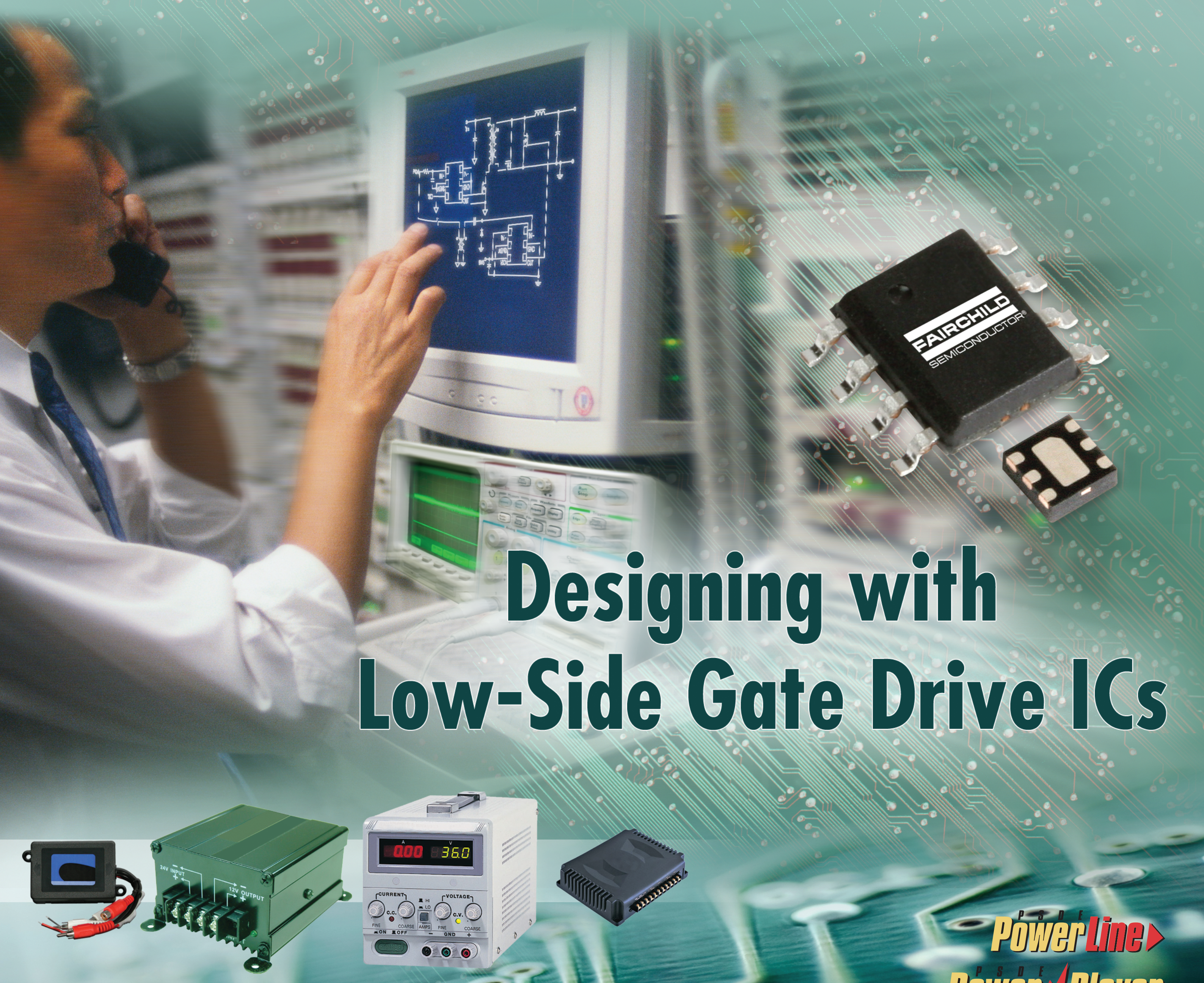
Power Systems Design
EUROPE

Empowering Global Innovation — December 2007



Designing with Low-Side Gate Drive ICs

PSDE PowerLine

PSDE PowerPlayer

MarketWatch

TechTalk

Design Tips

PSDE Green Power ENERGY EFFICIENCY

Special Report - White Goods Part II

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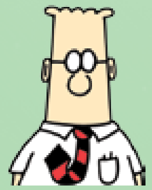
Power Systems Design Europe



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Winter Goes Green

As winter bites us in Europe and we have come to a close of the intensive product launch and exhibition season, it's nice to reflect that 2007 has been an extremely busy year for our industry, certainly as seen from my perspective where I made several visits to companies in our industry and of course, the most recent SPS show in Nuremberg. I have made a short report further into the magazine.

In this issue we have been inundated with white goods content in response to my editorial call at the beginning of the month. From my own experience just having replaced my own 7 year old washing machine, I can really appreciate how technology has made these products leaner, meaner and quieter than their older counterparts. This is, in the main, due to the power industry providing better motor control, power management and program control, making these ordinary household appliances 'green' as a result.

Speaking of design developments, I was invited to attend a seminar run by the design automation company, Ansoft. The tools these people provide are truly amazing. As a lapsed engineer, I was truly impressed by the accuracy in simulation with what happens in the 'real world'. I had a very enlightening interview with the company's most eloquent boss, Dr. Zoltan J. Cendes, who converted me easily to the faith in these very sophisticated tools. You can see my report later in this issue.

One positive signal that I see is that recruitment is on the increase. Early days yet, but I can see the signs that engineers are in strong demand. Power Systems Design Europe on-line department has been helping more companies to find those elusive power designers.

If you go to the GreenPage at the back of the magazine, hopefully after reading the content between, you will see how power semis are helping the world to become leaner and greener, making maximum use of power from renewable resources and using this energy with maximum efficiency and minimum waste. Maybe one day we'll have a server farm that doesn't need an air conditioner to stop it melting with wasted energy.

Speaking of the G-word, PSDE are launching a 'GreenPower Leadership Awards' program to recognize editorial contribution of individuals, companies and organizations that significantly advance the development of energy efficiency and/or renewable energy sources. Winning articles are chosen from those published by Power Systems Design Europe bearing the 'GreenPower' logo.

Voting is tabulated automatically as subscribers to Power System Design Europe read PSDE's eNewsletter, so no committees. This is digital and 'clean'.

The winners will be announced at PSDE's podium discussion May 2008 at the PCIM Europe Conference and Exhibition in Nuremberg, Germany and will also be published in the May 2008 issue of Power Systems Design Europe.

Finally, check out Dilbert on the green page at the back of the magazine. I think it will appeal to many of us!

All the best!

Cliff Keys

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

International Rectifier Announces Promotion to Operations Team

Marc Rougee, 53, has been promoted to executive vice president, operations. Mr. Rougee will report directly to Don Dancer, the company's acting chief executive officer.

Mr. Rougee's responsibilities include wafer fab and assembly operations and planning and logistics. He will also focus on improving integrated sales and operations planning and inventory management. Mr. Rougee joined IR in 2003, when he was appointed vice president and general manager of IR Newport Ltd. (Wales). In this role he was responsible for integrating the Newport acquisition and driving the ramp up of the facility. He was then promoted to vice president, worldwide wafer fab operations, where he oversaw supply strategy, cost programs and integration of the Epi operation in Mesa, AZ.

With over 25 years of semiconductor industry experience, Mr. Rougee previously held positions at Motorola, Silicon Manufacturing Partners, and Chartered Semiconductor Manufacturing.

Don Dancer, IR's acting chief executive officer, said, "Marc has a wealth of global semiconductor operations experience that he brings to the senior management team. He has a proven record in planning, supply chain strategies and implementing a global operations strategy that has led to increased efficiency and greater productivity. We believe Marc is a tremendous asset and will contribute strongly to our strategic growth objectives."

www.irf.com

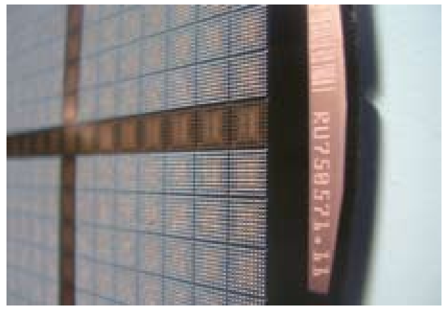
Digi-Key Receives Distributor of the Year Awards

Digi-Key Corporation was recently named Distributor of the Year in the Passive Components Product Portfolio and Optoelectronics Delivery Service categories by Elektronik, a leading magazine for design engineers and technical management within the German electronics market.

Mark Larson, Digi-Key president and COO, recently accepted Distributor of the Year awards from Sonja Diehl, International Media Advisor for Elektronik magazine. Digi-Key received awards in the Passive Components Product Portfolio and Optoelectronic Delivery Service categories and was given high rankings in several other categories as well. While Digi-Key has served overseas customers throughout its 35-year history, its German catalog and website, de.digikey.com, were introduced to the market in 2004.

www.digikey.com

Infineon Lays Foundation for New Industry Standard Package Technology



Infineon Technologies, has announced a partnership with Advanced Semiconductor Engineering Inc. (ASE) to introduce semiconductor packages with a higher integration level of package size with an almost infinite number of contact elements. This new package form achieves a 30% reduction in dimension compared to conventional (lead-frame laminate) packages.

Semiconductor pattern sizes are continuously shrinking to permit the implementation of more complex and efficient semiconductor solutions. Although the chip becomes smaller, the need for adequate connection space has imposed physical constraints on package shrinkage.

Infineon has now succeeded in extending the benefits of Wafer-Level Ball Grid Array (WLB) technology – namely, cost-optimized production and enhanced performance features – by a new technology, embedded WLB (eWLB). All operations are performed highly parallel at wafer level, as with WLBs, signifying concurrent processing of all the chips on the wafer in one step. To promote these advantages, Infineon and ASE have forged a partnership uniting the technology developed by Infineon with the packaging know-how of ASE in a license model.

The new package technology sets the benchmark in integration level and efficiency. Infineon and ASE expect to pave the way to provide the industry and end consumers with a new generation of energy-efficient, high-performing mobile devices.

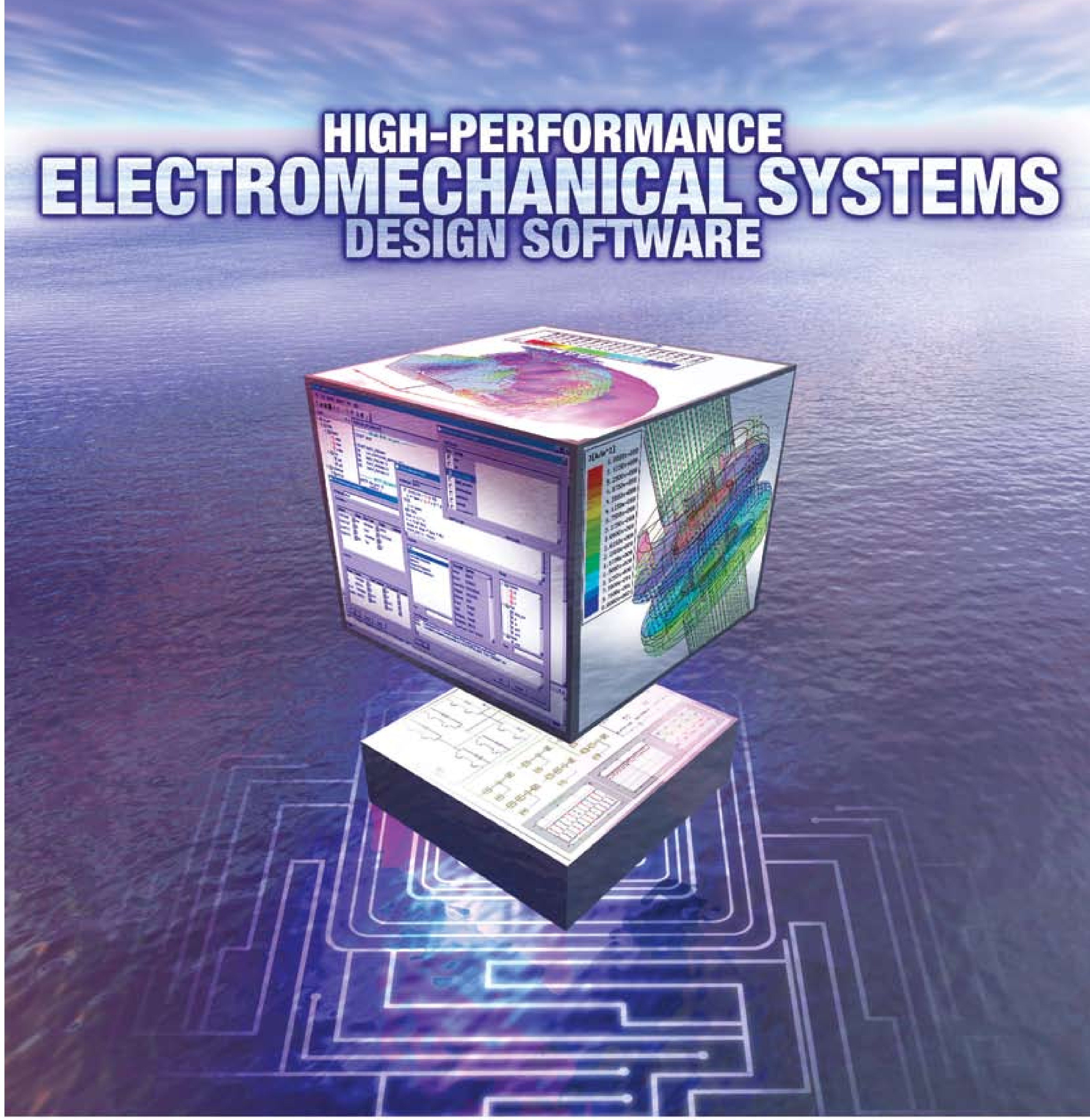
www.infineon.com

www.aseglobal.com

Applied Materials Named Green Energy Innovator of the Year

Applied Materials, Inc. has been named Green Energy Innovator of the Year for its pioneering work on the Applied SunFab™ Thin Film Line.

"Applied Materials is focused on lowering the cost of solar photovoltaic generated energy through the application of nanomanufacturing technologies," said Mark Pinto, Senior Vice President, Chief Technology Officer and Gen-



eral Manager Energy and Environmental Solutions. "The nominees in the category of Green Energy Innovator were international in breadth and included leading global green energy innovators. Amongst such competition, I am pleased to receive this acknowledgement and proud of the great work our teams around the world are doing to help make solar energy an affordable solution to the world's power needs."

The award highlighted the revolutionary SunFab, the world's first and only integrated production line for manufacturing thin film silicon solar modules using 5.7 square meter (m^2) glass panels. These ultra-large substrates, sized at 2.2m x 2.6m, are four times bigger than today's typical thin film solar modules.

Key to the SunFab's success is that it can be replicated by customers around the globe to rapidly establish solar panel manufacturing capacity and achieve lower production cost per watt to drive down the cost of solar electricity.

"Our judges' panel was impressed by Applied Materials' demonstration of an innovative solution to an important global challenge and with this award we are pleased to recognize their commitment to environmental responsibility and the advancement of solar power around the world," said Platts President Victoria Chu Pao.

The Platts awards showcase extraordinary accomplishments by energy businesses and individuals worldwide. Finalists and winners are determined by an independent international panel of judges. Platts, a leading global energy information service, is a division of the McGraw Hill companies.

Applied Materials is the global leader in Nanomanufacturing Technology™ with a broad portfolio of innovative equipment, service and software products for the fabrication of semiconductor chips, flat panel displays, solar photovoltaic cells, flexible electronics and energy efficient glass. At Applied Materials, we apply Nanomanufacturing Technology to improve the way people live.

www.appliedmaterials.com

Tyco Introduces LED Lighting Connector for Quick Installation

Tyco Electronics has introduced a poke-in connector for the LED lighting market. The new poke-in connector is a low profile, surface mount (SMT), two-position connector ideally suited for use in PCB-based LED strings, lighting controls, and other applications that can benefit from an easy poke-in wire termination to the PCB. The LED connector offers quick and reliable wire termination as a low-labour alternative to hand-soldering wires particularly when used with single-sided aluminium clad circuit boards. The new device is available in tape & reel packages for high speed SMT processing equipment and the high temperature plastic

housing is reflow solder process compatible. The RoHS compliant connector incorporates tin over nickel plated copper alloy contacts with a UL94-V0 rated high temperature thermoplastic housing. Packaged in reels of 800, the tape & reel packaging conforms to ANSI/EIA Standard 481-C Although optimized for use with 18AWG 6 through 16 strand wire, the poke-in LED connector also accepts 18 through 22AWG solid wire as well as 18 through 20AWG prebond stranded wire. The connector is UL c/UL recognized for 4A at 48VDC and 4A at 250VAC. Mechanical wire retention is rated for 2.27kg.

www.tycoelectronics.com

Microsemi Awarded $1.6m R&D Contract by AFRL to Develop Silicon Carbide RF Power Products for Airborne Avionics

Microsemi

Microsemi Corporation has announced that the Air Force Research Laboratory (AFRL) has awarded $1.6 million to allow Microsemi's Power Products Group (formerly Bend, Oregon-based Advanced Power Technology) to develop technology related to the use of silicon carbide RF Power semiconductor components in military avionics applications.

The development of the new silicon carbide technology supports future designs of lighter and more efficient jet fighter avionics, communications and radar systems, and will enable substantial growth of Microsemi's operations in Bend. The AFRL program complements the initial license agreement with Northrop Grumman Corporation released in February 2006, where Microsemi will provide leading edge silicon carbide products to this leading defense contractor.

www.microsemi.com

KEMET Announces Distribution Awards for 2007

Image L to R: Marianne Culver, Group Director/Senior Vice President Global Electronics Supplier Management, Premier Farnell, Chris Godfrey, Supplier Account Manager, Farnell, Graeme Dorkings, Director Distribution Sales - EMEA & Sales Director - UK, Ireland & RSA, KEMET, Jim Bruorton, Vice President of Channel Marketing, KEMET

KEMET has announced the winners of its distribution awards for its fiscal year 2007. TTI Europe has received the Distributor of the Year Award for the second consecutive year, while Farnell has been selected for the Sales Growth Award having achieved an increase in business of 260% during KEMET's FY 2007.

The distribution channels are a key element of KEMET's successful business model in Europe. Both TTI and Farnell have had great success in securing new business and supporting existing applications for KEMET's industry leading portfolio of capacitance products, which now includes ceramic, tantalum, paper, film and electrolytic capacitors.

Commenting on the awards, Graeme Dorkings, Director Distribution Sales – EMEA, KEMET Electronics, said: "Our distributor awards format is structured around the business parameters that are most important to KEMET, and FY07 was a very successful year for our European distributor network. TTI continues to operate a business model that delivers strong performance on all key criteria and their award recognises the fact that their model truly works. Farnell meanwhile has worked hard and utilised its extensive and sophisticated distribution channels to deliver excellent growth."

www.kemet.com

Zetex Wins Manufacturing Site of the Year Award

Zetex Semiconductors has won the National Microelectronics Institute's Manufacturing Site of the Year Award for 2007. Sponsored by Sematek, the award was made to Zetex's Mick Conlon, Rob Davies and Iain Scott by NMI CEO Derek Boyd and Sematek's Gerrie Pimm at the NMI's annual awards dinner in London.

The selection criteria for the manufacturing site award is based on a number of factors including: collaboration with other manufacturing sites, willingness to help other manufacturing sites in times of need, contribution to key initiatives and positive influences on the industry at both strategic and tactical levels.

In making the award, Pimm announced, "This year the winner of the award [Zetex] has excelled in all areas and has been involved with the NMI's technical network in almost every discipline."

www.zetex.com

Power Events

- ***EMV 2008,*** *February 19-21, Düsseldorf, Germany, www.mesago.de/en/EMV/main.htm*
- ***5th Symposium Hybrid Vehicles and Energy Management,*** *February 20-21,Braunschweig, Germany, www.iav.com/en/index.php?we_objectID=4705*
- ***FC Expo 2008,*** *February 27-29, Tokyo, Japan, http://www.fcexpo.jp/fc/english/*
- ***APEC 2008,*** *February 28-28, Austin, Texas, USA, www.apec-conf.com*
- ***CIPS 2008,*** *March 11-13, Nürnberg, Germany, www.cips-conference.de*
- ***PCIM China 2008,*** *March 18-20, Shanghai, China, www.mesago.de/en/PCChina/main.htm*
- ***electronica & ProductronicaChina 2008,*** *March 18-20, Shanghai, China, www.global-electronics.net/link/en/16545154*
- ***China Hydrogen Energy & Fuel Cell Exhibition,*** *March 31-April 2, Shanghai, China, www.fuelcelltoday.com/events/event/2008-03/2008-China-Hydrogen-Energy--amp-*
- ***SENSOR+TEST 2008,*** *May 6-8, Nürnberg, Germany, www.sensor.test.de*
- ***PCIM Europe 2008,*** *May 27-29, Nuremberg, Germany, www.mesago.de/en/PCIM/main.htm*
- ***euroLED 2008,*** *June 3-5, Birmingham, United Kingdom, www.euroled.org/2008/index.php*
- ***European Fuel Cell Forum 2008,*** *June 30-July 4, Lucerne, Switzerland, www.efcf.com/exhibition/*
- ***EPE-PEMC 2008,*** *September 1-3, Poznań, Poland, www.epe-pemc2008.put.poznan.pl*
- ***23rd European Photovoltaic Solar Energy Conference,*** *September 1-5, Valencia,Spain, www.photovoltaic-conference.com*
- ***electronicIndia 2008,*** *September 2-5, Bangalore, India, www.global-electronics.net/link/en/16545148*
- ***Husum WindEnergy,*** *September 9-13, Husum, Germany, www.husumwind.com*
- ***electronicAsia 2008,*** *October 13-16, Hong Kong, China, www.global-electronics.net/link/en/16545145*
- ***SPS/IPC/Drives 2008,*** *November 25-27, Nürnberg, Germany, www.mesago.de/en/SPS/main.htm*

IR's Energy Saving SupIRBuck™ Integrated Regulators Shrink Silicon Footprint by 70 Percent

International Rectifier, has very recently launched their SupIRBuck™ family of versatile wide input, single output synchronous buck voltage regulators for high density, high performance data center and consumer applications where space saving and energy efficiency are paramount.

Data centers are now particularly under scrutiny for making significant improvements in power efficiency due to their huge demands on power utility companies. Government and authorities are also becoming 'green-conscious' in this demanding application.

The IR38xx SupIRBuck family of point-of-load (POL) voltage regulators integrates IR's benchmark HEXFET® trench technology MOSFETs and a high performance synchronous buck control IC in a compact 5mm by 6mm Power QFN package, shrinking the silicon footprint by 70% compared to discrete solutions, and offering between 8 to 10 percent higher full-load efficiency than competing monolithic ICs.

"Because SupIRBuck has a unique, scalable common footprint, designers can simply 'cut and paste' their design to significantly reduce risk and enable faster-time-to market," said Tim Phillips, vice president of IR's Enterprise Power Business Unit. "The addition of the SupIRBuck POL family to IR's industry-leading XPhase® and DirectFET® multi-phase architecture allows us to provide the most efficient and complete power solution for the data center including enterprise servers," he added.

Designed for four, seven and 12amps output load current at 600kHz switching frequency, the IR38xx operates from a wide input voltage range of between 2.5V to 21V, and provides output voltage as low as 0.6V. Common features include pre-bias start up, fixed 600kHz switching frequency, hiccup current limit, thermal shutdown, and precise output voltage regulation. Optional features include tracking, programmable power good, and 300kHz switching frequency to provide an additional two amps of output current capability. The SupIRBuck family's thermally enhanced

package with slim 0.9mm profile, allows mounting on the rearside of the motherboard, making the devices ideally suited for space constrained, high-density server applications.

IR's optimized power management solutions are designed to deliver benchmark power density, high efficiency and performance to meet the relentless challenge of dramatically reducing the huge power penalties currently experienced in the running costs of today's data centers. From the graph above it can be seen that IR's solution is the best technology fit to contribute to the achievement of this challenge. Only by developments such as SuperIRBuck can we hope to reduce the power wastage due to inefficiency in data centers and to realize a better environmental performance without the design trade-offs of technologies and performance versus cost and ease-of-design.

www.irf.com

Specifications:

Part Number	Vin Max/Min	Vout Max/Min	Max Current	Fsw	Package	Features
IR3812MPBF	21/2.5	12/0.6	4A	600KHz	5 mm x 6mm QFN	OCP + OTP + TRACKING
IR3822MPBF	21/2.5	12/0.6	4A	600KHz	5 mm x 6mm QFN	OCP + OTP + PGOOD
IR3822AMPBF	21/2.5	12/0.6	6A	300KHz	5 mm x 6mm QFN	OCP + OTP + PGOOD
IR3811MPBF	21/2.5	12/0.6	7A	600KHz	5 mm x 6mm QFN	OCP + OTP + TRACKING
IR3821MPBF	21/2.5	12/0.6	7A	600KHz	5 mm x 6mm QFN	OCP + OTP + PGOOD
IR3821AMPBF	21/2.5	12/0.6	9A	300KHz	5 mm x 6mm QFN	OCP + OTP + PGOOD
IR3810MPBF	21/2.5	12/0.6	12A	600KHz	5 mm x 6mm QFN	OCP + OTP + TRACKING
IR3820MPBF	21/2.5	12/0.6	12A	600KHz	5 mm x 6mm QFN	OCP + OTP + PGOOD
IR3820AMPBF	21/2.5	12/0.6	14A	300KHz	5 mm x 6mm QFN	OCP + OTP + PGOOD

PSDE Power Player

PSDE Green Power ENERGY EFFICIENCY

Save Our World's Energy!

By Michele Sclocchi, Senior Principal Applications Engineer, Power Management, National Semiconductor Europe

The global energy demand increases together with severe CO_2 emission; government bodies will emphasize the importance of more efficient sub-systems and innovative technologies.

But if countries around the world do not change their policies exploring new solutions, the world's energy needs could be well over 50% higher in 2030 than today. China and India together will account for 45% of the increase in global primary energy demand in this scenario. These trends lead to continued growth in global energy carbon-dioxide emissions from 27Gt in 2005 to 42Gt in 2030 with a rise of 57%.

Existing renewable and nuclear energy policies alone will not be able to compensate these trends. Emission savings should primary come from improved efficiency in industries, transportation and lighting.

Semiconductor industries are pioneering this path by offering innovative technologies to actively contribute to the offset of this energy demand increase, but as always the final "spin" should be taken by the end customer by quickly absorbing more energy friendly solutions.

