V	3210 uJ

High Voltage ICs

Part Number	Package Type	Voltage	Sink/ Source Current (mA)	UVLO
IRS2106	8-Lead DIP, SOIC	600V	290/600	V_{CC} & V_{BS}
IR2086S	16-Lead SOIC	200V	1200/1200	V_{CC} & V_{BS}

Heatsink Temperature vs. Output RMS Current

F_{SW} = 20kHz, Rth(s-a) = 5°C/W, T_{AMB} = 30°C Full Bridge DC-AC Inverter



IR's new family of 600V IGBTs reduce power dissipation by up to 30 percent in uninterruptible power supply (UPS) and solar inverter applications up to 3 kW.

Features

- Lower conduction and switching losses than previous-generation IGBTs
- Increased current density from same package
- 175°C maximum junction temperature
- Square RBSOA
- 100%-tested for clamped inductive load

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