More than 35% of world energy consumption is used for lighting. It has been proven that today LED technology can be 4-5 times more efficient than the conventional Edison incandescent light bulb. A conventional 35W MR16 halogen lamp can be replaced by a 10W LED bulb, with an estimated five years cost saving of €100. LED lighting units will never be as cheap as incandescent light bulbs; however their higher initial costs are paid back in significant saving over time, the 'true cost-of-ownership' law.

LED Semiconductor technology together with dedicated driver solutions will further boost the adoption of LED subsystems in large TFT displays,

pendant lights, automotive front lights, and all the other applications where efficiency and reliability are needed.

The new LED technology solves maintenance problems, provides environmentally friendly solutions compared to fluorescent lighting technology, allows compact solar powered lighting solutions with efficiency up to100 lumens/watt in light efficiency and offers well controlled contrast color spectrum emissions.

In the transportation sector, alternative vehicles such as electric cars, hybrid-engines and hydrogen fuel-cell based driver systems are available now in the market. These new technologies could reduce harmful emissions by 10-15% if fast adoption is encouraged.

Hybrid electric drive vehicles are today the most attractive alternative solution for urban car or bus transportation. The overall system efficiency is secured with smaller, high efficiency electric motors together with more efficient energy storage systems. Novel technologies such as the emerging ultracapacitor solutions could overcome the limitations of hybrid electric batteries by offering 15-20% higher efficiency over conventional battery systems by providing higher power energy solutions from their ability to store braking energy and their proven longer lifetime cycles.

In home-appliance applications the energy used during standby operation *(the energy consumed by an appliance while it is not performing its main function)* is about 10-24% of total energy consumption. This will likely grow in the future as more and more portable equipment is left on charge and plugged in the mains. In the industry aptly named 'vampires'. Using cost-effective technologies and design changes, standby power consumption can be reduced by up to 75%. Intelligent control systems that change operation mode based on power level requirements (e.g. off-line PWM/ burst mode controllers) and low consumption processes can easily address these needs.

Overall efficiency of portable battery power equipments is guaranteed by dedicated enhanced systems such as the PowerWise® solution developed by National Semiconductor. PowerWise technology, first introduced in 2002 for handset solutions, enables microprocessors to use only as much energy as is absolutely required for each specific task, thereby reducing the overall energy consumption of a conventional free-running system. This same technology will be utilized in all high performance, energy saving applications.

If in our world, where we all profess to be committed to a 'green is good' policy, we eventually invest in ever more energy/ environment friendly system innovation, by simply utilizing the technologies that are available right now, we can optimize the whole energy process resulting in a significant contribution in saving, or better said, conserving the world's energy for our future generations. It simply needs commitment and investment.

www.national.com

Appliances - No Seasonality Needed

Many platforms – endless opportunities

By Marijana Vukicevic, iSuppli Corporation

The key drivers in the appliance market are typically trends in house buying and renting that is responsible for 30 percent to 35 percent of appliance sales. The correlation between the U.S. housing market and major appliance sale is approximately four months after the corresponding change in housing market starts.

The U.S. housing market has been quite strong prior to 2006 but the slow-down in the housing market that began in 2006 is affecting appliance sales too.

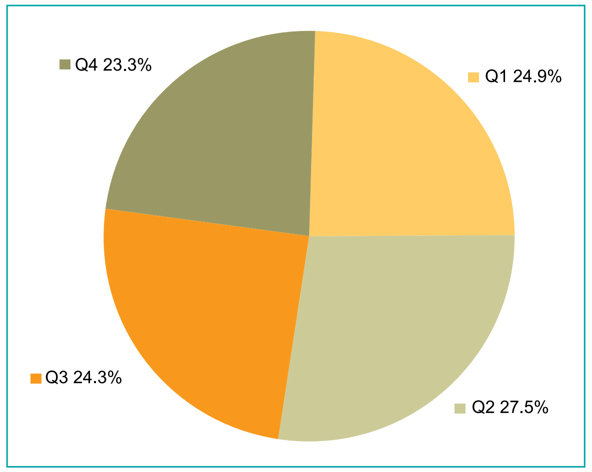


Figure 1: Major Appliance Shipment Seasonality.

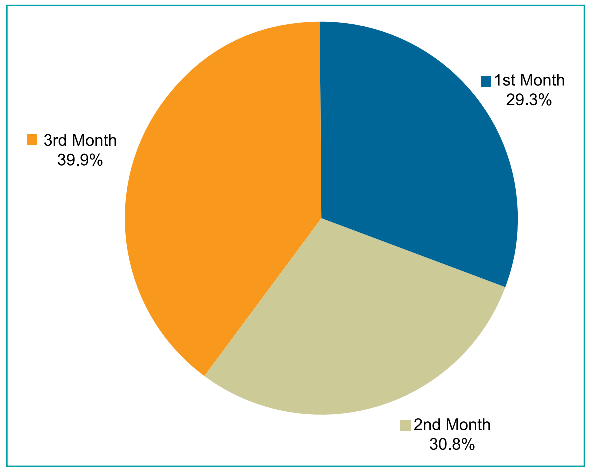


Figure 2: Major Appliance Quarterly Shipment Pattern.

Another factor not to be neglected is consumer confidence. Statistical analysis has shown very strong reverse reciprocity between appliance sales and interest rates, i.e. appliance sales increase when interest rates fall, and vice versa. There are several reasons for this strong relationship:

- Many consumers finance the purchase of major appliances either through credit cards or retail-based programs.
- Lower interest rates result in more new home sales. Consumers often replace or upgrade appliances when buying a new home
- Lower interest rates also contribute to more home equity financing that may result in upgrades.

Apart from the consumer economical status as the influential factor in appliance volume shipments, raw material and fuel costs have a big impact on the cost of appliances and along with that the rate of appliance replacement inside homes as well as the spent per piece of appliance equipment.

Raw materials typically account for 50 percent to 65 percent of the cost of appliances. Steel is the raw material for appliances, particularly larger major appliances. During early 2005, many appliance makers passed higher steel costs onto the consumers through price increases in an attempt to preserve margins, which as a result influenced a drop in sales during that period of time. Other key raw materials include plastic, derived from petroleum, and copper, which has risen in cost steadily in recent years. Increase in the costs of oil also has made a significant impact on manufacturing and transport cost.

The appliance market unlike the rest of consumer electronics market is not highly seasonal as annual shipments typically break even over the quarterly year as shown in Figure 1. To be more precise, the second quarter in the year is usually higher in the shipments than other quarters. However, shipments within any given quarter typically follows the same pattern, with much higher shipments in the third month close to 40 percent of the total quarterly shipment as shown in Figure 2.

The world market for major appliances is expected to reach 462 million units in 2010. That is a Compound Annual Growth Rate (CAGR) of 5 percent for the period of 2006 to 2010 compared to the 4 percent CAGR for the period from 2001 to 2005.

www.isuppli.com

DESIGN TIPS

Switching Power Supply Noise

Switching power supplies are inherently noisy. Large amounts of EMI are generated on both the input and output sides of the switching converter, and in most designs, the noise is not well characterized or controlled.

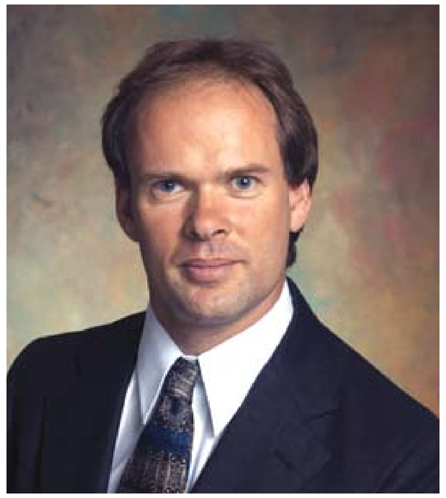
By Dr. Ray Ridley, Ridley Engineering

High-frequency switching power devices and diodes generate large amounts of EMI in all switching power supplies. On the input side of the converter, there are stringent limits on the noise that may be carried back to the AC power line, and these limits are extraordinarily low. The only way to meet the emission specifications are with two- or three-stage filters, carefully selected to attenuate the measured noise, and properly damped to avoid instability [1]. Both common-mode and differential mode filters are used to pass the EMI testing criteria.

However, most power supply specifications for output noise are very poorly defined. People refer to peak-to-peak noise, rms noise, but rarely do they specify the noise in the same stringent way as the input. As a result, most switching power supplies put irresponsible amounts of noise on their output leads.

For many loads, this is not an obvious problem – the loads are either insensitive to the high-frequency noise, or they have been bypassed with capacitors to clean up the rails at the point of usage.

There is no reason for power supplies to be so noisy on their outputs. Simple application of multistage filters provides very clean output with minimal cost, and should be applied in most situations. As microprocessor voltages drop, the susceptibility to noise increases, and the



risk of weak standards on output noise are not worthwhile.

Measurement of Output Noise

Most engineers assess the output noise of their converter with an oscilloscope. A spectrum analyzer would be more appropriate, but this is rarely done.

If you are going to use an oscilloscope to measure the noise, there are several precautions that must be taken. Figure 2 shows the standard oscilloscope probe test leads. A ground lead approximately 10cm long clips to the ground of the circuit, and a spring-loaded barrel on the probe hooks on the test point. It is best to use the oscilloscope on its maximum bandwidth for these measurements to ensure that you are seeing all the components of the output noise.

Using this test setup, the first thing to do is measure the residual noise being picked up by the probe. That is done by connecting the probe tip to the same ground point as the ground clip. The waveform in Figure 2 shows that this test setup is not effective at removing the residual measurement noise. There is 90mV peak-to-peak.

Figure 3 shows the same oscilloscope probe with a proper setup for low-noise measurements. Both the probe barrel and the ground lead have been removed from the probe. There is a ground ring around the shaft of the probe, and this is grounded as close to the test point as possible. This setup reduces the noise in the measurement to just 8mV, low enough for most output noise measurements.

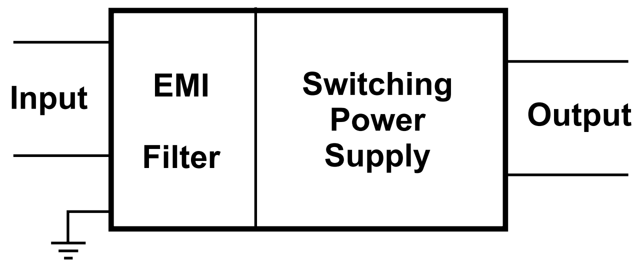


Figure 1: Power supply with EMI filter on the front end.

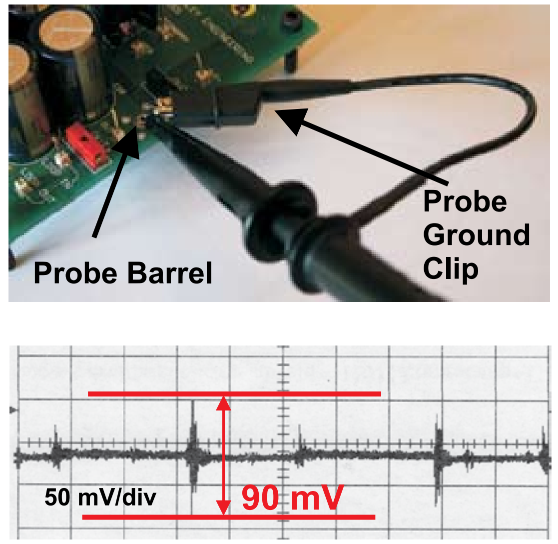


Figure 2: Oscilloscope probe with standard setup, residual ground noise.

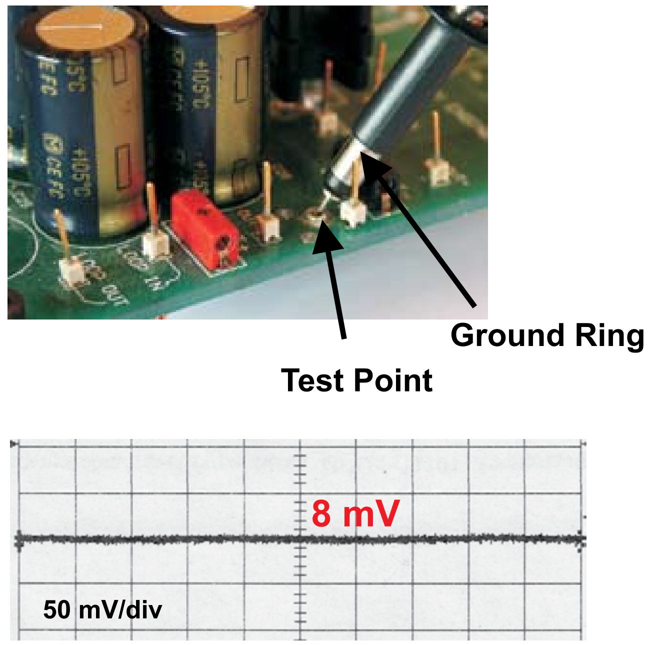


Figure 3: Oscilloscope probe with probe tip and ground lead removed.

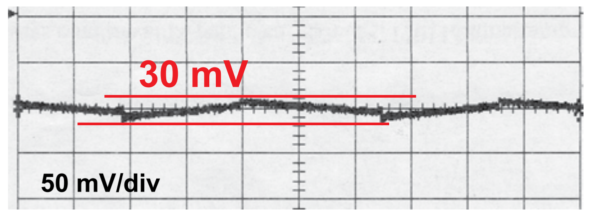


Figure 4: Increased noise pickup with improper routing of probe cable to oscilloscope.

This setup reduces noise pickup by minimizing the loop of the earlier connections. This loop acts as an antenna picking up stray magnetic fields. The smaller probe tip, and elimination of the ground clip also minimizes surface area. This reduces electrostatic field pickup.

You must also be careful with the routing of the cable from the probe to the oscilloscope. Figure 4 shows how the noise pickup is increased to 30mV when the lead runs too close to the switching devices of the power stage.

There is one more suggestion that has appeared recently in some semiconductor applications notes. They recommend soldering a couple of capacitors across the oscilloscope probe tip. While this will no doubt reduce the noise measurements, it will not have any meaning as you have introduced a second stage filter in the system. You should never characterize your system with additional capacitors across the instrumentation – the results are simply wrong.

When you are preparing to measure your power supply, take these steps first to make sure you have a good clean background when you make the ground measurement.

Filtering the Output Noise

Flyback converters are popular for many different applications, ranging in power from fractions of a watt, to about 50 W. The flyback converter has the disadvantage of a pulsating current on the output of the transformer. The current pulses are absorbed by the output capacitor, and the fast-rising edges give rise to considerable noise, as shown in Figure 5.

The noise in this figure is for a 24W flyback converter operating in continuous conduction mode, and switching at 100kHz. The peak noise is about 280mV, using 880µF of output capacitance. Notice that there is wideband frequency

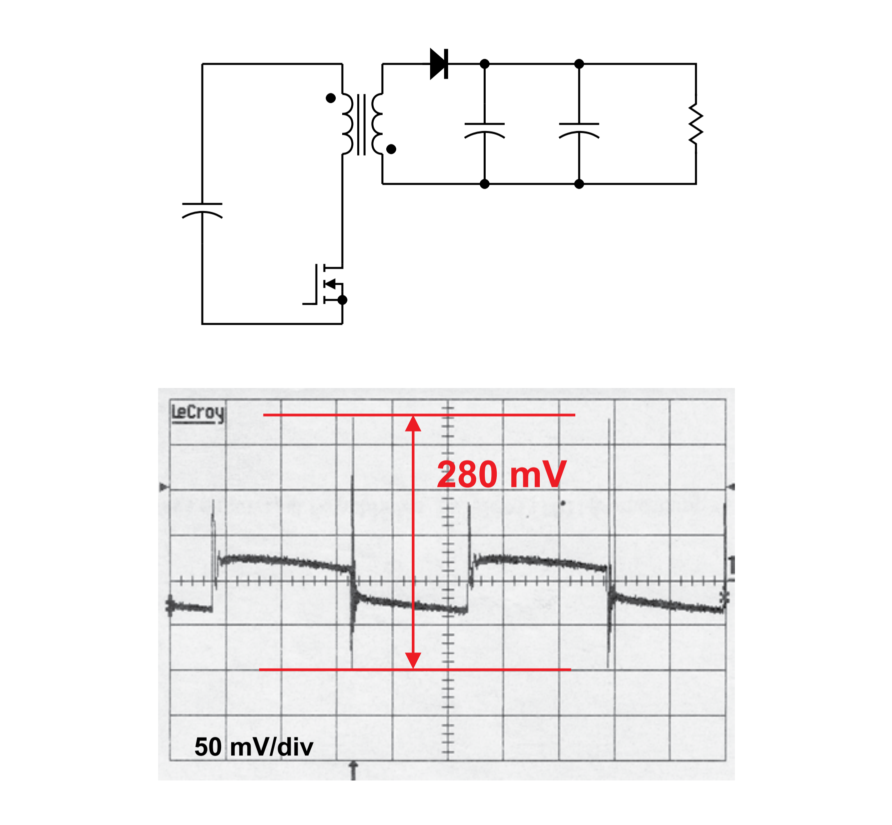


Figure 5: Flyback converter output voltage noise.

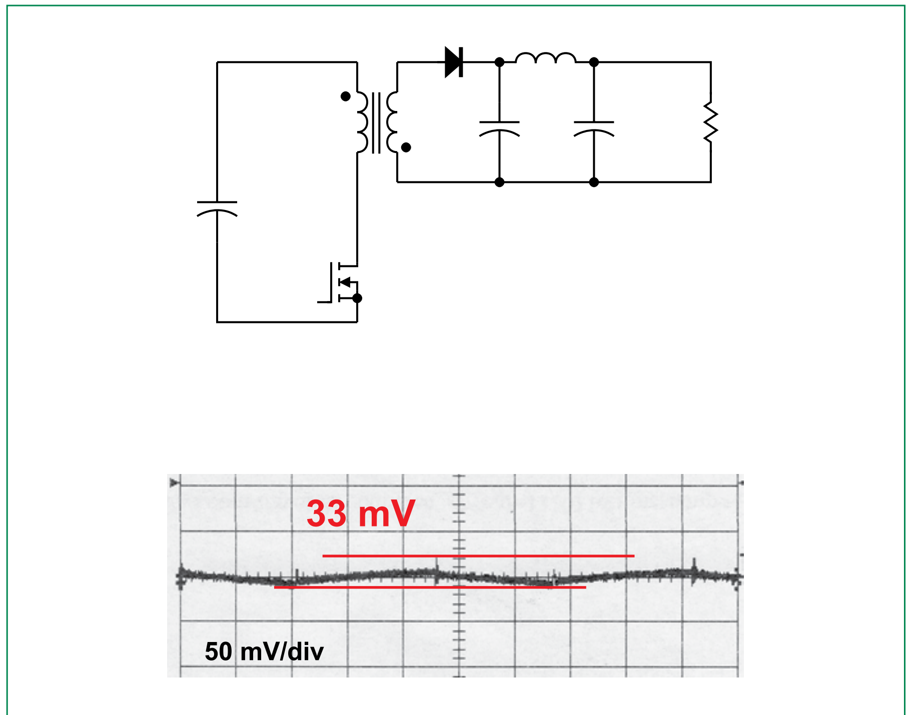


Figure 6: Flyback converter with two-stage filter.

content in the noise spectrum starting at 100kHz, and extending into many tens of MHz for the noise spikes.

There is no reason to tolerate this level of noise from your switching power supply. A simple 2-stage filter can provide drastic reduction as shown in Figure 6.

To build a two-stage filter, the output capacitor is split (usually into approximately equal parts) by a small inductor. The rules for selecting the inductor and filter parameters are covered in detail in [2]. In this particular example, the inductor was physically equal to about 25% of the volume of the output capacitor bank. The effect on the output noise is dramatic. The peak-to-peak noise level is now only 33mV, almost a ten times reduction.

The two-stage filter is undoubtedly a more complex system, but with careful attention to the design rules, it is not that difficult to implement, and the system remains stable even if the feedback point is taken from the output of the power supply.

Summary

Almost every switching power should incorporate at least a two-stage filter on the output to reduce the noise. In high-performance systems, there should also be common-mode filtering, just as for the input filter design. Do not be tempted to skip this crucial part of the design.

Remember when looking at output noise to make sure that you have your instrumentation set up properly. Always test the residual ground noise measurement before looking at the output noise.

Additional Reading

[1] "Evolution of Power Electronics" http://www.switchingpowermagazine.com/downloads/Evolution of Power Electronics.pdf

[2] "Second-Stage LC Filter Design" http://www.switchingpowermagazine.com/downloads/Evolution of Power Electronics.pdf

www.ridleyengineering.com

Environmental Concerns Drive – Power Market in Major Home Appliances

I met with Matthew Towers, Senior VP, IMS Research, who founded the company in 1989 and retains responsibility for the worldwide operations of IMS, with particular emphasis on Europe and China. During his time with IMS Research, he worked as a senior analyst in a variety of industries including semiconductors, wireless communications, power electronics, and consumer appliances, providing consultancy services and producing detailed market reports.

He remains especially active in the power and energy arena, working closely with both power supply and power semiconductor industries. The article below follows a detailed study on electronics content within major home appliances, completed mid-2007.

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

Environmental concerns have never been higher up the global political and social agenda and as a result our political leaders are under extreme pressure to review existing green policies and develop new policy initiatives. In the appliance industry, this will drive a major change. In the past, the impression has been (possibly wrongly!) of regulators "pushing" appliance makers to improve energy efficiency, with the industry seen as "reluctant" participants in many parts of the world – especially in the US.

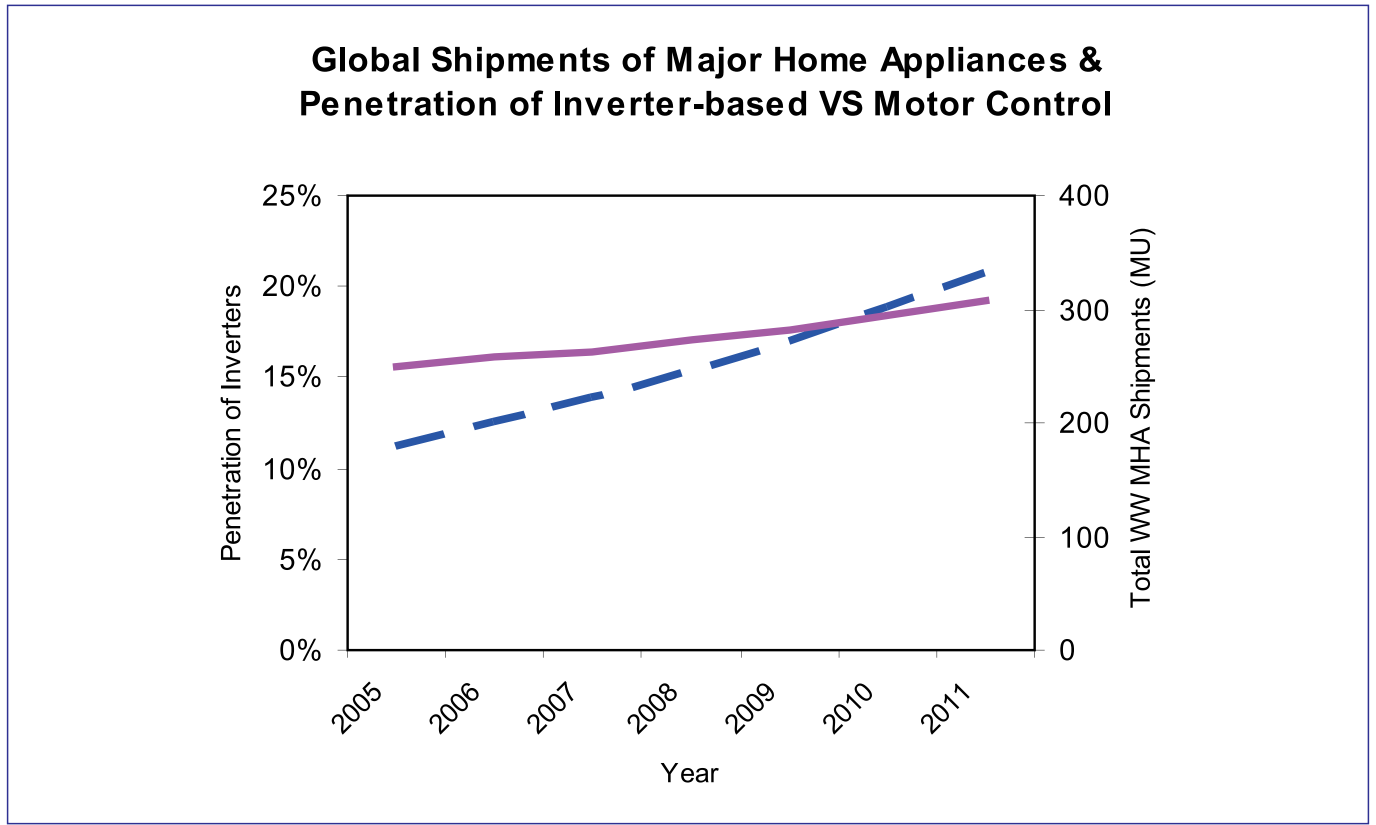
Now, not only do regulators face greater government pressure to improve efficiency, but consumers themselves are starting to take more notice of energy and efficiency issues. This includes everything from home power generation, to energy efficiency light bulbs, to reducing the use of stand-by mode in electronic goods. In this new market environment, where consumers dictate their requirements, appliance makers are starting to realise that by positioning their products as "energy efficient" or

"environmentally friendly", they can gain a significant competitive advantage.

For appliance makers there are many ways to improve the energy efficiency of their appliances and any calculation of the best options is complex. In wet appliances, a number of trade-offs have to be considered, such as the amount of water used, the time needed to heat the water, and the overall length of the cycle. In cold appliances, insulation, compressors and other components can all be improved but developments in one area can cause problems in another.

For the power semiconductor industry, the most interesting route that appliance makers can take towards improved efficiency is the use of inverter-based variable speed control for motors or compressors. When this control approach is used in an appliance it dramatically increases its power semiconductor content, leading to much higher market growth.

The advantages of inverter-based control are many and varied. In washing machines, more advanced wash and spin cycles can be used to improve the effectiveness and efficiency of the appliance and noise is reduced. In cold appliances and room air conditioners the



speed of the compressor can be regulated so that it is not simply switched on / off but adjusted incrementally to reduce power consumption and noise levels.

Inverter-based control has been around for many years, but is still not widely adopted in appliances. Current penetration across washers, dryers, dishwashers, cold appliances and room air conditioners is only around 10% globally, around half this level in Western Europe, and even lower in Eastern Europe. However, it is our view at IMS Research that the next 5-10 years will see strong growth in the use of inverter-based variable speed control in the appliance industry, both in Europe and globally.

Figure 1 shows the current status of inverter control in the global appliance industry and its projected development path. These numbers are extracted from our latest research on the global Major Home Appliance market, which focused particularly on the future of high-end appliances and the electronic content of appliances generally. The graph shows that overall appliance volumes for the above categories are forecast to rise relatively slowly, from 249MU in 2005 to 308MU in 2011, a CAGR of 3.6%. However, penetration of inverter-based control is forecast to almost double over the same time period from 11% to 21%, taking the number of appliances with an inverter from 27MU today to around 65MU by 2011.

So what is driving this growth? It comes down to a combination of different factors, some appliance specific and some generic. For washing machines, the trend in the US to front-load washers is helping to support increased inverter penetration. The 110-120V a.c. supply in the US makes chopper control of the motor using triacs problematic, and has made inverter control the preferred solution to variable speed control in horizontal axis washers. In Europe, the uptake of inverter based control has been slower, but even here significant progress is anticipated over the next 5 years.

Room air conditioners (RAC) is another focus area for appliance makers, due to the relatively high annual power consumption of an air conditioner, and inverter control is forecast to increasingly penetrate RAC products in most world regions – especially in Europe. Tighter regulation of RAC efficiency will almost certainly be seen over the next decade as they are a major consumer of electricity.

At a more general level, there is now greater pressure from consumers and regulators on appliance makers. For regulators, forcing more efficient appliances is a painless way (for them!) to save the environment. For consumers, there is a "feel good" factor associated with buying an energy efficient product, and the prospect of lower running costs. In addition, inverter solutions have been cost reduced so that the price gap between an inverter board plus 3-phase motor/compressor and a traditional solution has closed significantly.

The number of power semiconductor companies targeting the major home appliance market has increased significantly over the last few years, and it is likely that the market will continue to become more competitive as it grows further. For those that succeed, the prize is likely to be substantial revenue growth over the next 5-10 years.

www.imsresearch.com

On the Road

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

Ansoft

I attended the well presented seminar given by Ansoft, leaders in the high performance segment of the EDA market and was fortunate enough, not only to attend the well populated sessions, but also to talk with the company's founder, Dr. Zoltan J. Cendes Ph.D., CTO and Chairman of the Board.

I must admit, that this is a grey area for me and I had a lot to catch up on. I learnt a lot at the sessions but it was so eloquently explained by Dr. Cendes, that I came out converted to the cause.

When looking at the simulations carried out with Ansoft's products, I was astounded at the close resemblance to the actual measured results of the customers finished products. To me, simulation tools gave me an idea of where the design was going, but the accuracy of these simulations was uncanny.

Ansoft Eliminates Problems by Design

"The accuracy is dependent on the quality of the input data" said Dr. Cendes. I asked if this was a difficult task for designers requiring a steep learning curve in programming skills. "Not at all, naturally one must learn to work with the tool, but it is not difficult. One simply enters the design parameters, which are known, and the program does the rest. This saves a great deal of time in avoiding the usual design iterations that cost valuable time-to-market and lost profits."

It seems that as we progress in our designs in power, the level of sophistication and complexity also increases. Areas such as EMI are difficult to predict and when discovered late in the cycle, can have a disastrous effect on the product launch date.

Ansoft's tools, among many other things, can do this and advise the designer up-front, thereby avoiding the re-iteration of slugging the affected areas and even redesigning critical layout paths.

"Engineers are now embracing these tools because they realize the practical advantages of avoiding problems before they occur. Everyone is under great pressure to deliver on time and the power engineer in normally at the back end of the product development and consequently under more stress. The smarter Managers too are seeing the cost benefits. They want their products on the market as fast as possible. There is just no time these days for trial and error. That's why we call this seminar series 'First-Pass System Success' enthused Dr. Cendes. "Our growth is staggering, over the next ten years I am convinced we will see an escalation of these tools."

But it is not just new designs that are getting the time to market boost. Successful existing designs can be improved with the use of Ansoft's tools to give greater added value to the customer.

Creativity of designers can also be enhanced. Sometimes bending the traditional design rules in terms of layout can really push the envelope and give great benefits against all the existing doctrine. As one famous Italian racing driver once said, "If everything seems under control, you're just not going fast enough!" With simulation a designer can really give his instincts a practical run to try to get that elusive competitive edge, all without going through a prototyping cycle.

In terms of speed, this was in the early days, always a sticking point. Simulation

was slow, but as Ansoft have developed and highly tuned their tools, they have made tremendous leaps in compacting the process. This, together with the relentless progress in microprocessor performance has lead to a very fast evaluation process.

A brief overview of the products presented follows:

The entry level product PExprt, is ideal for designing inductors and transformers in automotive and aerospace converters, switch mode power supplies and electronic ballasts, whose electromagnetic, thermal and system performance can be very quickly calculated taking into account all combinations of core size, materials, wire gauge, turns and gap length to meet their specifications.

RMxprt is used for the quick analysis of a wide range of rotating electrical machines. This comprises many kinds of DC-, induction, and synchronous motors or generators, including such of brush-type commutation, permanent magnet or electrical excitation. In a very fast and accurate process, designers can explore hundreds of 'what if' scenarios.

Easy-to-use electromagnetic field simulation in greatest detail is provided by the powerful Maxwell products (2D and 3D). Ansoft's unique autoadaptive meshing functionality allows especially motor, solenoid and other electromagnetic component design engineers trusting his simulation results, even without having to have long-term experience in finite element meshing. The Maxwell Transient with full Large Motion simulation feature lets designers explore essential interactions between magnetic fields, mechanical motion as well as integrated power electronic switching.

In multi-layer PCBs with complex ICs often found in many of today's complex systems, Ansoft's Q3D-Extractor ensures these designs will meet specs for timing, signal integrity and crosstalk. This includes package, cable and other electromagnetic interconnect effects strongly influencing the design behavior.

The premier software program is Simplorer. It provides fast detailed analysis at system level in highly complex, switching nonlinear multi domain systems commonly found in power electronic and industrial automation, automotive and aerospace, defense and many other systems. It is very easy to use. Maxwell, Q3D, RMxprt/PExprt and others can seamlessly be integrated into Simplorer to account for interactions between system and component. Simplorer's support for VHDL-AMS allows designers exchanging models with OEMs or suppliers to evaluate trade-offs early in the design process.

This is just a quick snapshot of the tools and systems that have fueled the impressive growth of this outstanding design based company. Further information can be viewed at the company's website.

www.ansoft.com

Linear Technology

I recently visited Linear Technology in Milpitas, California and met with the management team responsible for this latest rich harvest of top quality DC/DC power modules, which can deliver outstanding performance for a broad range of demanding applications, where designers can experience severe difficulties. Afshin Odabaee, Product Marketing Engineer for power products ran me through the range explaining up front that the design objective is to 'make it simple' but to deliver top-of -the-range performance. Here follows a run-down.

Linear Unveils Latest Developments in DC/DC µModule Family

Today, more Power Supply Rails are needed for systems based on the new generations of FPGAs and ASICs; Sub-1V, 1.0V, 1.2V, 1.5V, 1.8V, 2.5V, 3.3V.

There is much less margin for inaccuracy, these latest FPGAs use lower voltages, higher currents and drive faster signals and are extremely sensitive to supply noise.

Additionally, the increase in power re-

quirement creates a great deal of thermal stress on components, a vital factor in the choice of power device. In order to provide an easy route for manufacturability, power parts need to be compact, easy to use and be friendly to standard tooling.

Higher Density Systems, now commonplace require more efficient, higher power and smaller solutions together with an outstanding thermal performance. Achieving the vital noise figure for these highly noise sensitive FPGAs

Photo Caption: Simplest High Power Buck-Boost DC/DC Solution.

Photo Caption: 98% Less Heat, 190% Smaller than Linear Regulator.

for better signal integrity, demands cleaner grounding paths normally requiring a full and in-depth understanding of power supply, layout and advanced analog design techniques.

DC/DC µModule™ Systems have been designed by Linear to deliver all the benefits of a Switch-mode Buck Converter with the implementation simplicity of a traditional Linear Regulator. All main power components are contained within these advanced packages, including the inductor and bypass capacitors, with built-in compensation, all protected by a rugged encapsulated surface-mount LGA.

The tiny form factor of these devices also gives manufacturers of high density boards the ability to mount the µModule on the rear side of the board with the associated density advantage.

The new µModule family features alternatives for high Vin, high power, buck boost technology or very high Vin for low to mid power applications.

With the huge reduction in components versus discrete solutions that Linear's talented and much envied design teams have achieved, an extremely simple layout can be very easily achieved.

The LTM 4600, for example, for more simple applications can achieve 10A at 20Vin. There is also a military plastic version available at mil temp. specs.

For more complex solutions, **the LTM 4601** features PLL, tracking and margining. The device can be mounted remote from the POL due to its remote sense feature which keeps the POL voltage where it should be, regardless of track impedance.

Thermal balancing in current sharing modes are perfectly matched and, as usual specified very accurately by Linear, a key differentiator for this high end analog company. Efficiency is up in the 90% range.

LTM 4604 operates in the 2.375 to 5.5V range with a 4A output capability featuring a 2.3mm profile and 9 x 15mm footprint. Again, extremely detailed specs with total integrity are available from the company.

LTM 4608 delivers 8A and can be very simply paralleled to multiply this figure.

New LTM4605 Buck-Boost DC/DC µModule Regulator Uses Few Components and Dissipates Less than 2.4W at 60WOUT

The LTM4605 is the first device in a new family of buck-boost products and operates from 4.5V_{IN} to 20V_{IN}, regulates an output voltage from 0.8V to16V and delivers an output power up to 150W. The LTM4605 integrates a synchronous buck-boost DC/DC controller, four N-channel MOSFETs, input and output bypass capacitors and the compensation circuitry in a 15mm x 15mm x 2.8mm land grid array (LGA) plastic molded package. Only an inductor, feedback and sense resistors and bulk capacitors are required to implement a very low profile, compact and high efficiency design. The LTM4605 provides a compact regulator solution in applications such as networking, industrial and automotive systems and high-power battery operated devices.

With the LTM4605's on-board proprietary 4-switch synchronous MOSFET design, the product achieves up to 97.3% efficiency in boost mode and up to 97.7% efficiency in buck mode (V_{IN}: 4.5V to 20V, V_{OUT}: 12V, IOUT: 5A). Whereas other topologies such as SEPIC (Single Ended Primary Inductor Converter) require as many as 20 components and custom magnetics, this buck-boost µModule solution uses only eight components and an off-the-shelf inductor. In addition, the efficiency of a comparable SEPIC circuit is approximately 76% to 84%. Furthermore, to reduce undesirable frequency harmonics, the LTM4605 is phase-lockable to an external clock frequency ranging from 200kHz to 400kHz. Safety features include overvoltage and foldback current protection. The LTM4605 is offered for operation from -40ºC to 85ºC temperature range. 1,000-piece pricing starts at $18.85 each.

New LTM8020 36V_{IN}, 200mA DC/DC µModule achieves 98% Less Heat Dissipation and 190% Smaller Design

The LTM8020 is the first in a new family of DC/DC µModule™ regulator systems that operate from higher voltage input supplies of up to 36V (40Vmax). The LTM8020 is a 200mA complete DC/DC solution that includes a DC/DC controller IC, power switches, inductor, compensation circuitry and input and output bypass capacitors. This solution is extremely compact at only 6.25mm x 6.25mm and low profile at 2.3mm in height. Compared to a linear regulator circuit, the LTM8020's more efficient switch-mode topology provides cooler operation, dissipating 98% less heat and occupying 190% less volume (area x height) with its compact package and no-heatsink requirement (comparison conditions: $36V_{IN}$, $1.5V_{OUT}$, 200mA, T_A=25ºC). Target applications are systems with 24V and 28V input supply rails such as medical, industrial, avionics and after-market automotive.

The LTM8020 is a complete 200mA, current mode, switching DC/DC point-of-load regulator system in a 6.25mm x 6.25mm x 2.3mm LGA (Land Grid Array) surface-mount package. The package can be mounted on the back side of a circuit board, allowing more room for digital ICs on the top side. Input voltage range is from 4V to 36V and output can be adjusted with only one resistor from 1.25V to 5V. Encapsulated packaging protects the circuit components against mechanical, chemical and ambient factors, thus improving the reliability of the design. The LTM8020 is rated for operation from -40ºC to 85ºC and is ROHS compliant. Its gold-plated pads allow both Pb- and Pb-free solder to be used during board assembly. 1,000-piece pricing starts at $4.95 each.

With this new family, coupled with Linear's dedicated suite of advanced web design tools, highly demanding design situations can be overcome with the minimum to time wastage and design stress. I believe we will see even more from this family in the future.

www.linear.com

SynQor

I met with Phil Goff of SynQor who walked me through the company's latest offering. The company is focused on higher performance products (>10pts efficiency) utilizing known designs for higher reliability to get their customers quickly to market. The company has a solid penetration of the telco business and is now positioned for growth into diversified markets such as industrial and medical.

High Efficiency 24 Volt Input Eighth-Bricks

SynQor has announced the release of a new range of isolated DC/DC converters targeting the industrial marketplace as part of the ongoing expansion of its InQor product range. The IQ24-EGA series of industry standard Eighth-Brick devices operate over an input voltage range of 18-36V and provide up to 25A, or 75W of output power. The

available output configurations include 1.8V/25A; 3.3V/20A; 5V/15A; 7V/10A; 12V/6A; 15V/5A and 24V/3A.

Targeting a diverse range of applications including industrial process control systems and industrial computing, the IQ24-EGA series is available either as an open frame device, or as a fully encased device with an attached baseplate for cold-plate or heat-sink mounting in harsh environments. Sized at just 58.4 x 22.9 x 10.41mm in open frame format, the devices offer an extremely high power density, at efficiency levels of up to 90%.

The high efficiency and optimum layout of the patented synchronous rectifier based topology employed in the IQ24-EGA, leads to maximum output current availability with minimal derating. In many cases, the Eighth-Brick IQ24-EGA will be able to replace traditional Quarter-Brick packages from competitors used in existing designs, offering great advantages to the board designer. Fixed switching frequency operation offers predictable EMI performance, and MTBF figures in the region of 2.5Mhrs reflect the high reliability of the devices.

The IQ24-EGA series is capable of withstanding transients on the input to 50V for 100ms, and has a basic isolation level from input to output of 2000Vdc. Control and protection features include remote sense, a wide output voltage trim range of –10% to +10%, input under-voltage lockout, output OVP, current limit, short circuit protection, active back bias limiting and thermal shutdown. Operating temperature range is -40 to +100ºC.

www.synqor.com

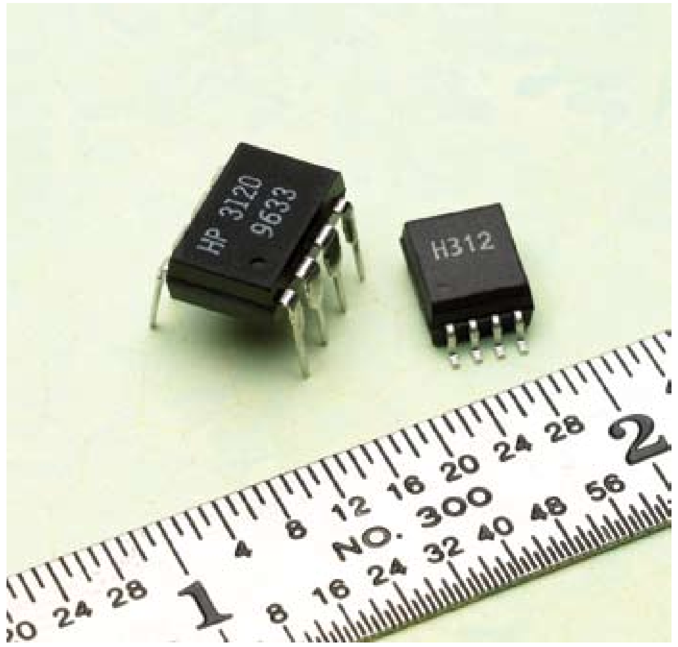
Special Report

SPS/IPC/Drives in Brief

During the recent SPS/IPC/Drives Exhibition in Nürenberg, Germany I had the opportunity to meet with several company executives and discuss their new product offering being introduced and on display. Following are the high lights.

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

Avago

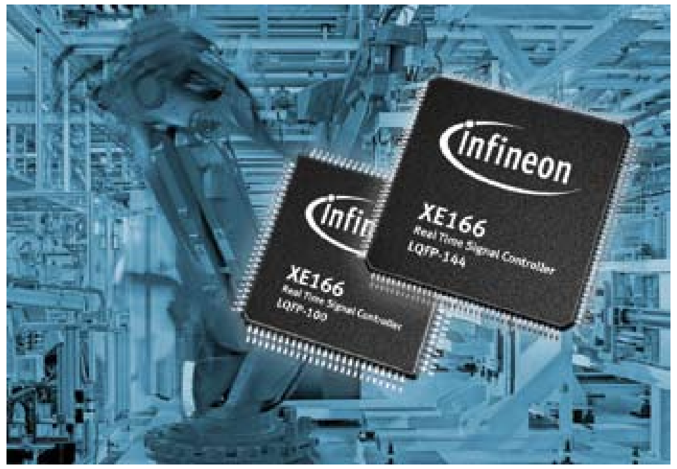


Announced the industry's smallest 2.5A gate drive optocoupler. The compact and highly integrated ACPL-H312 is available in a stretched SO-8 package which is 40% smaller than conventional dual-in-line packages.

Also announced was an industry-high output current gate drive optocoupler with under voltage lockout (UVLO). By combining optocoupler technology with a 5.0A power transistor into a single 8-pin package, Avago's ACNW3190 delivers a high output current gate optocoupler driver which minimizes PCB space, offers component savings to lower design costs and provides high CMR noise isolation.

The latest addition to its optocouplers family targets the hybrid electric vehicle (HEV) market. This new automotive-grade ACPL-M46T is a 1MBd Intelligent Power Module (IPM) digital interface optocoupler designed for HEV applications and offers high reliability, high performance, ease of integration and superior heat dissipation.

Infineon



Introduced a new family of 16-bit real-time signal controllers that feature fast interrupt response time and context switching specifically targeting industrial drives applications. The new XE166 family of Real-Time Signal Controllers (RTSC) can control up to four individual motors simultaneously.

ITT Cannon

Designed as a replacement for two circular connectors, new Cm2 series high voltage connectors from ITT Cannon provide maximum power in a minimum size package and can be installed simply and at low cost.

An addition to the range of Cm3 connectors is launched for small servo motors. The low profile Cm3 2x power connectors use one standard power connector to feed the motor (three power contacts plus one ground contact) plus an additional power connector (featuring four power contacts) for the two-way brake and two-way thermal sensor.

The new Cm5 connectors feature the highest maximum current of 40A for motor flanges of up to 150x150mm. Designed as a replacement for two circular connectors, these connectors benefit from a minimum size package and can be installed simply and at low cost.

A range of small 'two-in-one' servo motor connectors reducing the connector footprint on the servomotor by half and meeting the latest requirements for cost reduction, miniaturization and maximum performance, designed as a replacement for two circular connectors.

LEM

Complementing LEM's superior range of products for advanced battery management applications, the new DH family of DC current transducers offers precise measurement of bipolar currents up to 2000A. Measuring only 174 x 86 x 54.1mm, these compact split-core transducers combine Hall-effect technology and signal conditioning in a single housing with a large rectangular sensing aperture for non-contact measurement (supporting up to 104 x 40mm busbars or Æ 40mm cables).

Vicor

The PFC FlatPAC uses Vicor's field-proven VI-HAM and Maxi DC-DC converters to deliver up to 575 watts of clean, reliable power. It is a single-output power supply available with standard output voltages from 2 to 54Vdc. It operates from an input of 85-264Vac, includes active power factor correction (0.99 power factor), and meets EN61000-3-2 harmonic current limits. Internal filtering provides compliance to EN55022-A conducted EMI. It is available in Vicor's ultra low profile 34.8mm FlatPAC chassis, in either finned or conduction-cooled (CC) versions.

Designing with Low-Side Gate Drive ICs

A designer's guide for using low-side gate driver ICs in power supplies

The design of switching power converters can be simplified by the use of low-side gate drive ICs, but they must be applied correctly to realize their full potential for minimizing size and maximizing efficiency of a power supply. This article explains some important aspects of designing with these devices -, namely how to choose the right driver with respect to current rating and features; what complementary components are needed around the driver; and how to determine thermal performance including the loss calculations & estimating junction temperature.

By Dr. Van Niemala, Senior Member of the Technical Staff, Fairchild Semiconductor

Low-side gate drive ICs are specialised amplifiers commonly used in power supplies to switch ground-referenced MOSFETS and IGBTs according to an input signal from a PWM controller. For low-power converters less than 100-200W, these drivers can be successfully integrated into the PWM controller to reduce component count, which works fine as long as certain conditions are met. These conditions are that the MOSFET switching times are fast enough to provide acceptable switching losses; noise from the relatively high drive-current pulses does not disturb the control functions; and heat dissipation on-board the PWM IC is manageable. On the other hand, in higher-power converters, separate drive ICs are typically used to provide more drive power or to more easily manage the noise and heat dissipation. Furthermore, power-supply efficiency can be improved by using a lower supply voltage for the controller and a higher voltage to drive the power switches, and this voltage-level translation is performed very well by gate drive ICs.

Discrete components are sometimes used to construct simple gate-drive circuits to save cost, which makes sense when the advanced features and performance of a driver IC are not needed. However, this approach has several limitations. For example, if an NPN/PNP emitter-follower output stage is chosen, the biasing circuit must be carefully designed, and the output-voltage swing is reduced by the output saturation voltage of the transistors—as high as a volt with fast switching. If instead a PMOS/NMOS inverter is used at the output, the control logic must accommodate the logic inversion, and there is typically some shoot-through as the driver switches states. With either technology, this low-gain stage requires fast edges on the input to produce rapid switching, more circuitry is needed to implement features such as voltage-level translation and as the component count increases, space, assembly time & reliability are negatively affected.

Gate drive ICs can solve most of these problems. They have integrated features such as enable and Under Voltage Lockout (UVLO) that make it easier to control the power switch during the most troublesome operating conditions: startup, shutdown & faults. Small logic gates can easily drive their high-impedance inputs, and because driver ICs contain high-gain circuits with positive feedback, the output always switches quickly as soon as the input voltage crosses a threshold. When the IC is designed to stabilize this threshold voltage over temperature, it becomes easy to insert a fixed time delay with a simple RC circuit at the input. In summary, IC drivers offer high performance and sophisticated features in very small packages---as small as 2x2mm for a 2A driver and 3x3mm for a 9A driver (or dual 4A).

The rest of this article will explore important considerations for designing with low-side driver ICs. First, how to choose the current rating of the driver depending on how it is used in the circuit; next, some discussion of where particular features might be useful and what components are often used around the IC. Finally, a simple method for assessing thermal performance is described, as a gate-drive IC can easily be the hottest component in the circuit.

COVER STORY

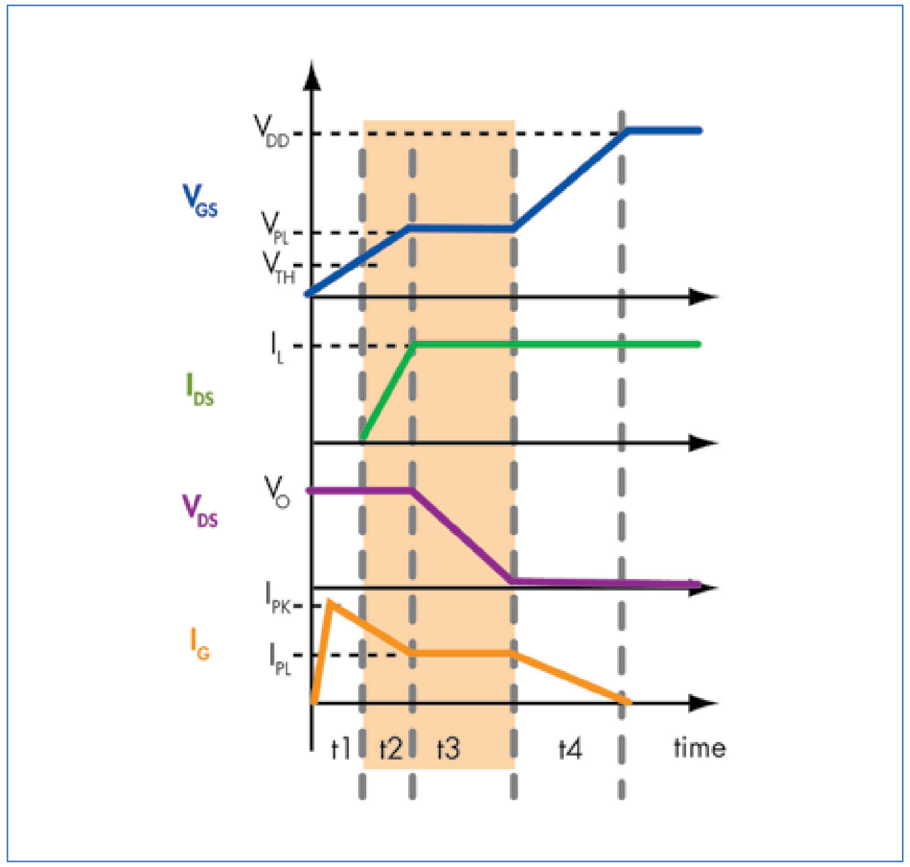


Figure 1: Idealized turn-on waveforms for a power MOSFET under clamped inductive switching, showing that almost all the switching losses occur during drain-current ramp-up (+2) and the "Miller" region (+3).

Sizing the driver

Two common types of switching where low-side drivers are used are clamped inductive switching, characteristic of primary-side switches in hard-switched topologies, and synchronous rectification. The criteria for sizing the driver for each are quite different and will be reviewed here.

The idealized turn-on waveforms for clamped inductive switching are shown in Fig. 1, characterized by no overlap between the rise of the drain current and the fall of the drain-to-source voltage. This produces worst-case switching loss, which is commonly expressed as an average power dissipation over the entire converter switching period T_S even though the actual power dissipation occurs only during t2 & t3 in this figure.

$$P_{SW-ON} = \frac{1}{2} I_L V_O \frac{t2 + t3}{T_S} \quad (1$$

The length of (t_2+t_3) depends on the average gate drive I_G current and the amount of charge that must be delivered to the MOSFET gate to traverse these intervals, either found in the MOSFET specifications or read from the total gate charge curve.

$$t2 + t3 = \frac{Q_{gs2} + Q_{GD}}{I_G} \quad (2$$

The turn-off waveforms are the mirror image of Fig. 1, and the turn-off switching losses can be calculated in a similar manner and added to (1) to give the total switching losses in this power switch.

From these equations it is clear that the switching losses are inversely proportional to the gate-drive current during the lossy intervals, and for clamped inductive switching, this is the main criterion for sizing the gate driver. In fact, the most important driver characteristic is its output current when its output voltage is near the middle of the operating range.

Driver ICs are available from several suppliers in standard sizes such as 2A, 4A, and 9A, but unfortunately, the test conditions for measuring this current are not standard. For some suppliers it is the approximate peak current driving some defined load, while for others it is a steady-state current with a clamped output voltage, so two drivers with the same current "rating" could have very different current capability. If we use a rating that is the steady-state current at the middle of the output voltage range, Table 1 is a handy guide showing how fast a certain amount of gate charge can be delivered or removed by each size driver with no external resistance in the drive path. This table was calculated from (2) but with times extended by an empirical factor of 1.5 to account for non-ideal behavior measured in the lab. These times are still optimistic, however, because even when no series gate resistor is used, the internal gate resistance of the power switch slows down the switching.

When gate drivers are used with synchronous rectifiers (SR), the sizing criteria are completely different, because switching losses are negligible thanks to body-diode conduction both before and after MOSFET channel conduction. In this case, the drive-current needs are determined by timing and the prevention of dv/dt turn-on.

To prevent shoot-through and the resulting unnecessary power loss, the

Table 1: For each of three common driver current ratings (measured at V_{OUT}=$V_{DD/2}$), the minimum switching time of the MOSFET as a function of the total gate charge that must be supplied or removed. Actual switching times are longer depending upon the amount of series gate resistance present.

Q_G (nC)	Min. Switching Time (ns) for Driver Current Rating		
	2A	4A	9A
5	3.8		
10	7.5	3.8	
20	15	7.5	3.3
50	38	19	8.3
100	75	38	17
200	150	75	33
500	375	188	83
1000	750	375	167

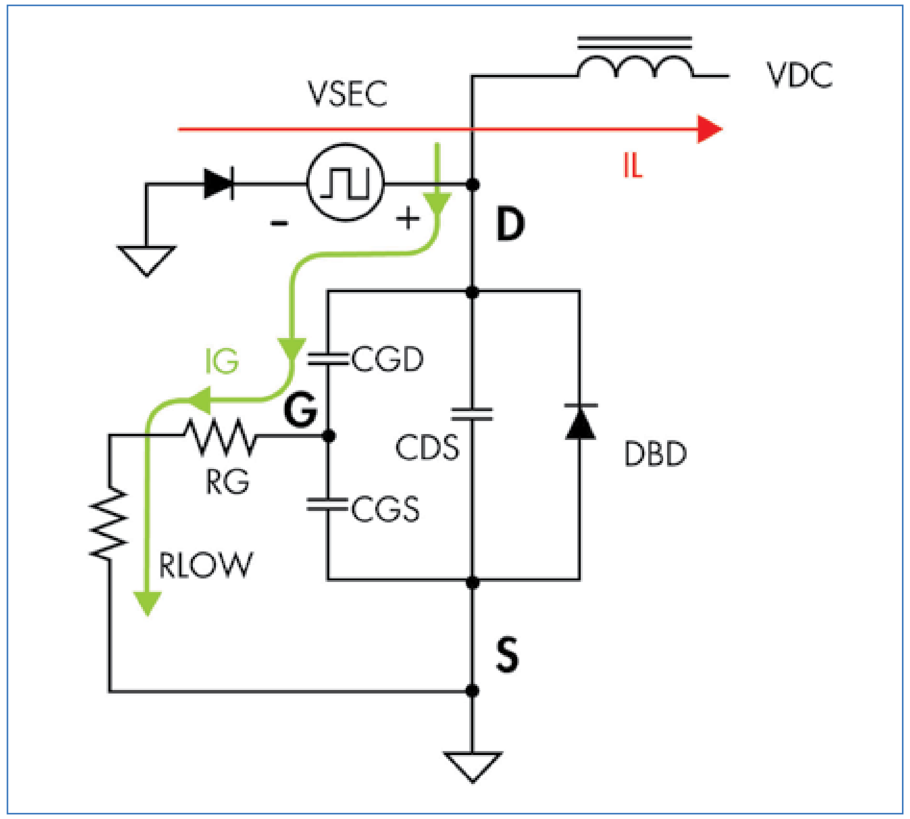


Figure 2: Model of a MOSFET in the "off" state used as a synchronous rectifier, illustrating that while the drain voltage is rising rapidly, the driver must sink current to prevent dv/dt turn-on and the resulting shoot-through losses.

SR must be switched off fully before a voltage is imposed across it, usually by one or more primary switches turning on. To set ensure this condition is met while leaving the SR on as long as possible to maximize efficiency, it is necessary to know how long it takes to turn off the SR. Referring to the MOSFET model in Fig. 2, the turn-off time may be calculated:

$$t_{SW-OFF} = \frac{(C_{GS} + C_{GD,SR})V_{DD}}{I_G} \quad (3$$

where C_{GS}=C_{ISS} - C_{RSS} is the linear gate-to-source capacitance of the MOSFET, and $C_{GD,SR}$ is a low-voltage value of the nonlinear gate-to-drain or "Miller" capacitance C_{GD}=C_{RSS}. A useful choice for this capacitance corresponds to the middle of the voltage swing during SR turn-off, $V_{DD/2}$. This value may be read from a curve of C_{RSS} versus voltage if provided, or it may be calculated from a value $C_{RSS,SPEC}$ given in the datasheet for some higher voltage $V_{DS,SPEC}$ by the following empirical formula[1]:

$$C_{GD,SR} = C_{RSS,SPEC}\, 2\sqrt{\frac{V_{DS,SPEC}}{(V_{DD}/2)}} \quad (4$$

Once the SR is fully turned off, the main switch in the power converter can be turned on, which causes the drain voltage of the SR to rise rapidly. Fig. 2 shows this situation, where the capacitive voltage divider formed by C_{GD} and C_{GS} causes the internal drain voltage to rise—and the MOSFET to turn back on briefly—unless the driver sinks sufficient current to keep the internal gate node below the threshold voltage of the MOSFET. This is often the main criterion for sizing an SR driver. Near the beginning of the drain-voltage rise, where C_{GD} is largest, the sink current needed is approximately

$$I_G = C_{GD,SR} \frac{dV_{DS}}{dt} \quad (5$$

If a larger driver cannot be used and it is already positioned very close to the SR, a last resort to eliminate dv/dt turn-on is to reduce dv/dt by slowing down turn-on of the main switch, but unfortunately this increases switching losses in the main switch.

Choosing features

Besides the current rating, a designer is faced with feature choices when choosing driver ICs, namely input logic and configuration, input thresholds, and package. Speaking of a single driver channel, available inputs include inverting, non-inverting, dual, and enable. The choice between inverting and non-inverting is usually made to put the correct polarity of control signal at the gate of each MOSFET, sometimes different for different switches driven by a single control output. If both polarities are needed, fewer different components are needed with a dual-input driver, which can be configured either way thanks to one inverting and one non-inverting input. If additional control is needed over when the MOSFET switches, e.g., to set a higher UVLO threshold or to disable SRs during startup, a second, enable input can be useful.

Drivers are available with either TTL or CMOS input thresholds. A TTL "low" input is defined as below 0.8V and "high" is defined as above 2.0V independent of the supply voltage, so TTL thresholds are approximately constant and always between these limits. In contrast, CMOS thresholds are approximately 40% & 60% of the supply voltage. TTL is more common and especially useful when the input signal has a relatively low amplitude, as from a low-voltage PWM controller. In noisy environments, however, CMOS is preferred for its greater noise margin, and RC time delays can be set more precisely with CMOS because the thresholds are closer to half the supply voltage. When precise timing is needed, temperature stability of input thresholds and propagation delays is also important.

Most power supply designers are familiar with the package tradeoff, usually between the low cost of a standard leaded package vs. the smaller size and better thermal performance of an MLP, which typically has an exposed thermal pad to aid heat removal.

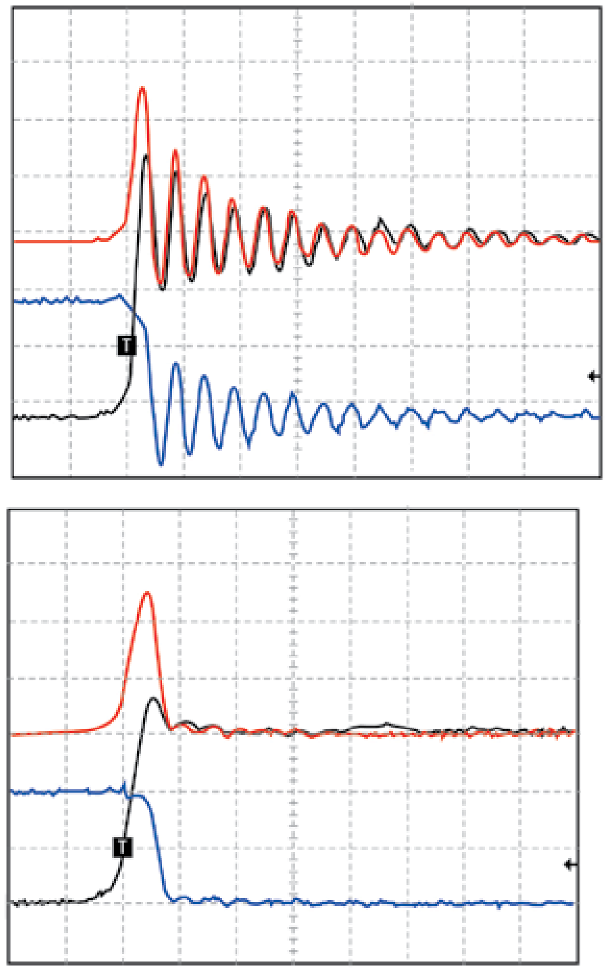


Figure 3: Clamped inductive turn-off of a MOSFET comparing different values of series gate-drive resistor, 3.3Ω (upper) and 10Ω (lower). The waveforms and drain current (bottom, 2A/div), drain-to-source voltage (middle, 100V/div), and instantaneous pow (top,500W/div) all at 25 ns/div. Test setup is FDD6N50 + ISL9R460, U=300V, I=4A.

Complementary components

There are two key complementary components to consider when designing with driver ICs: bypass capacitors and series gate resistors. Because a driver delivers short pulses of current, a very low impedance supply is needed to deliver maximum current, usually implemented as a pair of bypass capacitors placed right next to the driver, which should itself be located right next to the power switch to minimize the stray inductance of this current loop. The larger capacitor is typically electrolytic or another lower-ESR type, with a value 2 to 10 times the effective load capacitance which may be calculated from the total gate charge as

$$C_{EFF} = \frac{Q_g}{V_{DD}} \quad (6$$

The second, ceramic bypass capacitor is typically about one tenth this value. When sensitive control circuitry is supplied from the same voltage source, it is also good practice to add a few ohms of series resistance in the supply line to separate the driver section from the control section.

A series gate resistor between the driver and the power switch is often omitted when driving synchronous rectifiers, but otherwise it is common to use one in the range 2 to 20 Ohms for any of three reasons: First is to dampen ringing between the power switch gate capacitance and the stray inductance of the gate-drive loop, illustrated in Fig. 3, because excessive ringing increases EMI and can increase losses by turning the switch on an off quickly.

The second reason is to slow down switching, also to reduce EMI, but higher switching losses will result. The third possible reason for using a series gate-drive resistor is to shift some of the gate-drive losses from the driver to this external resistor, while the total gate-drive losses remain constant.

As mentioned previously, with a driver IC that has well-controlled input thresholds, a fixed time delay can be inserted in the control path using a series resistor followed by a small capacitor to ground at the input of the driver.

With the addition of a gate-drive transformer and several other components shown in Fig. 4, a low-side driver can also be used to drive high-side (floating) switches, as an alternative to a high voltage driver IC. Some common reasons this is done are to cross an isolation boundary, to shorten propagation delays, and to produce a more rugged drive circuit.

Thermal design

Attention should always be given to thermal design because driver IC power dissipation can be significant. This is a two-step process: first calculate the dissipation expected in the driver, and then estimate the junction temperature to ensure it is within design limits.

For the simple gate-drive circuits discussed here (control-driven & non-resonant), the total gate-drive loss associated with switching a power MOSFET or IGBT on and off one cycle can be obtained from the total gate charge curve in the switch datasheet, by reading the total gate charge Q_g that corresponds to the chosen gate-drive voltage V_{DD}, then calculating

$$P_{DRIVE} = V_{DD}\, Q_g\, f_{SW} \quad (7$$

This power dissipation is independent of the value of the series

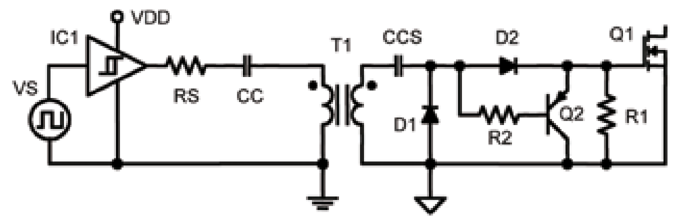


Figure 4: A practical high-side drive circuit using a low-side driver and a gate-drive transformer. R1 is a bleeder resistor for shutdown; Q1, R2&D2 form a turn-off speed-up circuit, D1&CSS are a charge pump to restore the dc level on the secondary, CC is the dc blocking capacitor to keep the transformer from saturating, and RS is a damping resistor. (The driver bypass capacitors are not shown.)

gate drive resistor, which does affect how much of the power is dissipated in the driver IC versus the other series resistances of the drive circuit. In fact, the fraction of power dissipated in the IC is the simply the ratio of its effective output resistance to the sum of all the resistances around the drive loop, which is different for turn-on and turn-off. To perform this calculation, the simplest estimate of effective driver output resistance is one half the supply voltage divided by the steady-state source or sink current with the output clamped at one-half the supply voltage. Other loop resistances that should be included are the external and internal series gate resistances of the switch, and the ESR of the large bypass capacitor. Because some of these resistances are not known very precisely, the total gate drive power (7) can be used as an upper limit on the driver IC dissipation, or some fraction of that value based on experience can be used in the calculation.

Once power dissipation in the driver IC has been determined, whatever thermal parameters are available in the datasheet should be used to estimate maximum junction temperature. The junction-to-ambient thermal resistance qJA is the most common parameter available, but unfortunately it is accurate for only the prescribed thermal design including PCB construction, heat sinking and air flow. In low air flow without a top-side heat sink, the large majority of the dissipated power flows into the PCB. In this case, if junction-to-lead or junction-to-board thermal resistance is given, and if the maximum operating PCB temperature is limited by design, an upper limit on the operating junction temperature can be calculated by assuming the lead temperature equals the maximum board temperature:

$$T_{J,MAX,OP} < P_{DRIVE}\, \theta_{JL} + T_{L,MAX,OP} \quad (8$$

If this junction temperature is too high, the choices are to refine the estimate, provide more cooling, or choose a lower-impedance driver. One way driver suppliers obtain better results—as well as some of the thermal parameters provided in datasheets—is detailed finite-element analysis of the package and thermal environment as illustrated in Fig. 5.

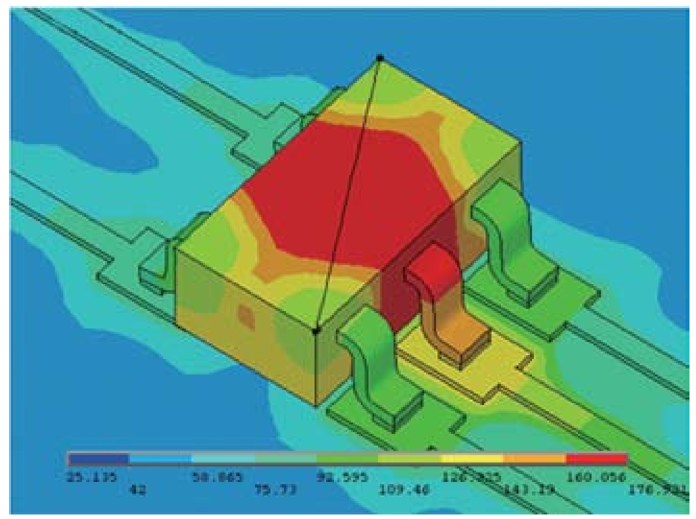


Figure 5: Some results of finite-element thermal analysis of a driver IC in a SOT23-5 package, mounted on a PCB with natural convection cooling.

Summary

This article has provided design guidance for using low-side gate driver ICs in power supplies. This includes how to choose the right driver current rating and features, what support components are needed around the driver, and how to estimate losses and junction temperature. Properly applied, gate drive ICs can increase efficiency, reduce size, and simplify the design of switching power supplies.

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Pitfalls to Avoid in Selection of Reset Generators and Voltage Supervisors

Components require multiple lower-power supply voltages to operate

Market pressures are constantly forcing engineers to enhance product features while reducing the product's cost and form factor. This challenge typically is met with the use of ICs and microprocessors with a higher degree of integration.

By Srirama Chandra, Product Marketing Manager,
In-System Programmable Mixed Signal Products, Lattice Semiconductor Corp.

These supply voltages are generated by on-board power supplies (or DC-DC Converters) operating from the input supply. In order to provide the same level of reliability as simple single supply boards, all of the supplies on the board must be monitored. A new generation of voltage supervisors and reset generators facilitate the monitoring of these multiple power supplies.

What are Reset Generators and Voltage Supervisors?

Most microprocessors provide a "Reset" pin to enable the external hardware to begin program execution from a fixed memory location. This pin should be driven by an external IC, called a Reset Generator, which activates the reset signal for a brief period of time after all the supplies powering the processor are turned on. Reset generators also activate the reset signal when an external input, such as a manual reset input, is activated.

So, what happens when the board supply is turned off, or when one of the on-board supplies develops a fault?

When the input power is turned off, all on-board supplies begin to turn off and their output voltages start to drop. On the other hand, when the supply develops a fault, its output voltage can drop below a specified level or increase to dangerous levels. While the supply voltages are dropping, processors can execute instructions incorrectly and jump to unintended memory locations. Consequently, the processor can overwrite its Flash memory contents, rendering the system inoperable.

To prevent such a system failure, a voltage supervisor IC is used. The supervisor IC monitors supply voltages and interrupts the on-board processor when any supply becomes faulty. The processor can then safely abort its current activity or save its mission critical information. After that, the reset generator can hold the processor in reset condition until all the supplies are turned off.

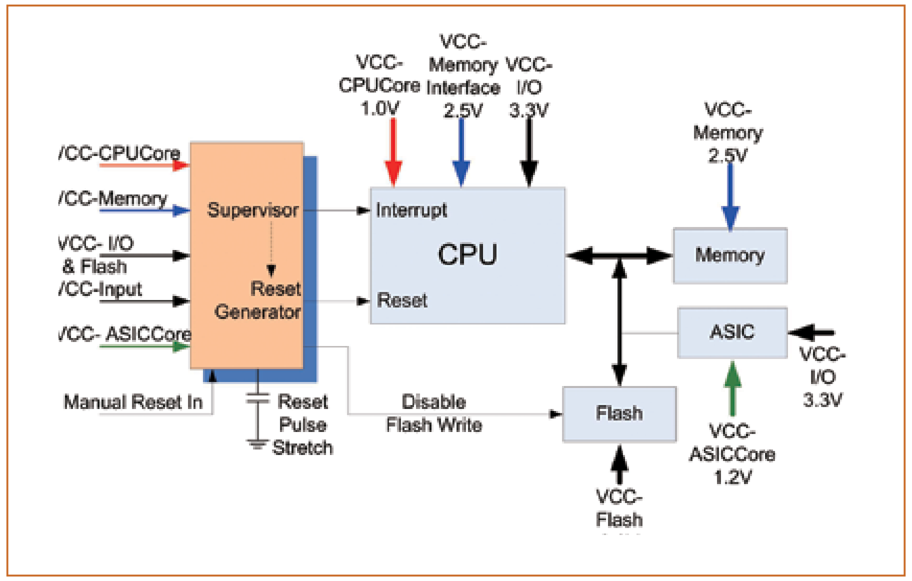

Figure 1: Block diagram of microprocessor board.

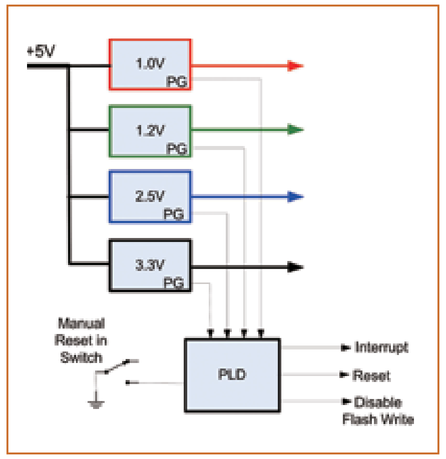

Figure 2: Voltage monitoring with a PLD.

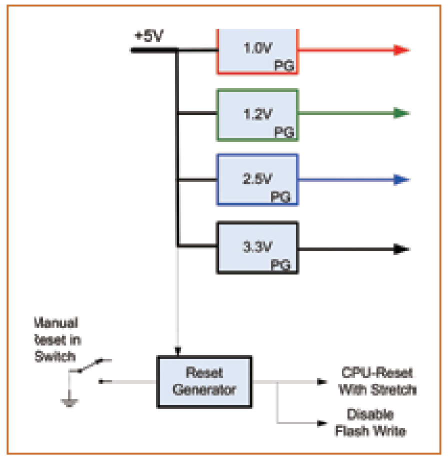

Figure 3: Monitoring just the input voltage.

Figure 1 is a block diagram of a simple microprocessor board. The microprocessor is powered by its core voltage and a couple of I/O supplies. The memory, ASIC and Flash memories are shown with their supplies.

Voltage supervisor and reset generator operation

The Reset Generator waits for all supplies to stabilize and then releases the reset signal of the CPU after a reset pulse stretch period (determined by the capacitor). Then the Flash memory write feature is enabled. If for some reason any of the on-board supplies becomes faulty during power on, the reset for the processor is not released, preventing the corruption of Flash memory.

When all the power supplies are turned on, the supervisor monitors all supply voltages (including the input supply). The supervisor generates an interrupt to the processor if any of the supplies become faulty and, after a brief period, activates the CPU Reset and disables the Flash write signal.

The effectiveness of a supervisor depends on its voltage monitoring accuracy and the speed of voltage fault detection.

Selecting the voltage monitoring threshold for a supervisor

In Figure 1, the CPU Core voltage specification is 1V ± 5%. The supervisor monitoring threshold should be set to 1V-5% = 0.95V. With this setting, the supervisor IC generates a low voltage interrupt when the VCC-CPU Core is less than 0.95V. The supervisor IC in Figure 1 activates the CPU interrupt signal when any of the 5 monitored supplies drop below their corresponding voltage threshold levels.

Voltage supervisor accuracy

For the supervisor in Figure 1, a 0.95V threshold accuracy of 2% means that the CPU interrupt signal can be activated anywhere from 0.95V+2% to 0.95V-3% (~0.97V to 0.93V). Using this supervisor IC, the supervisor threshold should be set at 0.97V to prevent the processor from operating at a voltage less than its tolerance level. However, this setting restricts the DC-DC converter tolerance. In general, supervisors with an accuracy of around 1% provide the optimal solution.

Supervisor fault detection delay

Fault detection delay is measured from the time the power supply voltage drops below the threshold of the supervisor to the time the output of the supervisor toggles to indicate the fault. However, the supply voltage continues to drop during the fault detection delay. The longer the delay, the lower the power supply voltage will be at the time of fault reporting. Consequently, the fault detection delay should be as short as possible (optimally, in the tens of microseconds).

The following section examines several Voltage Supervision and Reset Generation circuits as well as their advantages and disadvantages.

Monitoring power supply voltages using power good signals

The PG (Power Good) signal of a DC-DC Converter indicates that the supply has reached approximately 90% of its rated voltage. In the circuit shown in Figure 2, all of the PG signals, as well as the manual reset signal, are connected to the PLD (Programmable Logic Device). The PLD generates the CPU reset, interrupt to CPU and the disable Flash write signal through logic equations. This arrangement is also used frequently to implement power supply sequencing.

Advantages: the PLD provides flexibility for the generation of Reset, Interrupt and Disable Flash write signals and it enables efficient implementation of sequencing of supplies. Because this circuit is independent of the output voltage of the DC-DC Converters, it can be used as a standard solution across many applications.

Disadvantage: inaccuracy of voltage monitoring. The threshold accuracy of the PG circuitry in most DC-DC Converters is between 5% and 10%. With this margin of error, it is impossible to monitor a supply voltage variation of 5 %.

Additionally, this method does not monitor the input voltage; consequently, it does not provide sufficient time for the microprocessor during the board turn off process.

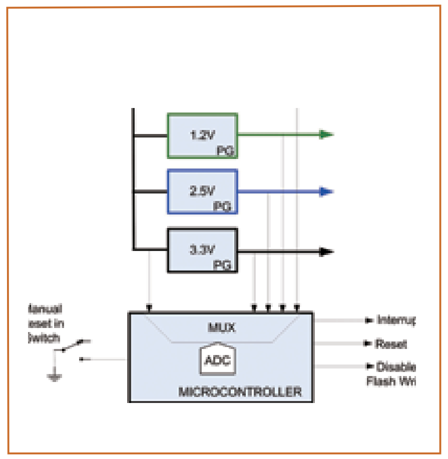

Figure 4: Monitoring voltage using a microcontroller.

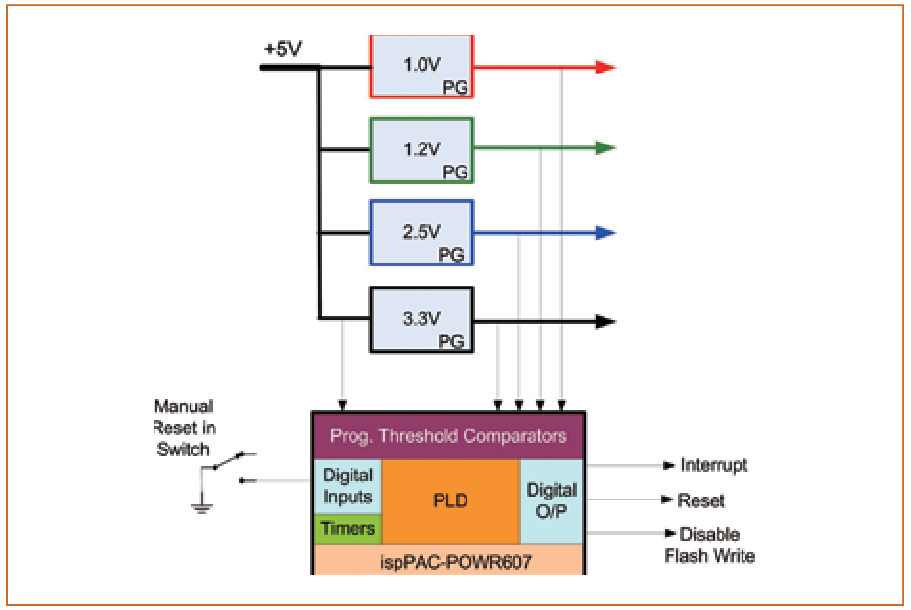

Figure 5: Voltage monitoring using a programmable power manager IC.

Monitoring only the input supply

The monitoring circuit in Figure 3 uses a low cost reset generator to monitor just the input voltage. None of the on-board DC-DC Converters are monitored.

The advantage of this method is that it provides a low cost solution for voltage monitoring and takes care of reset generation during power turn off and turn on.

The disadvantage of this method is that it has no way to determine whether the remaining supplies on the board are operating properly. Therefore, it cannot prevent errors such as Flash data corruption due to the failure of any of the on-board DC-DC converters.

Monitoring supplies using a microcontroller with ADC

The circuit in Figure 4 uses a low cost microcontroller with an integrated Analog to Digital Converter (ADC) for supervision and reset generation. The voltage monitoring software code in the microcontroller measures each of the supply voltages using the on-board ADC in a round robin format, compares the digital code with an internally stored voltage threshold, and determines if there is a power supply error. The voltage monitoring software usually is invoked by an interrupt once every 5 to 10 ms.

The advantage of this method is that it provides flexibility and enables setting the voltage monitoring thresholds with fine granularity (limited only by the ADC resolution). Additionally, the same arrangement can be used as a standard across various designs because it allows board specific customization through software.

The disadvantage of this method is that: the fault detection is too slow and usually needs an external band-gap reference to meet the accuracy requirements.

Major delay in the fault detection is due to the invocation of the monitoring routine: 5 ms to 10 ms. The monitoring software routine also adds to this delay due to sequential monitoring as well as averaging requirements. When most DC-DC converters become faulty or when the supply is turned off, their voltage decays below acceptable levels in about 2 to 5 ms. A fault detection delay of 5 to 10 ms is either too late or provides only an extremely short duration for the processor to safely shut down.

In most microcontrollers, the on-chip voltage reference, which is used by the ADC to monitor voltages, has a margin of error of 2 to 4 %, creating the need for an external voltage reference IC to increase the monitoring accuracy to around 1%.

Example of a supervisor and reset generation circuit

Figure 5 shows a programmable Power Manager device, in this case the Lattice POWR607, monitoring both the input and the on-board generated voltages. The POWR607 supports the monitoring of up to 6 supply rails using the on-chip programmable threshold comparators with a fault detection delay of 12 microseconds. Typical voltage threshold accuracy is 0.5%. The outputs of the comparators are connected to the on-chip PLD. Customized control signals can be generated using logic equations implemented in the PLD. The programmable timers enable the generation of a pulse stretched Reset signal. The POWR607 IC is in-system programmable and the configuration is stored in its on-chip E2CMOS memory.

Advantages of the supervisor and reset generation circuit example

This design monitors both on-board supply voltages and the input supply, combining the advantages of the circuits in Figures 2 and 3. The programmable threshold capability provides the advantages of the circuit shown in Figure 4 that uses the microcontroller. Because the typical threshold accuracy is 0.5%, this circuit does not have the disadvantages of the circuits in Figures 2 and 4. The on-chip PLD provides the same supply sequencing flexibility as that of the circuit in Figure 2.

Evaluating the various circuits, it is clear that the circuit in Figure 5 using the Lattice Power Management IC provides the most reliable supervisor and reset generation circuit.

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Tipping Point for Digital Power Management is Not What You Think

How good GUIs drive adoption

User interfaces drive technology. The tipping point for technologies like the PC, the Internet, and e-mail have all centered on user interfaces. The launch of the iPhone, and its simplified, intuitive interface is being billed as the "killer app" for the mobile Internet.

By Deepak Savadatti, Vice President of Marketing, Primarion

When the user interface becomes truly intuitive (Fig 1), technology reaches a mass audience. With semiconductor design, however, this may seem beside the point. After all, end users won't be directly reprogramming chips any time soon.

While that is true, it doesn't lessen the need for better design interfaces. Even though design engineers have the knowledge and wherewithal to handle highly complex systems and interfaces, what they don't have is time – time to spend figuring out various design tools and programming environments.

Certain technologies, such as digital power conversion, have suffered due to a lack of better interfaces. Power conversion is an arcane specialty and the development has historically been manually intensive. As a result, the adoption of digital power has been slower than it should be. Designers mistakenly believe that they will need to spend a great deal of time learning how to make the shift from analog to digital, so they stick with what they know.

In the past, power supply ICs for computing and communications used to be fairly simple solutions. Analog pulse-width modulation (PWM) ICs had two jobs: power delivery and voltage regulation. For designers, programming was straightforward, and the lack of any sort of design interface was standard. Engineers didn't expect to have complexity abstracted away from the project.

In those days, however, the projects

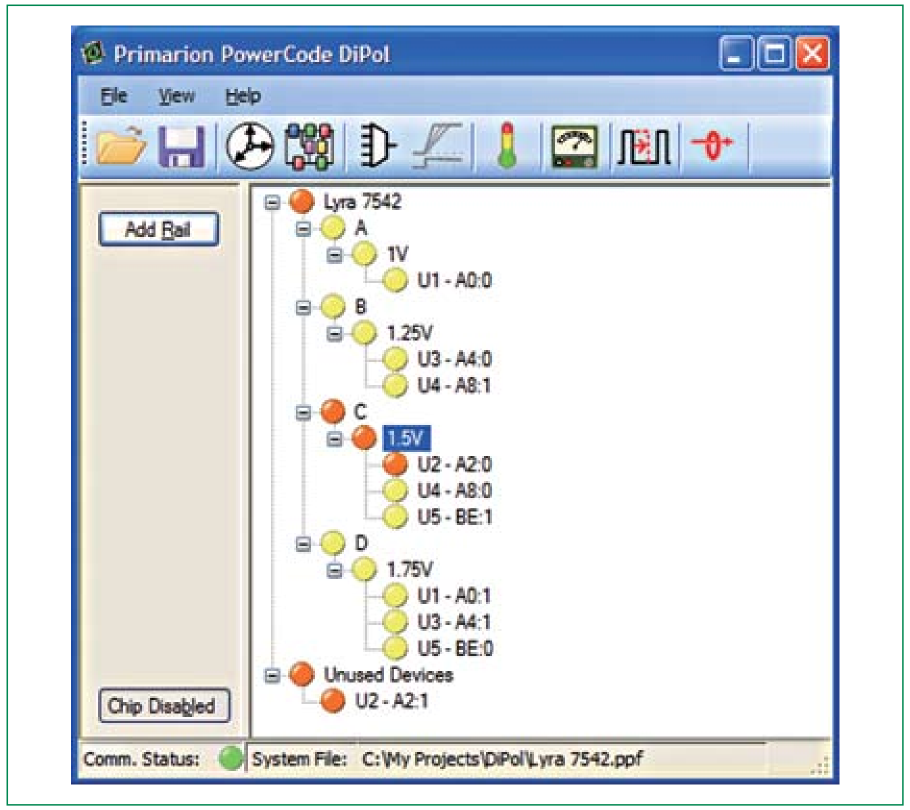

Figure 1: User Interface.

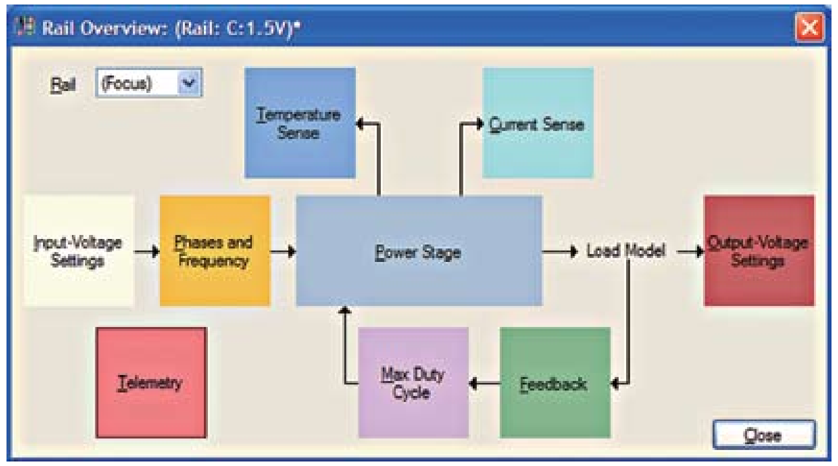

Figure 2: GUI Key Features.

were simple. Anything beyond power delivery and voltage regulation, such as monitoring or diagnostics, was considered superfluous. Or on those rare occasions when needed, these features were accomplished through add-on chips – in other words, they were separate design tasks.

Increasing Chip-Level Complexity Drains Design Time and Development Cost

However, the advancement of PWM solutions has followed Moore's Law, and processors have evolved from 100K gate solutions to those with over a billion gates per die. At the same time, the demand for efficient and reliable power management is ramping up at a rate faster than Moore's Law-paced development can accommodate. The main processing devices for computing and communications contain billions of transistors, and the power delivery requirements of these devices are ever more precise and complex. The incumbent analog solutions can no longer meet these challenges cost-effectively, and designers must consider many more variables in each project.

In the datacom space, 36 to 40 voltage rails now exist on a board, and in the computing world, it is not uncommon to have greater than 20 voltage rails operating various ASICS, memory, and processor chipsets on a motherboard. This level of complexity requires fine-grained diagnostics and control – yet another variable for designers to consider.

Without a sophisticated interface in place, the opportunity for error is huge. Design engineers waste time figuring out what has been overlooked, left out, or improperly programmed.

The Need for System-Level Efficiency Adds Even More Complexity

The drive towards system-level efficiency adds yet another layer of complexity. External factors, such as increasing energy costs and environmental pressures, put a premium on efficiency. More than fifty percent of the electricity supplied for computing applications doesn't get used for data processing. Instead, it is wasted on things like air conditioning or lost through inefficiencies in the system. The end result is that every wasted watt boosts the total cost of ownership and increases global energy consumption.

Meanwhile, the sophisticated power demands of servers and high-end graphics cards, for instance, necessitate digital power supplies that offer fine-grained controls and diagnostics. Analog solutions just can't keep up in these markets. At the same time, the high efficiency being demanded by today's energy-conscious end customers means that intricate system-level communication is needed so that features and components can hibernate or be turned off when not in use. Relying on traditional ways of programming these settings is overly labor intensive, however, and often the potential efficiencies are not realized.

Efficiency is nearly impossible without the ability to measure and diagnose the system. The typical analog power solution is a black box, yielding no diagnostic information. Faced with downward cost pressures, designers are increasingly seeking solutions where diagnostics of the power supply are not left to separate microcontrollers but are instead included with the power supply ICs.

Designers can spend weeks figuring out measurement and diagnostic parameters. The variables are endless. However, if an interface delivers known parameters from what are likely to be common projects, designers have a baseline to work from. They don't enter projects blind, instead having various power diagnostics factored into the interface itself.

That's the promise, anyway, but what needs to happen to reach this goal? How do we go about creating the interfaces that will drive the switch to digital?

Let's first look at the key features effective GUIs have in common. After we've addressed those, we'll look at the underlying logic of GUI design. Next, we'll apply these principals to digital power management interfaces, and, finally, we'll pose questions that can help you modify your GUI over time in order to better meet the needs of your end users.

What five key features must an effective GUI have? (Fig 2)

1. Automated wizards that guide designers through a step-by-step design process.

Designers expect digital design to take hours or even days. With appropriate wizards walking them through the process, and alerting them to variables easily overlooked, design can be reduced to hours or minutes. To accomplish this, the GUI must be able to walk the designer through design variables in simple, predictable, repeatable steps.

2. Menus that allow for easy modifications.

Design variables may change mid-project, and designers need easy navigation tools that allow them to make changes on the fly and effortlessly switch from one function to another.

3. The ability to set and save defaults.

One of the reasons analog power is so labor-intensive is that each project requires starting over from scratch. A good GUI will save the work every step of the way. As a result, designers never start a project from scratch. Even the first project builds on precedent, since useful defaults should be included in the interface. Reusing past projects saves time and trims the cost of successive projects.

4. The ability to get to the actual design process quickly.

Rather than wasting time on preliminary information and clumsy menus, an effective GUI will get the designer into the design process quickly. Design cycle time must be very short in order to reap the time and budget gains of the intuitive GUI.

5. An intuitive, and as the acronym implies, graphical design (Fig 3).

The human mind is wired for visual input. GUIs that overlook this add time and money to projects. Designers should be able to enter the interface and immediately begin working – without spending hours reading a bulky manual. Building logic and visual prompts into the interface ensures that it will make sense immediately.

Taking a Step Back: Considerations Prior to GUI Design

Many of the above points may seem obvious, yet few digital power management GUIs follow these principles. The typical GUI offers an overly complex integrated design environment (IDE) that forces designers to scrutinize many lines of code, with main features lacking organization or internal design logic.

Part of the problem is that while the main elements of GUI designs seem obvious – snappy menus, easy wizards, and useful defaults – the underlying IDE logic is overlooked.

Before creating a designer GUI, designers should ask five questions about the end user experience.

Five Questions to Ask Before Designing a GUI

1. How should the GUI look and feel?

Does the look and feel draw users into the environment or does it repel them? If the design is too complex and busy, users will hesitate before beginning a project. Even if a project is rather simple and should be finished quickly, a cumbersome interface will overwhelm end users, leading them to believe that there is no such thing as a small project using this GUI.

A GUI that pulls users in, conversely, separates features logically into manageable bits of information, while displaying it in a graphical way that delivers more information than raw data alone. For instance, when configuring output voltages, a voltmeter-style display presents information in a familiar, useful way – one that simplifies the input and illustrates a range of options that can be configured through a simple mouse click.

2. What is the workflow logic?

Do related tasks relate to each other within the interface? Can users negotiate these tasks through tabs or drop-down menus? If you force users to load new screens and to leave a common work area when juggling closely related tasks, the workflow becomes cumbersome and related variables seem falsely separate.

An intuitive workflow within a GUI reminds designers of how variables relate and walks them from task to task in a logical fashion.

3. How interactive is the interface?

Are users able to instantly see that their changes have been made, or does the GUI impose a click-and-wait process? The quicker users can visualize their changes, the better. Similarly, when questions arise or key variables are overlooked, the GUI should offer help menus or prompts that guide designers within the GUI, rather than sending them to websites or paper manuals.

4. How does the user feel at the end of the session?

Does the user feel like the project has been completed easily and effectively, or is the state of the project a mystery? If the GUI isn't logical and compelling, designers may be unsure of themselves, worrying over an array of variables, hoping each has been configured properly. Similarly, if the GUI is too cumbersome, even if designers are confident that their projects are successful, they will still regard the development process as tedious. Development will be something unpleasant that they'll try to put off as long as possible.

With a good GUI, on the other hand, the designer is confident about the project and considers future projects as manageable.

5. Does the process become easier over time?

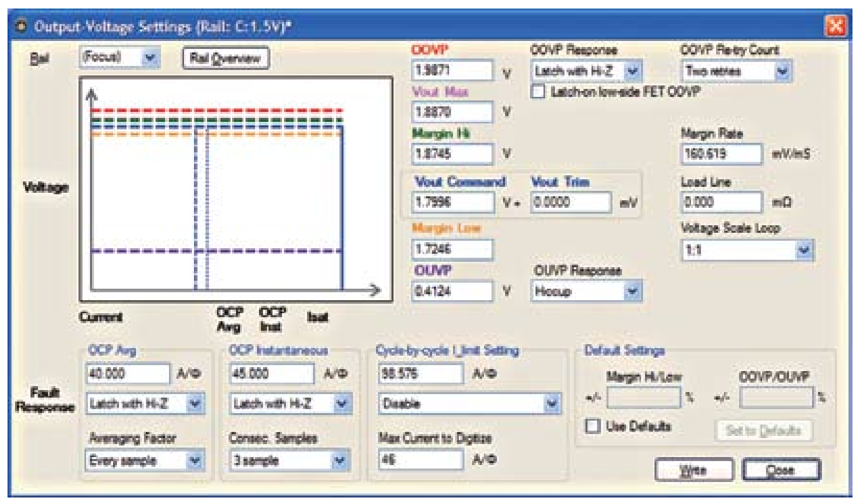

Figure 3: Intuitive Graphical Design.

A good GUI streamlines projects over time. As designers successfully complete an array of projects, the defaults and saved data make future projects that much easier. The work has already been done and doesn't need to be replicated. Over time, the development process is streamlined and simplified.

Applying Good GUI Design to Digital Power Management

The first thing to consider with a digital power management solution is that it offers many more features than its analog forbearers. As mentioned above, analog PWM ICs were expected to do two things: deliver power and regulate voltage.

Digital solutions add an array of telemetry and diagnostic features into the mix, including current monitoring, temperature monitoring, power efficiency capabilities, and fault reporting (Fig 4). The ICs also offer the flexible programmability of personalized parameters on a per rail basis for their power implementations.

That's a great deal to consider, but, fortunately, the inclusion of an advanced GUI means that designers do no direct programming. They interact with the GUI and the complexity is abstracted – so long as the GUI is designed in compliance with the principles outlined above.

A good GUI for digital power management should start with a main screen showing multi-POL or multi-device configurations. Other features directly related to POL configurations include duty cycle, switching frequency, temperature, and voltage ranges. Including these on the main panel makes intuitive sense. The interplay of these variables is what the designer must first consider; therefore, it makes logical sense to relate them in the GUI.

The next level of features should include power conversion settings, including output voltage, input voltage, switching frequency, maximum output current, and delay and ramp. Other features to consider at this stage include power management settings, file I/O, and PMBus commands.

Measurements and diagnostics should come in the next set of screens. Tools for setting fault limits and for monitoring and status should be considered.

Finally, all of these settings should be easily saved and stored. Reuse is one of the boons of a truly intuitive GUI, so it's important to remember auto-save features and project save prompts.

Taking the Complexity out of Power Design

To see how this applies to power management design, consider one of the most complex parts of the design process: loop compensation and optimizing the transient response. In the analog world, a designer is forced to run simulation software, plug the results into hardware, test them, and tweak component values in the system over and over until the proper results are attained.

In contrast, today's more sophisticated power management design GUIs, created with a designer's most pressing needs in mind, simplify the task. The system computes the default poles

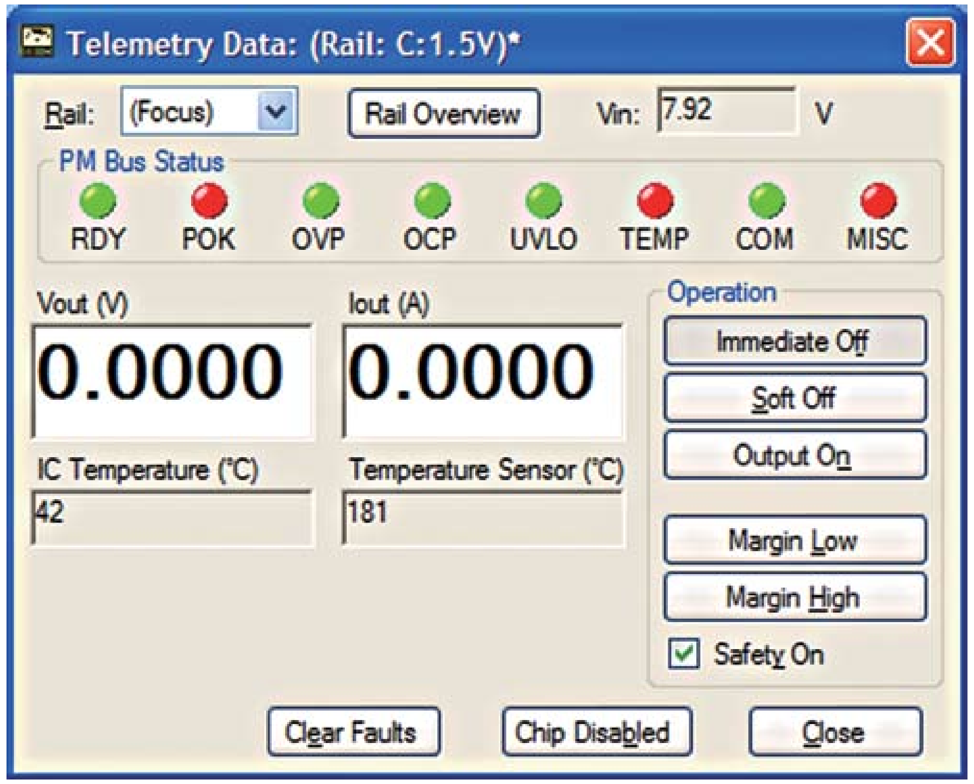

Figure 4: Telemetry and Diagnostic Features.

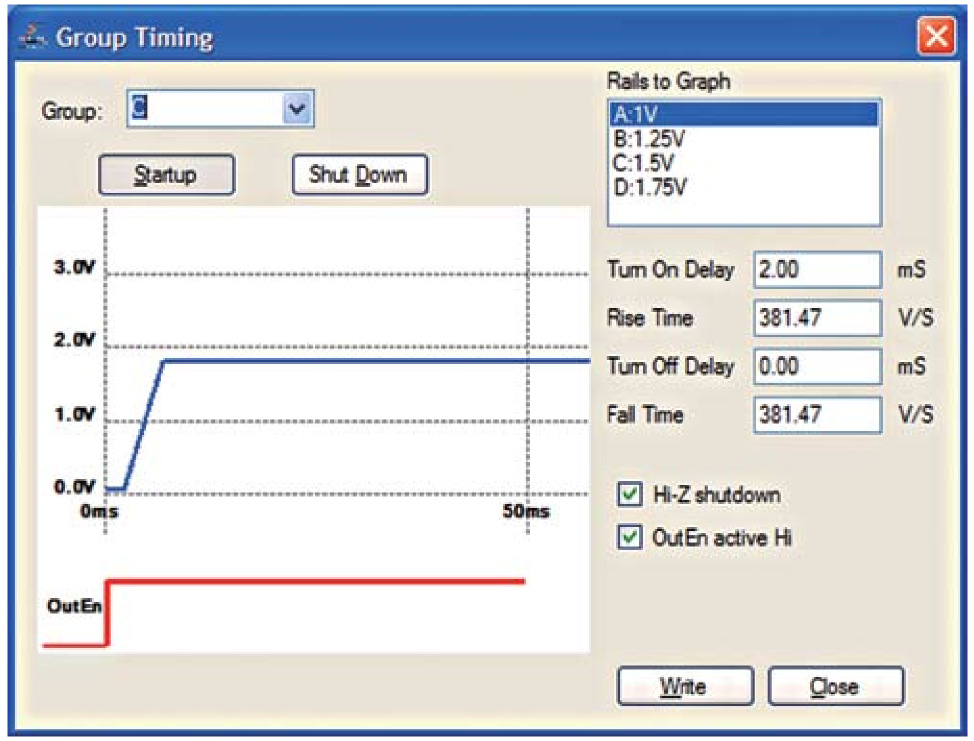

Figure 5: Advanced Power Management Features.

and zeroes based on the parameters entered. The designer can quickly look at the loop response and transient response in real time. Based on the system parameters, the designer can quickly tweak the values on the GUI and immediately see the effects.

In only a few minutes, the designer is able to optimize the design – a task that previously would have required a few days of design, simulation and testing.

A similar example is telemetry. With a good GUI and a step-by-step design processes in place, all a design engineer must do to alter the system is input values. Rather than running a simulation, performance is displayed in real time and changes can be made on the fly. Optimizing the system becomes no more difficult than a few keystrokes.

The design prevents errors and oversights because all of the critical and related values – such as voltage, current, and temperature – are displayed on a single page. The designer instantly sees how changes ripple through the system. The information displayed in the GUI can be used to predict failures and calculate optimal operational parameters.

Of course, none of this is possible without a sophisticated GUI. If this all sounds like a series of forced moves, with the GUI doing all of the work, that's only partly true. While the GUI will handle common tasks, a good design will also allow for personalization.

Even if designers should be encouraged to reuse projects and recycle the work they've already done, no two designers are exactly alike, and even subtle variations between projects may necessitate different considerations within the design environment.

The GUI should adapt to this, displaying not only important variables, but also allowing the designer to select those variables important to him – or to the project at hand.

Finally, a sophisticated GUI enables features that were previously unheard of for power management ICs. In a multi-rail system with 20 or 30 POLs, advanced power management features are a must (Fig 5). With a GUI abstracting the complexity, variables like sequencing, tracking, and fault response, are handled for the designer. The task of inputting and calculating all of these values and studying how each of the POLs interact and influence performance is automatic.

The final result is that optimization becomes just another design step.

Improving the Interface over Time

Now that you have a well-designed GUI, it's time to put it to the test. Remember, GUIs are not static. New features will emerge as technologies evolve and certain features may gain in importance as others fade. As such, it's important to view the GUI as an evolving tool. End-user input will guide changes, as will market demands.

Just because the first group of designers you tested the GUI on approved of it does not mean that it is as useful, visual and intuitive as it should be – especially if your testing was done in house. Periodically, your GUI design team should solicit feedback from actual design engineers and use that feedback to continually match the interface to real-world end-user needs.

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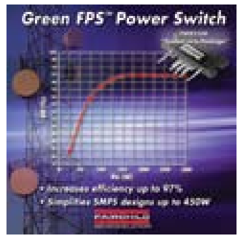
PowerPack Power Systems Design

Fairchild Semiconductor



Increase Efficiency up to 97 Percent and Simplify Design in Half-Bridge Resonant Converters with Fairchild's Green FPS™ Power Switch

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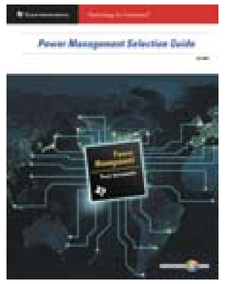
http://www.fairchildsemi.com/ds/FS/FSFR2100.pdf

Texas Instruments



Texas Instruments offers a full line of high-performance products ranging from standard linear ICs to plug-in and integrated power solutions. And, TI makes designing easier with leading-edge support tools such as training, a broad selection of evaluation modules, application notes, data sheets and more. Visit **www.ti.com/analogelab** for complete information on all TI's analog training opportunities. Free samples and small orders (shipped within 24 hours via TI authorized distributors) are available to help accelerate your time-to-market. Download your copy of TI's Power Management Selection Guide for a comprehensive review of TI's complete line of high-performance power products...

Linear Technology

Linear Technology Corporation announces the LT3080, a 1.1A 3-terminal LDO that may be easily paralleled for heat spreading and is adjustable with a single resistor. This new architecture regulator uses a current reference to allow sharing between multiple regulators with a small length of PC trace as ballast, enabling multi-amp linear regulation in all surface-mount systems without heat sinks.

The LT3080 achieves high performance without any compromises. Featuring wide input voltage capability from 1.2V to 40V, it has a low dropout voltage of only 300mV at full load. The output voltage is adjustable, spanning a wide range from 0V to 40V, and the on-chip trimmed reference achieves high accuracy of +-1%. The wide V_{IN} & V_{OUT} capability, tight line and load regulation, high ripple rejection, low external parts count and parallel capability make it ideal for modern multi-rail systems.

To learn more: www.linear.com

Indium Corporation

Indium Corporation's Indium5.1AT Pb-Free Solder Paste is an Award-Winning No-Clean, Pb-Free Solder Paste that delivers enhanced finished goods reliability by featuring;

- Low Voiding at Via-In-Pad
- Excellent Printability
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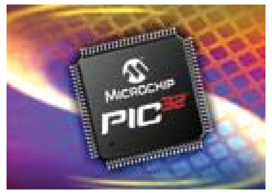
- Robust Reflow Profile Window

Via-in-pad technology for BGA components has reduced PCB real estate requirements, but this can also lead to significantly increased voiding. Indium5.1AT delivers voiding in the 5% range over many different profiles when soldering BGAs with via-in-pad technology.

For more information about Indium5.1AT Pb-Free Solder Paste visit:

www.indium.com/indium51AT

Microchip Technology



Microchip Technology Extends PIC® Microcontroller Line to 32 Bits With New PIC32 Family

Key Facts:

- PIC32 Family Launched with 72MHz, 1.5 DMIPS/MHz MIPS32 M4K Core
- 64 and 100-pin Devices offer up to 512 Kbytes of Flash and 32 Kbytes of RAM
- Pin, Peripheral and Development Tool Compatible with 16-Bit PIC Microcontrollers

Microchip announces the PIC32 family of 32-bit microcontrollers (MCUs), adding more performance and memory while maintaining pin, peripheral and development compatibility with Microchip's 16-bit MCU/DSC families.

The new PIC32 family is fully supported by Microchip's free MPLAB® Integrated Development Environment (IDE) which now offers unprecedented compatibility by supporting Microchip's complete portfolio of 8-, 16- and 32-bit devices.

Launching with seven general-purpose devices, the PIC32 family operates at up to 72 MHz and offers ample code- and data-space with up to 512 KB Flash and 32 KB RAM. The PIC32 family also includes a rich set of integrated peripherals including a variety of communication peripherals and a 16-bit Parallel Master Port supporting additional memory and displays.

Power Systems Design EUROPE

Special Report White Goods Part II

Special Report – White Goods Part II

Surface Mount Current Transducers Open New Applications

Traditional measurement systems not used in domestic electrical products and air conditioning systems

If isolation is needed in a shunt-based system, an optocoupler is needed, adding cost and bulk. For current measurements over 10A, losses in the shunt become significant resulting in an unacceptable temperature rise. At lower current levels, the shunt will need to have a high resistance to ensure that its output is not too small.

By Stéphane Rollier, Bernard Richard and David Jobling, LEM

These factors have long been major limitations to the use of current measurement in smaller electrical systems. However, there is now a growing demand for current measurement in such systems, as inverter control of electric motors becomes more popular, to bring about greater control of speed and position, and improved energy efficiency. Fortunately, new techniques are producing smaller and lower-cost transducers that can make current measurement a reality in systems such as these.

LEM has recently introduced the Minisens integrated current transducer. This device combines all the necessary electronics with a Hall-effect sensor and magnetic concentrators in a single eight-pin, surface-mount package (Fig 1). It can be isolated simply by mounting it on a printed circuit board on the opposite side to the track carrying the current to be measured, does not suffer

Figure 1: The Minisens/FHS.

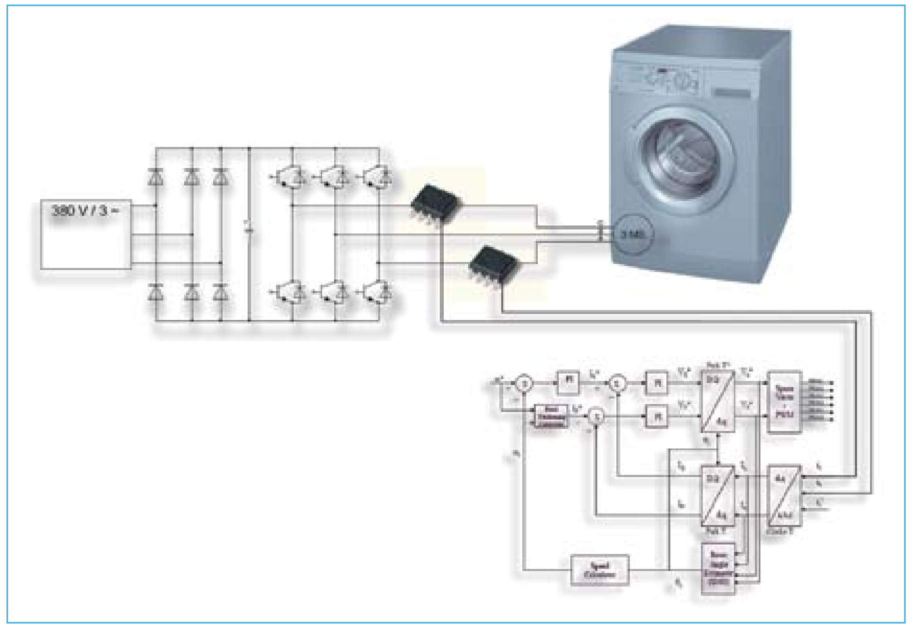


Figure 2

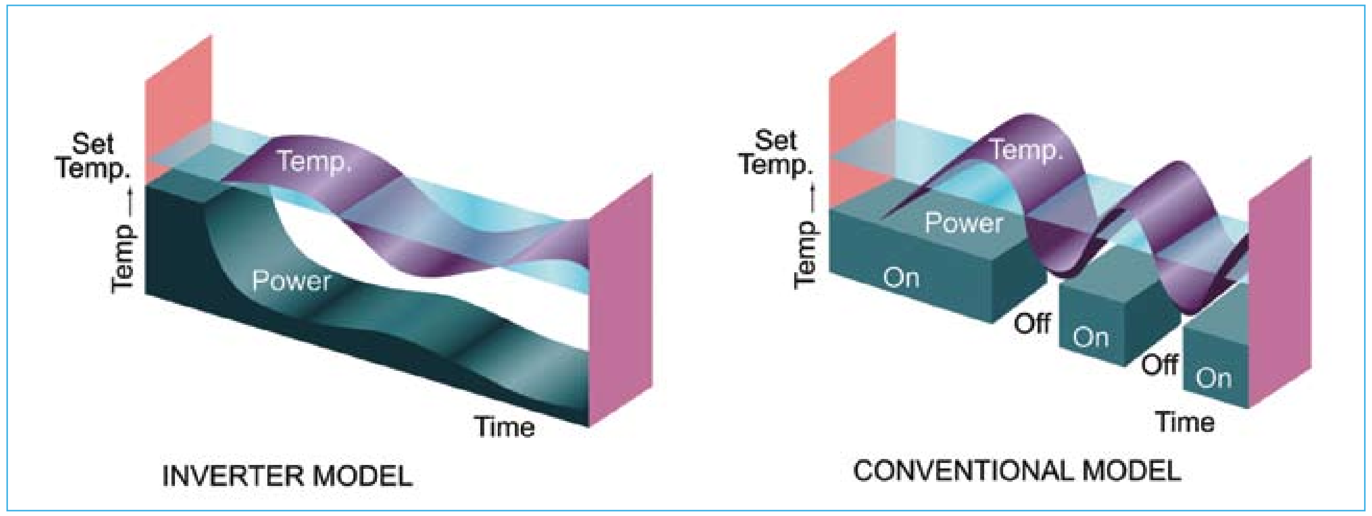


Figure 3: Inverter control vs. conventional control.

from losses and can make use of PCB design techniques to adjust sensitivity and therefore remove the need for an amplifier.

Two typical examples will show the advantages offered by Minisens in today's applications:

Washing Machines

Designers of modern washing machines are looking for more-accurate control of the electric motor, to save energy by improving the efficiency of the system and protect the environment by adjusting washing time and water usage. They are also aiming to improve the performance of the machine, in terms of out-of balance detection, vibration reduction, different programs for different types of clothes and noise reduction. An inverter-based system offers this finer control, allowing the designer to offer both new and improved functions. Such a system needs accurate measurement of motor current, and two Minisens transducers can be mounted directly onto the control PCB to provide the necessary measurements.

Air-conditioning units

Traditionally, air-conditioning units have relied on simple on/off control of the motor. However, this has resulted in a wide variation of temperature and has required a relatively large motor, which is either off or running at full power – resulting in a lot of noise. The newer way is again to use inverter control, starting the motor at full speed to adjust the temperature coarsely and then reducing the speed and oscillating closely around the target temperature (Fig. 3).

Such a system produces less noise, requires less power to maintain the target temperature, and can use a smaller motor. Japanese air-conditioner manufacturers have already moved to this method and those in the United States, China and Europe are now following.

Design considerations

The most common way to use Minisens is to locate it over a PCB track that is carrying the current to be measured. To optimise the function of the transducer, some simple rules must be applied to the track dimensions. By varying the PCB and track configuration, it is possible to measure currents ranging from 2 to 100 Amps.

One possible configuration places the IC directly over a single PCB track (Fig. 4).

In this configuration, isolation is provided by the distance between the pins of the transducer and the track and

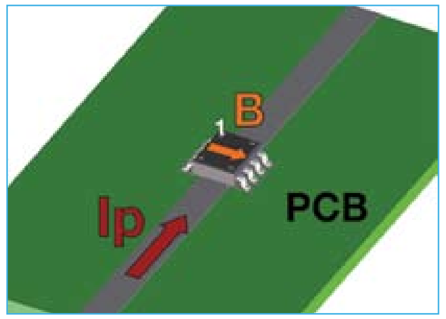


Figure 4: One possible PCB design: the track is located underneath the Minisens.

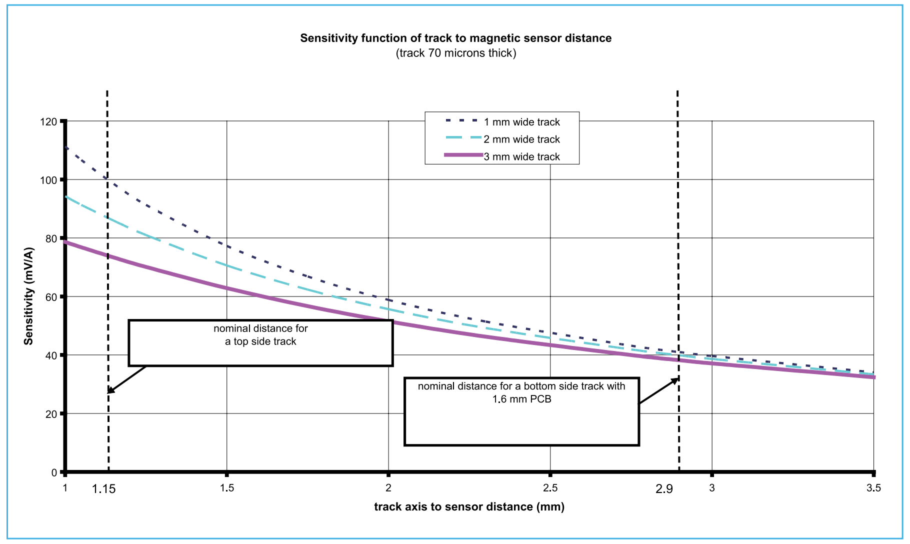


Figure 5: Sensitivity (mV/A) versus track width and distance between the track and the sensing elements.

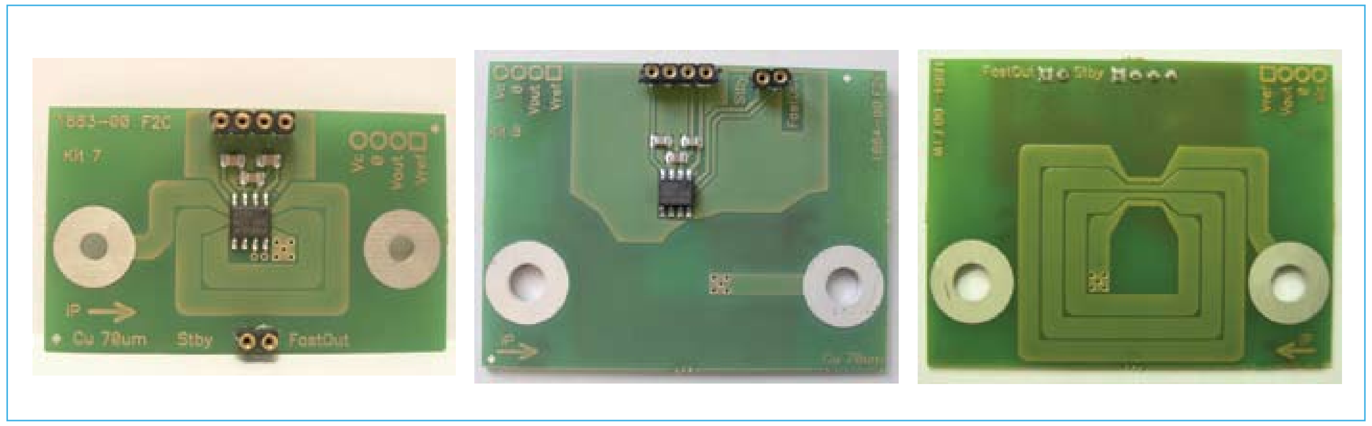


Figure 6 and 7: Possible "multi-turn" designs.

currents in the range from 2 to 20A can be measured.

Isolation can be improved by placing the transducer on the opposite side of the board, but still directly over the line of the track. The thickness of the board and the track itself will both affect the sensitivity. Sensitivity is also affected by the width of the track (Fig. 5). It is important to note that sensitivity is greater for thinner tracks. However, the thinner the track, the quicker the temperature rises.

The maximum current that can be safely applied continuously is determined by the temperature rise of the track and the ambient temperature. The use of a track with varying width gives the best combination of sensitivity and track temperature rise. To maintain temperature levels, the width, thickness and shape of the track are very important.

For low currents (under 10A), it is advisable to make several turns with the primary track or to use a narrow track to increase the magnetic field generated by the primary current. As with a single track, it is better to have wider tracks around the Minisens than under it (to reduce temperature rise) (Figs. 6 and 7).

For example, a four-turn design (Fig. 7) on the opposite side of the PCB to the Minisens provides a high insulation configuration. Another way to increase the sensitivity is to use a narrower track.

The sensitivity can be increased further by other techniques, such as using a "jumper" (wire) over the Minisens to create a loop with the PCB track, or multiple turns can be implemented in different PCB layers. Larger currents can be measured by positioning the transducer farther from the primary conductor or by using a wider PCB track or busbar.

Many Minisens parameters can be configured by on-chip non-volatile memory. This can be used to adjust the transducer's gain, offset, polarity, temperature drift and gain algorithm.

Two outputs are available: one filtered, to limit the noise bandwidth, and one unfiltered which has a response time under 3µs, for current short-circuit detection (IGBT protection) or threshold detection.

Minisens operates from a +5V power supply. To reduce power consumption in sensitive applications, it can be switched to a standby mode by means of an external signal to reduce the consumption from 20 milliamps to 20 microamps. It is manufactured in a standard CMOS process and assembled in a SO8-IC package.

The accuracy reached at +25°C by Minisens itself is determined by the following parameters:

Transducer error:
» sensitivity (V/T) error
» initial offset at no field
» non-linearity error

In addition to the transducer error we must allow for errors linked to the:

mechanical design:
» the distance and shape variations of the primary conductor vs. the IC as well as the IC placement error on the PCB (the mechanical design parameters), including:
- solder joint thickness
- copper track thickness
- PCB thickness
- primary track width
- positioning of the IC along the Y axis

» rotation of the IC around the X and Z axes
» the adjacent perturbing (stray) fields.

These parameters must be closely controlled in the production process. Alternatively, in-circuit calibration of the Minisens or the DSP can be used to avoid most of these errors. For the temperature range, two other parameters must also be taken into account: sensitivity temperature drift at +/-300ppm/K and offset drift at +/-0.15mV/K.

The overall accuracy at 25°C will be between 4% to 7% (with initial offset compensated) and between 5% to 8% over the temperature range (25°C - 85°C). With calibration, the overall accuracy (over temperature range) will be better than 4%.

By integrating all the necessary electronics and magnetics into such a small, easily mounted package, Minisens brings current sensing technology to many new applications, just at a time when it is needed most.

www.lem.com

TOPSwitch-HX Delivers High Power without Heat Sink

High efficiency power supply boosts efficiency in boilers

In the design of heating and air conditioning systems, high-efficiency heat exchange techniques coupled with sophisticated electronic controls results in better energy efficiency ratings. A highly efficient and rugged power supply provides the basis for efficient motor drives and reliable system performance.

By Silvestro Fimiani, Power Integrations, Inc.

With the cost of crude oil around $100 a barrel, the gains to be made from energy efficiency are greater than ever. In the domestic sector, this is particularly true for area heating or in heating appliances. The condensing boiler is one heating technology that offers higher efficiency by making use of the basic principles of thermodynamics. The application of modern electronics technology enables performance gains close to the theoretical maximum to be obtained.

A condensing boiler is a high-efficiency modern boiler that incorporates a large heat exchanger – and even a second heat exchanger – to extract the maximum heat energy from the flue gases. It produces lower flue gas temperatures, lower flue gas emissions, and reduced fuel consumption. It typically converts more than 88 percent of the fuel used into useful heat, compared to, typically, 78 percent for conventional types of boiler.

Recovering the heat from the flue reduces the temperature of the flue gases to a point where water vapor produced during combustion is condensed out, thus the name condensing boiler. The process of condensation is key because, as water changes from the vapor to liquid state, it releases the latent heat of vaporization, a more significant source of energy than the transfer of heat by cooling the vapor alone.

The natural buoyancy of the flue products is lost when the temperature is brought down, so it is necessary to have a fan in the flue to maintain the flow of exhaust gases. The fan must be powered, and its speed controlled correctly, to maximize the boiler efficiency.

To power the fan, the system timer and control electronics, a high efficiency power supply capable of operating reliably in a high-temperature environment is required.

A similar requirement for a power supply occurs in air conditioning equipment and white goods such as dishwashers and washing machines, particularly those with integrated condensing dryers.

Described below is a design for a

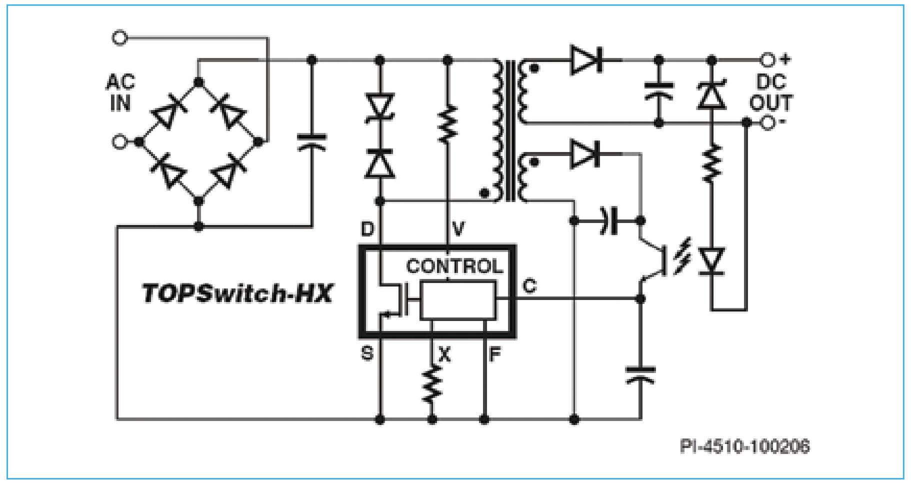


Figure 1: Typical TOPSwitch-HX flyback application.

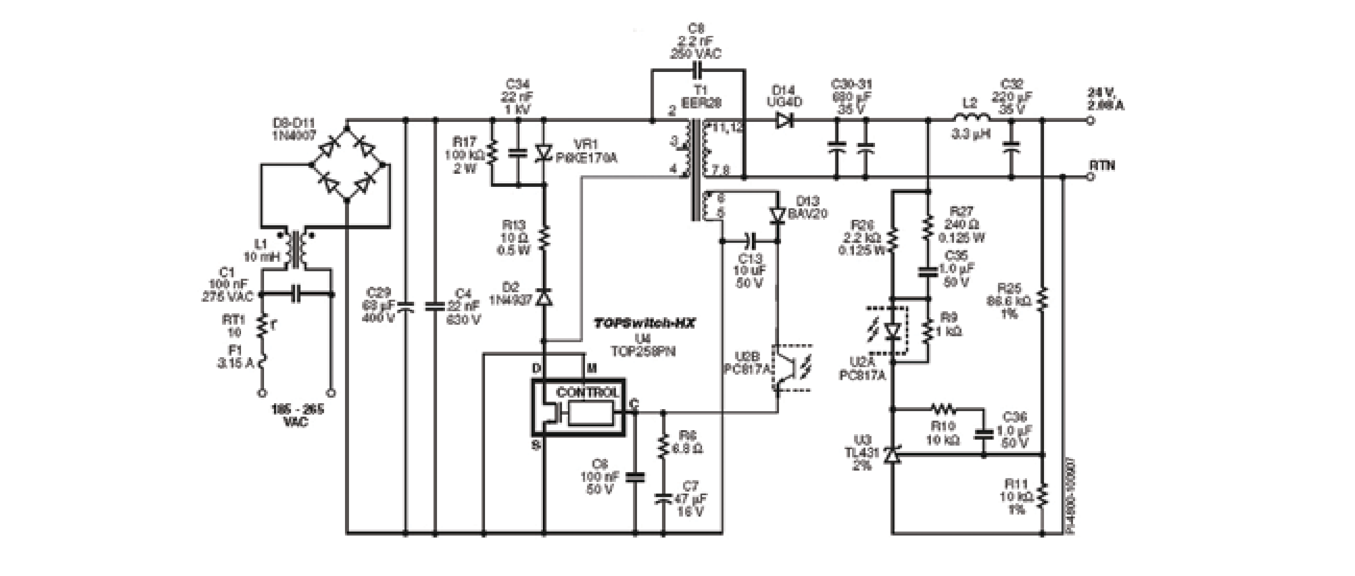


Figure 2: 50W continuous, 70W peak supply designed around a TOP258PN device.

switch mode power supply (SMPS) capable of delivering a constant 50W at 24V and a peak loading of 70W at an ambient temperature of 65°C without an external heatsink. The peak loading capability is important because it enables the high currents required for motor start-up to be delivered from components sized to support the continuous load. This provides a significant size, cost and weight advantage.

The SMPS design is built around a TOPSwitch-HX controller IC produced by Power Integrations Inc(1). TOPSwitch-HX incorporates a 700V power MOSFET, high-voltage switched current source, multi-mode PWM controller, oscillator, thermal shutdown circuit, fault protection and other control circuitry onto a single monolithic device. By combining these features into a single device, it is possible to greatly reduce the number of external components required to produce a functional power supply (See Figure 1).

TOPSwitch-HX is the fourth generation of the TOPSwitch family, first introduced in 1994. The latest version incorporates many enhancements and features important in white goods applications. TOPSwitch-HX switches seamlessly between four different modes of operation depending on the load conditions. This enables the SMPS to operate at constant high efficiency over an exceptionally wide power band and still be able to provide more than 600mW of output power for only 1W input in standby mode. These features are aimed at insuring that the power supply will meet all relevant existing and proposed energy conservation standards worldwide. TOPSwitch-HX also features enhanced user defined protection features to protect the power supply in the event of line undervoltage, overvoltage and output overload conditions. TOPSwitch-HX provides output over-voltage (OVP) protection configurable for latching or self recovering modes, thermal shutdown and auto-restart. Careful control of key parameters also significantly reduces maximum overload power. This in turn allows the use of smaller power train components (MOSFET, transformer, output rectifiers) reducing power supply cost. Improvements in silicon technology have permitted the use of a plastic DIP Package and a 1.8Ω on-resistance MOSFET (TOP258P), versus 3Ω minimum in the previous generation. This coupled with halving the switching frequency to 66KHz in the DIP-8 package enables the elimination of the external heat sink in many appliance applications.

TOPSwitch–HX features also offer benefits to white goods. The dual in-line P package incorporates >3.2mm creepage/clearance between high-voltage pins to prevent surface leakage currents

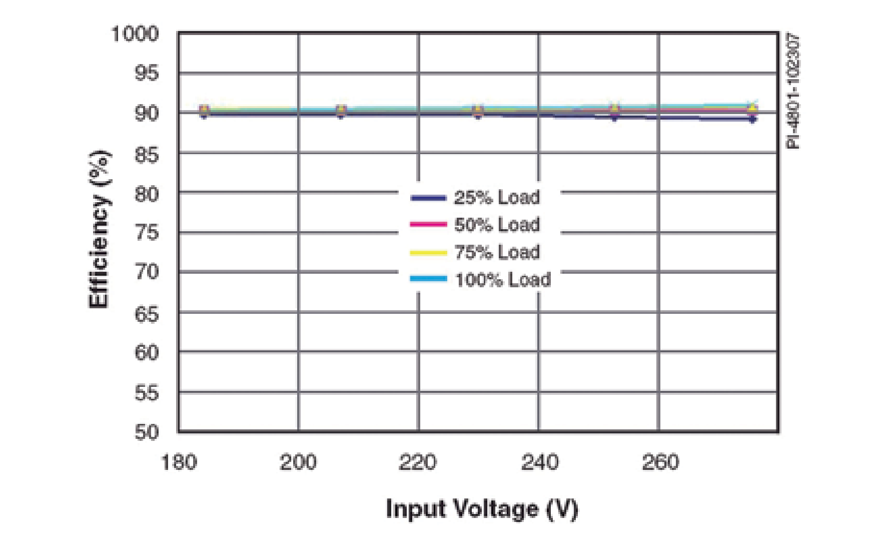


Figure 3: Efficiency versus Load, at standard line voltages.

occurring in high humidity and polluted environments. The thermal shutdown is auto-recovering and incorporates a wide hysteresis to maintain safe PCB temperatures under any fault condition. The auto-restart function protects against output short circuits and open feedback loops. These improved safety features fully protect the power supply and load under fault conditions and can prevent overheating or even a fire, a significant factor with appliances commonly being run unattended at night. Figure 2 is the complete SMPS circuit diagram.

The design meets EN55022 and CISPR-22 Class B conducted EMI limits with significant margins. Differential EMI filtering is implemented with X-capacitor C1, while common mode EMI filtering is accomplished by common-mode choke L1 and safety rated Y-capacitor C8. A metal film type capacitor, C4, which is located physically close to the switching circuitry, helps to decouple high-frequency noise from the DC bus and improve differential EMI.

An RCD clamp is formed by D2, R17 and C34, which prevents drain voltage spikes from damaging the integrated MOSFET in U4. Zener diode VR1 is in place to assure the maximum clamp voltage and does not conduct under normal operating conditions.

A bias winding on transformer T1, which is rectified by D13 and filtered by C13, powers the TOPSwitch and provides the control current used by phototransistor U2B.

Feedback is provided from the output via photodiode U2A, whose bias point is set through the TL431 programmable shunt regulator U3. Resistors R25 and R11 form a voltage divider network that sets the output voltage to 24V. Resistor R10 and capacitor C36 provide compensation for the feedback network. Resistor R27 and capacitor C35 form a phase boost network that helps to improve the phase margin of the system. Resistor R9 provides a bias current to the shunt regulator, U3, while the photodiode, U2A, is not conducting. Resistor R26 sets the overall loop gain as well as limiting the current through U2A during transients.

The SMPS operates over a wide supply input range of 185 to 265 VAC. The TOPSwitch-HX architecture enables an exceptionally high efficiency to be maintained over the complete input voltage range (See Figure 3).

A complete description of the SMPS design, including key design points and transformer parameters, may be found in 'Design Idea/DI-144' available from the Power Integrations website. The website also contains application guides and free software enabling a design engineer to quickly design and specify a SMPS customized to fit the system requirement.

www.powerint.com

Coordinated Circuit Protection for White Goods Components, Controllers and AC Mains Applications

Motors, controllers, and electronic components found in white goods can benefit from coordinated overcurrent/overtemperature protection provided by polymeric positive temperature coefficient (PPTC) devices.

PPTC devices offer low resistance, and are compatibly sized with fuse solutions. Like traditional fuses, they limit the flow of dangerously high current during fault conditions. The PPTC device, however, resets itself after the fault is removed and power to the circuit is cycled. Once the fault condition has been removed and the power cycled the protected equipment remains functional without needing to replace a blown fuse.

By Faraz Hasan, Global Industrial & Appliance Marketing Manager, Tyco Electronics/Raychem Circuit Protection products

Valid LCD heater protection technique. Liquid crystal displays (LCDs) are used in a wide range of appliance applications and may be subjected to significant temperature variations. Because LCDs perform poorly at low temperatures, heaters are often employed to raise the device's temperature and improve functionality. Typically, the heaters incorporate temperature sensors connected to a microprocessor- controlled switch that modulates the heater, as well as a high-temperature shut off function that turns off the heater if the LCD temperature exceeds a specified limit.

The disadvantage of this approach is that the overheat control mechanism relies on the same microprocessor that is controlling the heater element. Consequently, if the heater control malfunction is due to microprocessor failure or some other functional control component, the high temperature shut-off function may also be disabled. If this control circuitry fails, the current flowing through the heater element can increase and lead to thermal runaway.

Installing a PPTC device, independent of the main heater controller, helps protect the LCD and the heater control

Special Report – White Goods Part II

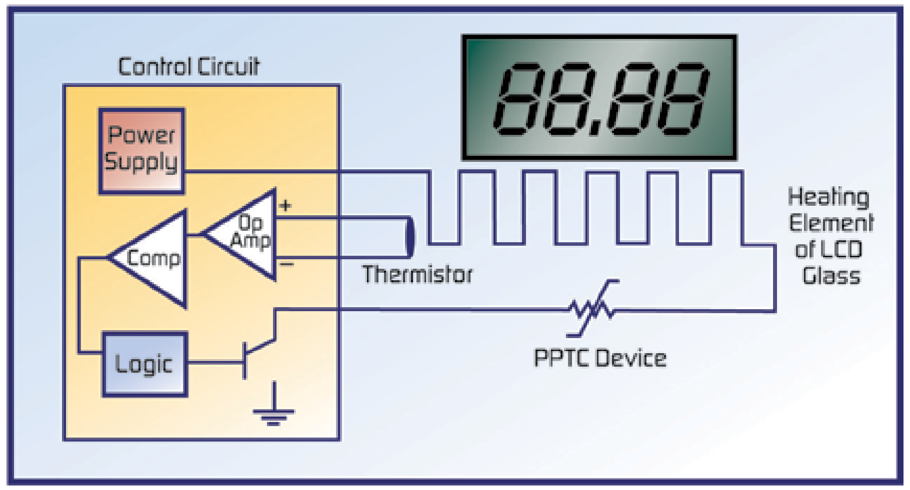


Figure 1: In an overheat condition, the PPTC device "thermally trips" to reduce current flowing to the heating element.

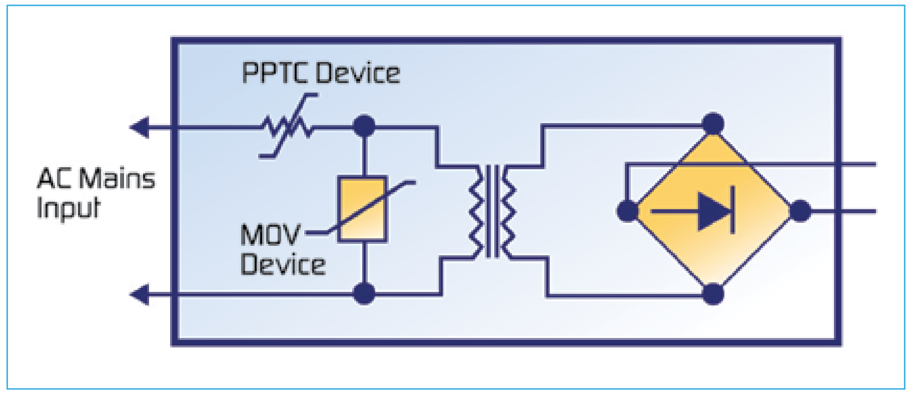


Figure 2: Coordinated overvoltage and overcurrent protection on AC mains circuit.

circuitry from overtemperature damage. As shown in Figure 1, the PPTC device is generally placed in line between the power supply and the heater, in a thermally conductive relationship with the heated LCD panel. In this way, heat emanating from the LCD is transmitted to the PPTC device. When the LCD reaches a specified shut-off temperature the PPTC device "trips" and reduces the current flowing through the heater element. Once the fault it removed and the power is cycled, the circuit will reset to normal operating conditions.

Coordinating protection for AC mains applications

From small countertop appliances to professional grade ovens, increasing complexity and functionality are driving the industry toward circuit integration and board size reduction. Protecting sensitive electronic components from voltage transients, short circuits and customer misuse is of primary concern to manufacturers.

In the past, for instance, control board designs often used no overcurrent protection on the primary or secondary side, relying on the transformer to sink sufficient heat to prevent control board damage in the event of a fault condition. However, the increased use of sensitive solid-state devices on the board now requires that voltage levels be limited.

Electrical equipment can be exposed to potential damage from large voltage or power transients on the AC Mains inputs caused by lightning strikes or power station load-switching transients. IEC 61000-4-5 is the global standard for voltage and current test conditions for equipment connected to AC Mains.

Coordinating overcurrent and overvoltage protection at the AC mains input can help designers comply with safety agency requirements and minimize component count and cost.

Figure 2 shows how a metal oxide varistor (MOV) is used in combination with a PPTC device to help improve equipment reliability in the harsh AC environment, and helps fulfill the IEC-61000 test requirements.

The MOV's high current-handling and energy absorption capability, fast response and low cost make it suitable for overvoltage protection in power supplies, control board transformers and electric motors. The PPTC overcurrent protection device is also rated at $240V_{AC}$, permitting maximum intermittent voltages of up to $265V_{AC}$ and can be installed with the MOV in the AC mains input lines.

Unlike a single-use current fuse, the resettable PPTC device helps protect against damage from conditions where faults may cause a rise in temperature with only a slight increase in current draw. When installed on the primary side of the circuit, in proximity to potential heat-generating components such as magnetics, field-effect transistors (FET), or power resistors, the PPTC device helps provide both overcurrent and overtemperature protection with a single installed component.

Certain mains overload conditions may cause the MOV device to remain in a clamped state where it will continue to conduct current. This may eventually result in an overtemperature failure of the device. While not directly applicable to passing IEC 61000-4-5 tests, placing the PPTC device in close thermal proximity to the MOV can help protect the MOV in extended overload conditions – by transferring heat to the PPTC device. This causes the PPTC device to trip faster, limiting the current through the MOV.

This approach lets designers leverage the temperature response of the PPTC device and replace other thermal protection devices in the circuit. Not only does the PPTC device perform dual functions in this case, it also provides a resettable solution. Because the device resets after the fault is cleared and power to the circuit is removed, maintenance or replacement are not normally required.

The PPTC and MOV devices chosen for a particular application depend on the IEC 61000-4-5 class rating for the equipment as well as the operating conditions of the equipment itself. When selecting a PPTC device, the primary consideration is to match the hold current rating of the device to the primary current drawn by the electrical equipment under normal operating conditions.

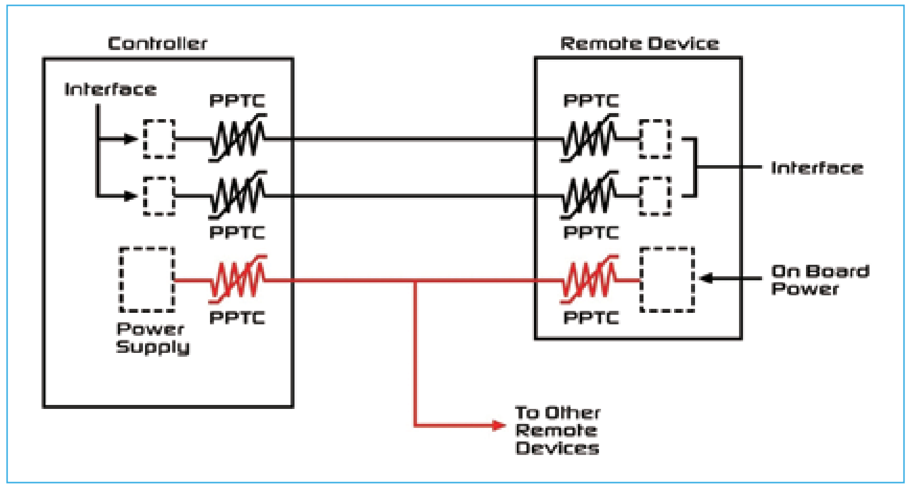


Figure 3: PPTC devices help protect the interfaces between controllers and remote devices as well as power inputs.

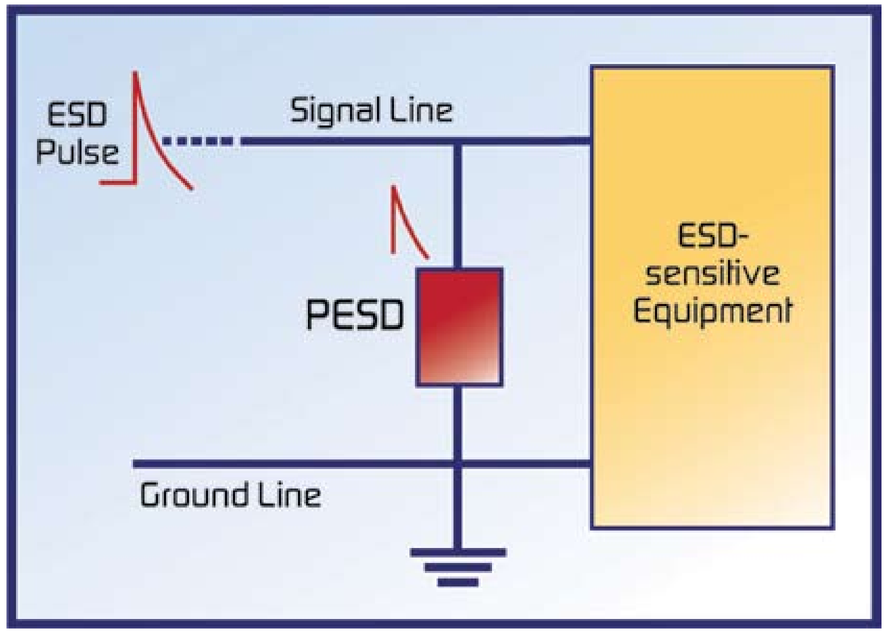


Figure 4: Low Cost diagnostic function.

Industrial controller protection strategy

Traditionally, single-use fuses have been used to protect electronic circuits from overcurrent events. With this technology, when a wiring fault or part failure creates a condition in which excessive currents can flow, the fuse blows, breaking the electrical connection and preventing more widespread damage or fire hazards.

If there is a failure in one system component it can disable other components downstream and throughout the system. Now, the fuse must be accessed and replaced on all the affected components before the system can be made operational again.

Controllers and remote devices that utilize resettable fault protection technology can help minimize the impact that failure has on the system, reduce the number of system components affected, and shorten repair time. PPTC devices offer a practical alternative to fuse technology and help protect valuable electronic systems, reduce warranty and service costs, and improve user satisfaction.

In many industrial controller applications, replacing single-use fuses with PPTC devices helps designers maintain the same level of overcurrent protection on the critical interfaces, but no longer necessitates fuse replacement or service when an external fault condition causes high current conditions in the system.

In addition to controllers, any remote sensor, indicator, or actuator that requires a power, analog, or communications bus interface can benefit from the use of PPTC devices (see Figure 3). These system components are subject to damage caused by miswiring, power cross, or loose neutral connections on AC Mains inputs.

Summary

Coordinating overcurrent, overtemperature and overvoltage protection can help designers minimize component count and reduce warranty returns resulting from failed motors and control board transformers. The low resistance, fast time-to-trip, low profile, and resettable functionality of the PPTC device helps designers provide a safe and dependable product and comply with regulatory agency requirements.

ESD Protection for Appliance Buttons and Keypads

The buttons and keypads used to control appliances may be exposed to electrostatic discharge (ESD) when the user presses a switch, causing damage to internal circuitry of the control panel.

Tyco Electronics' PESD devices are frequently used to help shunt ESD away from sensitive circuitry in electronic equipment. The PESD devices provide exceptionally low capacitance, and can help manufacturers meet IEC61000-4-2 testing requirements. They offer a lower trigger voltage and a lower clamping voltage than typical polymer ESD devices, resulting in improved protection of sensitive electronic components.

www.tycoelectronics.com

Special Report – White Goods Part II

Combining Inrush Current Limiting with PFC for White Goods Motor Applications

Devices that execute multiple application functions to reduce system complexities

When Europe mandated the requirement that electric loads of 80W or above draw current in a high power factor manner, it was another incremental step towards conservation and a greener environment.

By James Aliberti, Product Marketing Engineer, Texas Instruments

Many of the consumer products affected include white goods appliances. Many of these appliances such as air conditioners, refrigerators, washers and dryers have complex loads due to the inverter for the electric motor drive. In principle, complex loads generally have poor power factors. By mandating that theses appliances be power factor corrected (PFC) the transmission lines power delivery is better utilized, saving energy and reducing both the cost of electricity and the release of carbon emissions from the burning of fossil fuels. Around the world today, many government regulatory agencies have mandated similar requirements for PFC in these applications.

The front end of a motor drive circuit without PFC looks very similar to a switch mode power supply where bulk storage capacitance resides that smoothes out the DC from the rectified mains. When initially energizing the motor drive circuit, the mains input looks essentially like a short circuit because there is no charge on the bulk capacitors. When power is applied this condition results in high inrush currents to charge the capacitor. If this inrush current is not controlled or limited, the

current draw from the line will surge to magnitudes higher than its normal RMS operating current (Figure1). These excessive currents potentially can damage or stress both mechanical and electrical elements such as fuses, solder joints or electronic components, just to name a few.

Most white goods motor manufacturers have adopted the use of a negative temperature coefficient resistor (NTC) to limit inrush current. The NTC operation is very simple. Under cold or initial start up conditions the NTC is a high resistance device and limits the current quite well. After start-up or a few moments into normal operating conditions, the

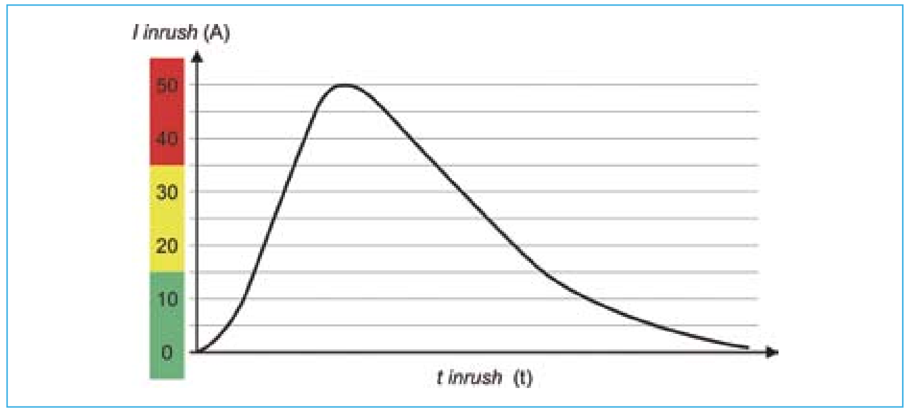


Figure 1: Typical 120VAC inrush current plot.

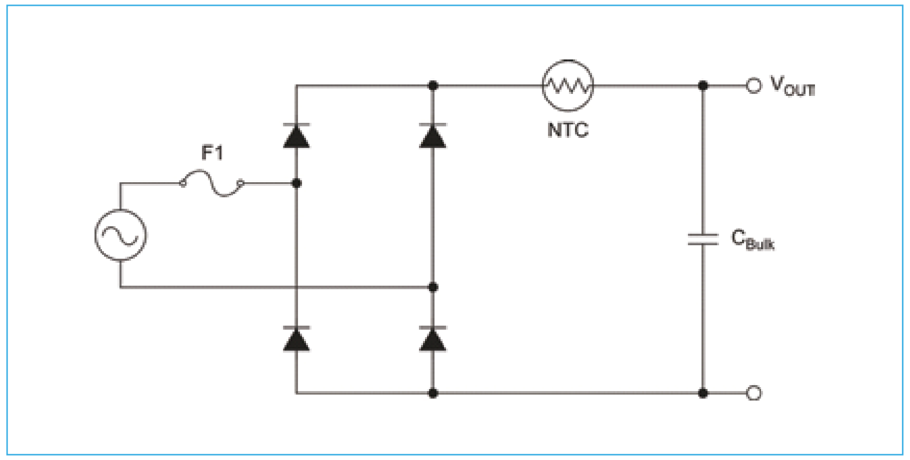


Figure 2: Typical inrush protection circuit.

NTC gets warmer due to power dissipation. As it gets warmer its resistance significantly decreases, making it a more efficient path for current to flow through. In most embedded motor drive circuits the NTC is placed somewhere in the high current path, either on the AC side or just after the bridge rectifier (See Figure 2).

There are some inherent shortfalls with the NTC approach that can adversely affect the embedded motor's drive reliability. As previously mentioned, the NTC's efficiency depends on the temperature. The hotter it becomes, the more efficient it is. An NTC cannot be heatsinked to conduct the heat away; otherwise it will not work as intended. This dissipation is left to heat the surrounding environment where the other semiconductor components reside. In the embedded environment the problem is exacerbated. An increase of just 10oC can reduce the semiconductors expected life or mean time between failures (MTBF) by as much as half, significantly reducing the drive's reliability.

Another major problem with the NTC is its thermal mass or time response. A problem could arise if the mains voltage were to momentarily dropout or severely brownout for a period just long enough where significant charge is depleted from the bulk capacitors. When the line voltage recovers, the NTC may not have had enough time to cool down, and is in its low resistance state. The inrush currents associated with the line recovery in this event allow even higher surge currents than normally present, even higher than those at initial start up. In this case there is no protection. These unusually high currents could damage power train elements such as fuses, solder joints, traces or all the elements in the path.

Figure 3 show an implementation that overcomes many of the undesirable problems of the NTC. This alternative method can use either a fixed value resistor or an NTC as the inrush resistor. The inrush circuit described here has two additional silicon controlled rectifiers (SCRs) and an unregulated voltage source from a small auxiliary winding from the PFC boost inductor.

During initial powering up of the motor circuit, current flows through the bridge rectifier through the inrush resistor, to the bulk capacitors where the current is limited by the inrush resistor. After some time, usually determined by the PFC controller circuit, it starts its operation. When it starts, the PFC controller starts switching the power MOSFET, which in turn starts pulsing the current in the boost inductor. This pulsing current then produces a floating unregulated voltage on the auxiliary winding that is used to trigger the gates of the two SCRs. The two SCRs are placed in the circuit in such a way as to provide a current path that bypasses two of the rectifiers in the bridge along with the inrush resistor. This alternative path provides a very efficient path for the current without an additional series element being added to the circuit. Even though SCRs have a slightly higher forward voltage drop (Vf) than the rectifier diodes, the voltage drop across the current limiting element, such as a fixed resistor or NTC, has been eliminated. Furthermore, the heat dissipated from the SCRs can be removed by heat-sinking to the chassis; an impossibility with the NTC. This heat removal capability can result in cooler operation resulting in higher system reliability or MTBF figures.

The turn ratio of the auxiliary winding must be selected to ensure that enough voltage is produced to trigger the gates of the SCRs under all specified line voltage limits. The timing of the gate triggering is usually inconsequential because the switching frequency of the PFC circuit is typically much greater that the line frequency. A PFC circuit running at a mere 40 kHz will most definitely ensure SCR zero crossing switching, making them act much like the simple rectifiers in the bridge.

Figure 3 shows a simplified schematic of the industries first single chip dual-phase interleaved PFC pre-regulator, the UCC28070 from Texas Instruments. Interleaving two phases 180o apart provides ripple current cancellation. This enables the use of a smaller electro-

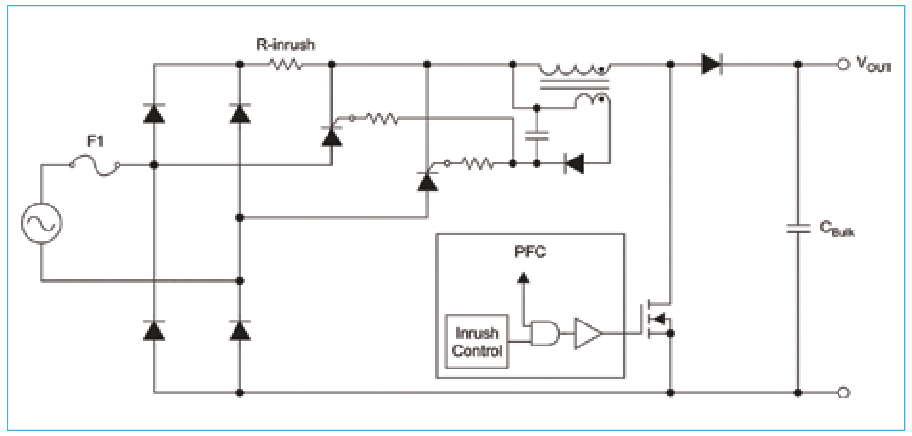


Figure 3: Inrush control function in PFC controller.

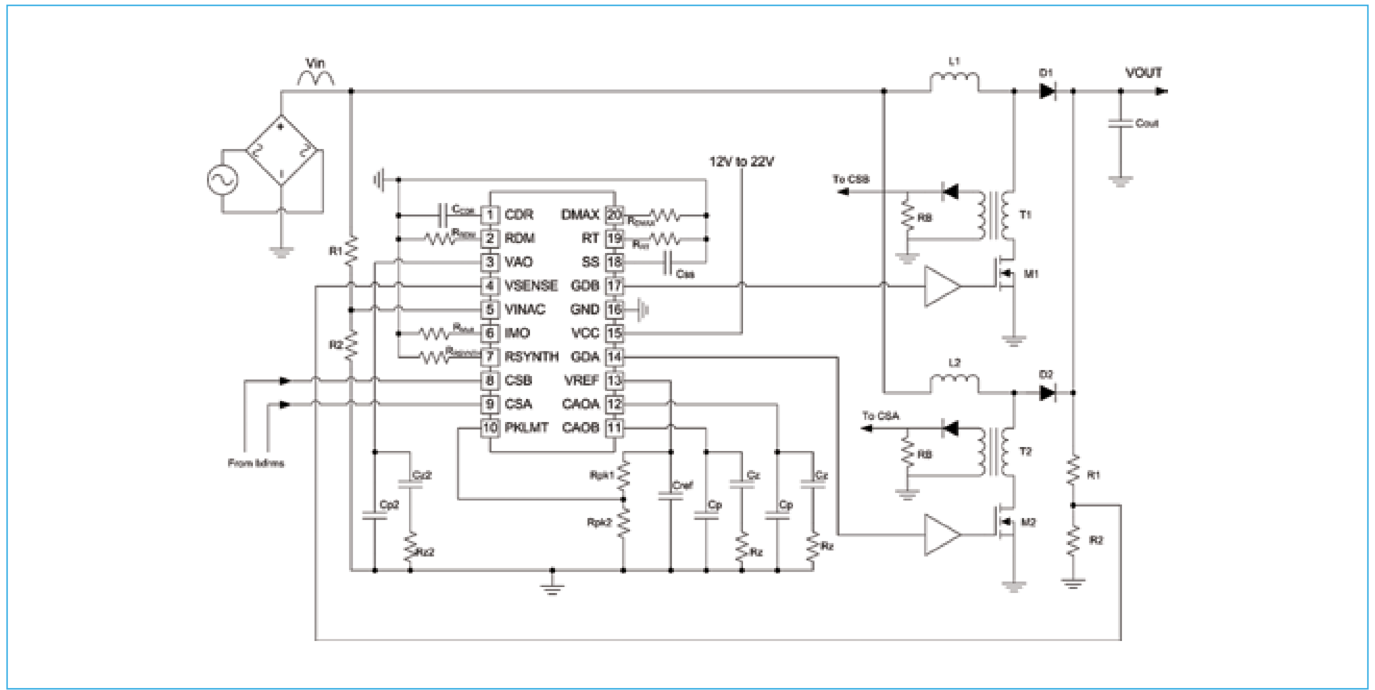


Figure 4: UCC28070 two-phase interleaved PFC.

magnetic interference (EMI) filter along with physically smaller PFC output capacitors. These smaller elements of the dual-phase interleaved topology make it an ideal solution for embedded motor drive circuit. An interleaved PFC can meet very high power density requirements including low height.

Other benefits of interleaving include easier thermal management since power dissipation is distributed over two phases. Reduced overall system cost from a smaller EMI filter, smaller PFC output capacitor sizes, and less magnetic material as the total inductor volume of the two phases are significantly smaller than a single stage design (Figure 4). Also, the MOSFET and diode current ratings can be reduced by at least 50 percent. Smaller MOSFETs are inherently faster, which further reduces MOSFET switching losses. Finally, the economy of scales increases the buying power on matching devices in each phase by doubling the volume of each.

The UCC28070 works in continuous conduction mode (CCM). Also available is the UCC28060 which is a transition mode (TM). The UCC28060 has similar benefits afforded with ripple current cancellation, but also offers some lower cost alternatives. Most notably is the use of low cost boost diodes since there is no reverse recovery condition in transition mode operation.

To incorporate inrush in the UCC28070 or its design, simply add the inrush components from Figure 3 to either of the phase inductors.

Texas Instruments PFC controller roadmaps include devices such as the UCC28070 or UCC28060 interleaved PFC controllers that have an additional functional block. This additional block monitors both the input and output sides of the PFC controller. If it determines that an inrush condition exists, such as a momentary loss in line voltage, it will override the gate drive output, stopping the MOSFET from switching and shutting down the power in the SCRs gate drive circuit. This will naturally engage the inrush element back into the high current path.

A final note

When it comes to system integration for white goods applications, many designers favor alternative paths. Some prefer to go the route of devices that can execute multiple application functions to reduce system complexities and enable faster time-to-market. For example, the C2000 digital signal controllers (DSC) from TI can replace the microcontroller traditionally used for motion control while adding advanced motor control algorithms such as field-oriented control. It improves efficiency while using smaller power electronics. Besides being adaptable to various PFC topologies including interleaving, C2000 DSCs can simultaneously implement all the necessary three-phase motor control functions, handle in-system communications, provide for a user interface, and also provide the inrush current limiting control described, all in a single C2000 digital signal processor (DSP).

www.ti.com

IGBT Gate Drivers in High-Frequency Induction Cookers

Efficiency of induction cookers is 84 percent

Today, with the constant demand for energy saving devices, high-frequency induction cookers, already a trend in Europe, are gaining popularity in the rest of the world. These kitchen devices offer high efficiency that reduces energy usage, reduces cooking time and, simultaneously, improves user safety, particularly around children, since all heat is localized to the pan itself.

By Gary Aw, Product Manager, Gate Drive Optocouplers, Avago Singapore

According to the U.S. Department of Energy, the typical efficiency of induction cookers is 84% compared to the 40 percent of gas cookers. In this article, two typical induction cooker designs, the half-bridge series-resonant and the quasi-resonant topology, are discussed. The merits and disadvantages of these two high-frequency inverter topologies along with three gate driver circuits, discrete transistors, optocouplers integrated circuit and transformers for high frequency operation are also discussed.

What is induction cooking?

In an induction cooktop, a magnetic field transfers electric energy directly to the object to be heated. By inducing an electric current into the ferrous cooking utensil, heat is generated in the object, and the cooking surface only gets hot from the heat reflected from the object being heated: no heat is directly produced by the induction element. Because of this direct transfer of energy, there are fewer losses, which translates to a higher level of efficiency.

This compares with conventional cooking in which a heat source, for example an electrical resistance element or a flame, transfers heat energy to the cooking pot. The two-step energy transfer is inherently less efficient than direct inductive heating.

How does an induction cooker work?

Figures 1 and 2 show two circuit topologies for induction cookers: the half-bridge series resonant converter, Fig. 1, and the quasi-resonant converter, Fig. 2. In both topologies, there exist the resonant elements Lr and Cr. For circuit simplification, the load pot, R, is assumed to be a purely resistive element. In both

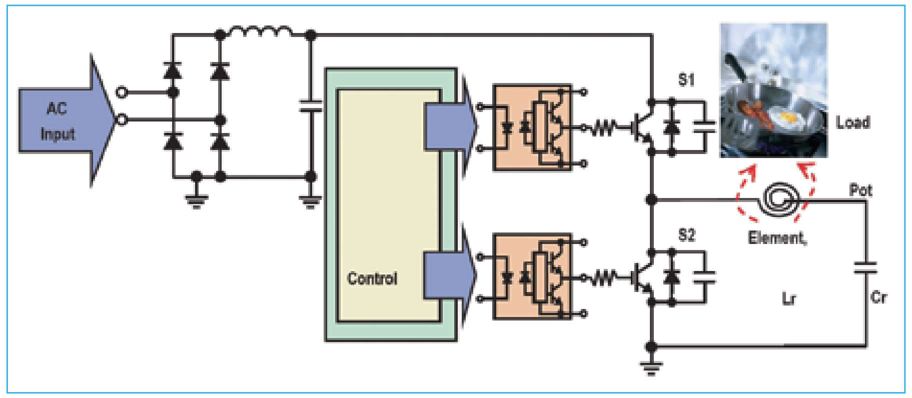


Figure 1: Half-bridge series-resonant topology for induction cookers.

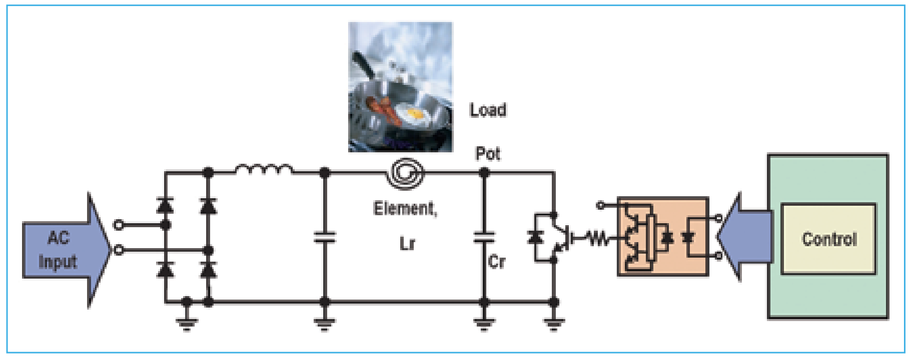


Figure 2: Quasi-resonant topology for induction cookers.

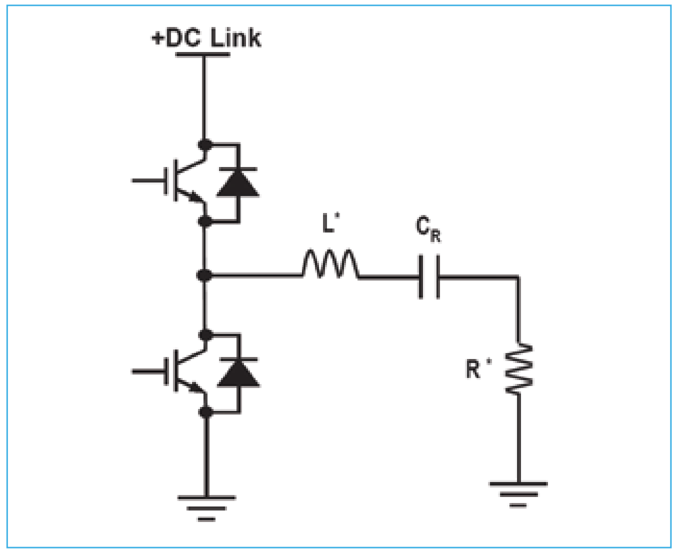


Figure 3: Equivalent half-bridge series resonant circuit.

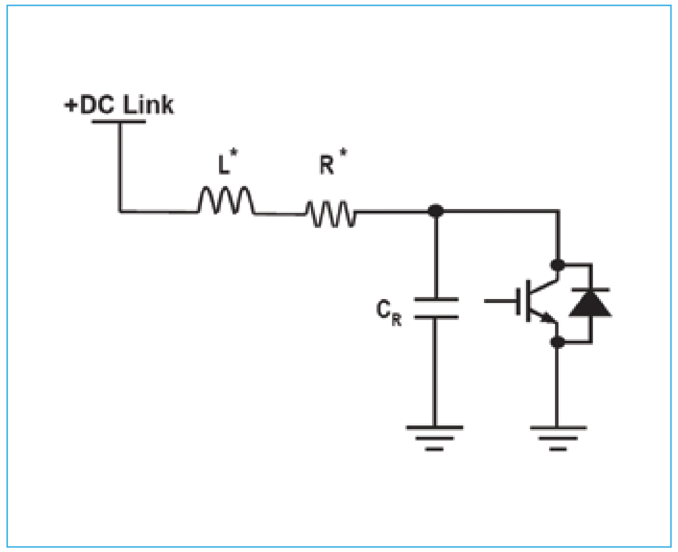


Figure 4: Equivalent quasi-resonant circuit.

topologies, an AC input supply of 220V 50 Hz is converted into an unregulated DC voltage by a full-bridge rectifier. This DC voltage is then converted into a high frequency AC voltage by the inverter IGBT (insulated gate bipolar transistor) switches—S1 and S2 in the case of the half-bridge circuit—which can be controlled using a microcontroller. Due to the high frequency switching AC, the element coil will produce a high frequency electromagnetic field which will penetrate the ferrous material of the cooking pot. From Faraday's Law and skin effect, this generates eddy current within the cooking pot which then generates heat to cook the food inside the pot.

By applying the transformer equivalent circuit, designers are able to map the load pot (secondary of transformer) to the primary side of the circuit where the resonant inductor, Lr, and capacitor, Cr, are located. From this, we can obtain the equivalent circuit for the half-bridge and quasi resonant circuits, shown in Figs. 3 and 4. From these equivalent circuits, the operation of the induction cooker, and the values of the resonant inductor, capacitor and control algorithm can be derived.

In order to reduce component size, minimize switching losses and reduce audible noise during operation, induction cooker circuits typically utilize resonant or soft switching techniques. Soft switching can be subcategorized into two methods: zero-voltage switching and zero-current switching. Zero-voltage switching occurs when the transistor turns-on at zero voltage. Zero-current switching refers to the elimination of turn-off switching loss at zero current flow. The voltage or current provided to the switching circuit can be made zero by using the resonance created by an L-C circuit. This topology is named a "resonant converter."

The advantages of a half-bridge series resonant circuit are stable switching and lower cost due to simplified design. The voltage within the circuit is limited to the level of the input voltage, which reduces the voltage stress across IGBT power switch. This, in turn, allows the designer to lower the cost by choosing an IGBT with a lower voltage rating. The disadvantage of this approach is that the control of the half-bridge circuit is relatively complicated and the required size of the heatsink and PCB area is greater, because of the high side gate driver circuit required for the upper IGBT, S1 in Fig. 1)

The advantage of a quasi-resonant converter is that it needs only one IGBT power switch, which reduces the size of the PCB and heat sink. The disadvantages are that the quasi-resonant switching develops a resonant voltage which can be higher than the DC input voltage, increasing stresses on the IGBT power switches. This requires higher-cost components with higher blocking voltage capabilities.

Gate driver circuits for IGBT power switches

Three types of driver circuits, using discrete transistors (Fig. 5), gate driver optocouplers (Fig. 6) or gate driver transformers (Fig. 7) can be used to drive the power switches in the induction cooker. There are several issues

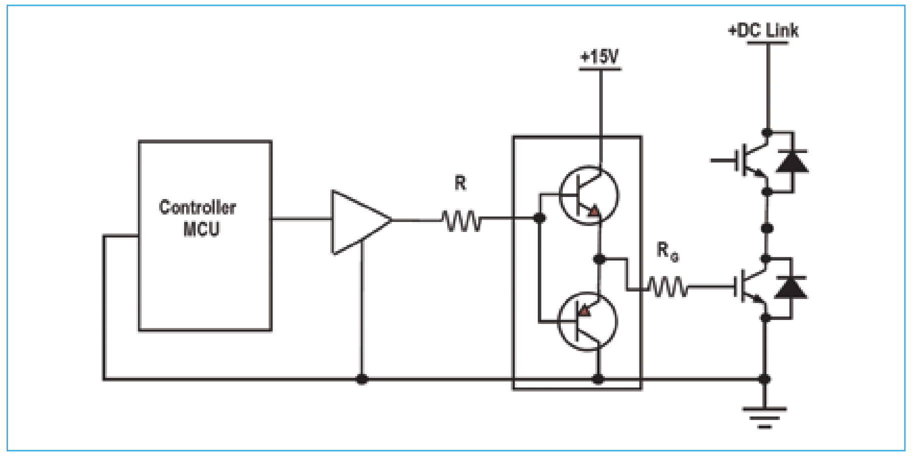


Figure 5: Discrete transistor gate driver (low side drive).

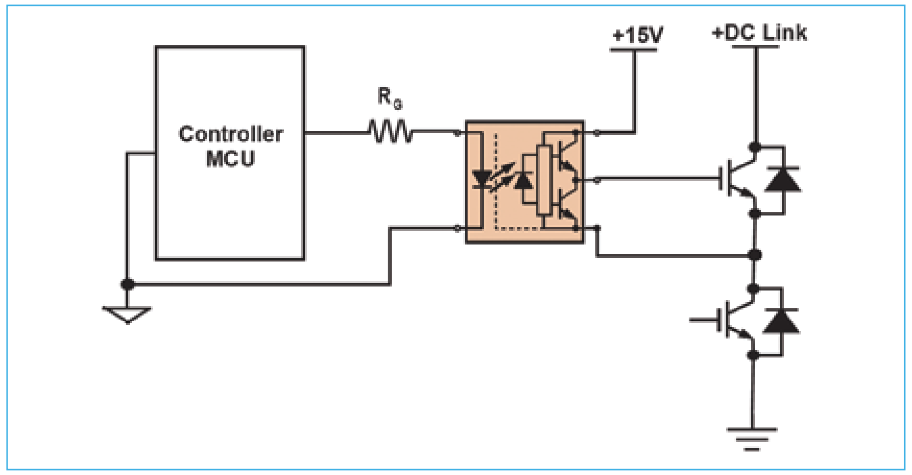


Figure 6: Gate drive optocoupler.

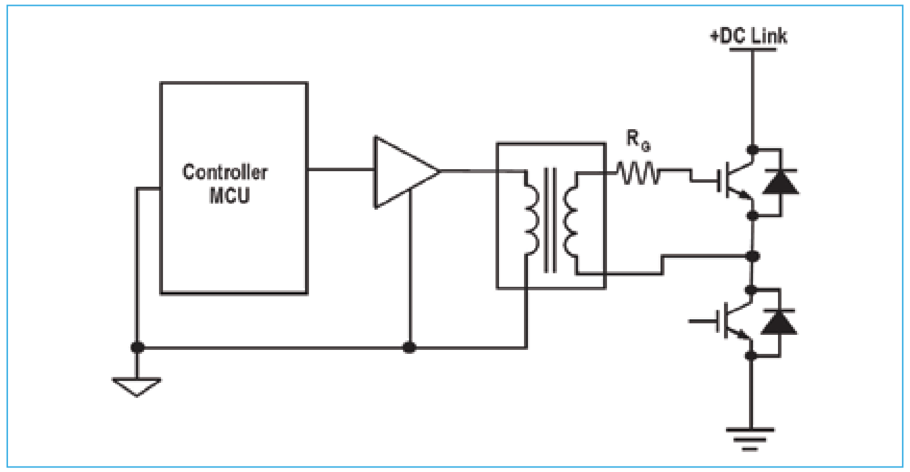


Figure 7: Gate drive transformer.

associated with high-frequency gate drivers: parasitic inductances, power dissipation in the gate-drive circuit and the losses in the power switching devices in the gate driver, all of which are involved when selecting an appropriate driver circuit.

Typically, the switching frequency of an induction cooker is between 25 kHz and 40 kHz. In order to rapidly turn on and off the power switch, the gate current inductance loop between the driver and power switch should be as low as possible. Hence it is advisable to design the layout of the circuit to reduce the parasitic inductances. Since the driver rapidly charges and discharges the gate capacitor of the IGBT, a relatively high peak gate current may be needed for proper operation. A higher peak current is also desirable to increase the charging and discharging rates during turn-on and turn-off, to help reduce the switching losses of the IGBT. Due to this, managing the power dissipation within the gate drive circuit becomes increasingly important as the switching speeds are increased.

Discrete gate drivers are constructed using bipolar transistors, and NPN and PNP emitter followers can achieve reasonable drive capability. However, using several discrete components to build the driver, while simultaneously incorporating necessary operational and protective functions such as under voltage lockout (UVLO), is not as space efficient as using integrated circuits. Moreover most discrete transistor driver designs do not provide sufficient safety isolation or noise immunity.

Two methods of providing electrical isolation are pulse transformers and gate driver optocouplers. The pulse transformer is a traditional and simple solution, which, however, suffers from the potential for core saturation in a reasonably-sized transformer, resulting in reduced efficiency. A pulse transformer can only transmit AC signals, and most designs have a limited duty cycle ranging up to 50 percent due to the transformer volt-second relationship. An additional capacitor and zener diode on the transformer secondary can be added to permit a higher duty cycle. However, this increases the circuit board size and parasitic inductances, which, in turn, increases power losses in the driver circuit.

The gate driver optocoupler IC integrates an LED light source and optical

Table 1: Summary of gate driver solution for induction cooker.

	Half-Bridge Series Resonant	Quasi-Resonant
Discrete Transistor Driver	Complex high side drive circuit, increased parasitic inductance due to higher component count and no isolation provided	Cost effective but no isolation
Gate Optocoupler Driver	High side driving while providing isolation, reduced parasitic inductance, integrated safety function and noise immunity	Provide integrated safety function and reduced parasitic inductance
Transformer Gate Driver	Provides isolation, requires more components and space for better performance	Provides isolation

receiver for safety isolation, with transistors to provide sufficient drive current, and protection functions such as UVLO or desaturation detection.

Gate driver ICs are easy to design with, and will save PCB board space. Due to the integrated design, the drive circuitry can be located very close to the power switch, which not only saves PCB space but also improves the overall noise immunity of the system. However, as with any ICs, power dissipation is a major concern.

For the single-switch resonant converter, the designer has the option of the discrete gate driver, gate transformer or gate driver optocoupler topologies. As discussed previously, the quasi-converter resonant voltage can be higher than the DC link voltage and this voltage stresses the power semiconductor switch. In most commercial low cost single switch induction cooker designs, the discrete gate driver circuit is used as there is no upper power switch, and both the controller and power semiconductor are able to share the same power ground. However, in cases where safety isolation and reduction of driver losses becomes an issue, the gate drive optocoupler or transformer are excellent alternatives.

For the half-bridge converter, a floating or high-side power switch needs to be driven. A high-side discrete solution would increase the component count, and not provide any isolation. As shown, the pulse transformer galvanic isolation solution becomes increasingly complicated for duty cycle switching above 50 percent. Also, the solution size is larger because of the additional discrete components on top of the transformer size. The gate driver optocoupler IC provides a good level of protection, isolation, and common-mode noise rejection. This resolves many of the problems that are associated with transformer or discrete transistor drivers.

Summary

In this article, the half-bridge series resonant and quasi resonant induction cooker topologies along with three gate driver methods were discussed. In order to reduce the design size and audible switching noise while improving power efficiency, these resonant converters are chosen. The discrete transistor gate driver circuit is cost effective but increases design complexity while providing no safety isolation. The required size of the gate drive transformer consumes board space, and requires additional work, cost and board space to achieve switching duty cycles above 50 percent. Finally, the use of gate drive optocoupler ICs saves board space through high level feature integration while providing high voltage safety isolation and noise immunity all in one package.

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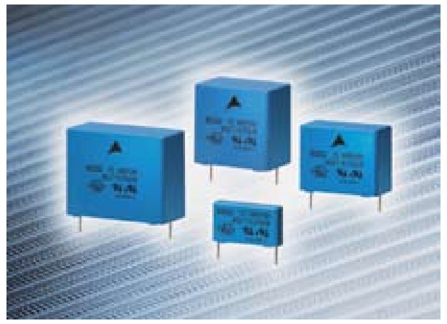
ACAL Offers Space-Saving Film Capacitors from EPCOS



ACAL Technology has announced new compact Y2 EMI suppression capacitors from EPCOS. Connected to protective ground between the neutral conductor and phase to suppress high-frequency interference and transients, they protect the equipment and allow it to operate reliably. Typical applications include power supplies and household appliances. The Y2 capacitors offer a rated AC voltage of 300 VAC and a temperature stability of 110 °C. Their design ensures extremely reliable performance in a compact format. Their dimensions range from 4 x 9 x 13mm^3 to 20 x 39.5 x 41.5mm^3. They also satisfy the most important international standards such as IEC, UL and CSA. The new B32021* to B32026* series will replace the previous B81122* series.

New X1 capacitors of the B32911* to B32916* series were simultaneously developed for a rated AC voltage of 330 VAC. These reliable components were designed for across-the-line applications in order to suppress symmetrical electrical interference and are intended specifically for equipment requiring a high level of interference protection. The series is designed for operation in equipment that is continuously connected to single-phase power grids. These capacitors also satisfy the IEC, UL and CSA standards.

Samples are available from ACAL Technology now and customer applications can be fully assessed and verified by testing prototype designs in ACAL's EMC chamber which can measure conductive and radiated emissions and test products to EN55022, EN61000 and EN61000-3-2. ACAL has a team of experts on hand to ensure any design is effectively and rapidly completed in partnership with their customers.

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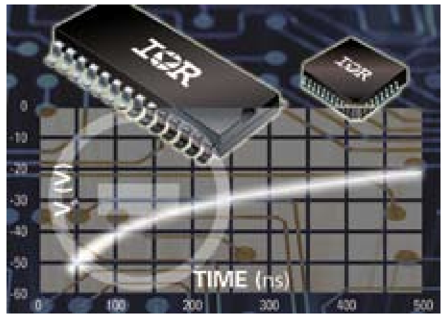
Three-Phase 600V ICs Offer Integrated Bootstrap Functionality, Negative vs Immunity, and Advanced Input Filtering



International Rectifier has introduced the IRS2336xD protected 600V three-phase gate driver ICs with integrated bootstrap functionality for appliance motor control, servo drives, micro-inverter drives, and a wide range of general purpose applications.

IR's latest high-voltage gate drivers are ideal for three-phase applications that require industrial level ruggedness. These new ICs feature IR's proprietary negative Vs immunity circuitry, allowing the devices to withstand the very large negative Vs transients that are seen during high-current switching and short-circuit conditions. Additionally, an advanced input filter improves system performance while the integrated bootstrap functionality reduces the circuit footprint.

Integrating power MOSFET/IGBT gate drivers with three high-side and three low-side referenced output channels, the IRS2336xD ICs provide 180mA/330mA drive current at up to 20V MOS gate drive capability operating up to 600V.

Part of International Rectifier's G5 HVIC platform, these devices incorporate advanced functionality including negative Vs immunity circuitry to protect the system from catastrophic events that can be seen during high-current switching and short-circuit conditions, critical for industrial systems that require high levels of robustness and reliability. Also, an advanced input filter has been integrated to reject noise and reduce distortion, improving system performance in many motor control applications.

To address the needs of applications suffering space constraints and to simplify design, the IRS2336xD ICs feature integrated bootstrap functionality. This functionality can reduce the bootstrap power supply from six components to three, while providing VBS over-voltage protection for the system through the use of additional integrated intelligent protection circuitry.

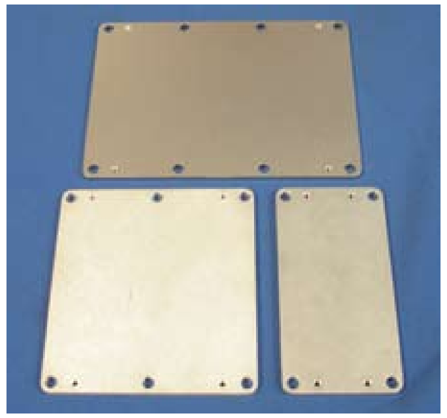
The new devices utilize IR's advanced high-voltage IC process which incorporates next-generation high-voltage level-shifting and termination technology to deliver superior electrical over-stress protection and higher field reliability. In addition to the over-current and over-temperature detection input, these ICs feature under-voltage lock-out protection, integrated deadtime protection, shoot-through protection, a shutdown input, fault-reporting, and are compatible with 3.3V input logic.

Specifications:

Part Number	Input Logic	UVLO	$V_{IT,TH}$	t_{ON}, t_{OFF}	V_{OUT}
IRS2336D	HIN/N, LIN/N	8.9 V/ 8.2 V	0.46 V	530 ns, 530 ns	10 V – 20 V
IRS23364D	HIN, LIN	10.4 V/ 9.4 V	0.46 V	530 ns, 530 ns	10 V – 20 V

www.irf.com

CPS Offers AlSiC Metal Matrix Composite Base Plates for High Power and High Reliability IGBT Modules



CPS Corporation offers AlSiC (Aluminum Silicon Carbide), a metal matrix composite ideally suited for base plates material for insulated gate bipolar transistor (IGBT) used in high-power traction, power control, Hybrid Electric Vehicle power systems, and fly-by-wire applications. AlSiC has been tested and meets the requirements of the Restriction of Hazardous Substances Directive (RoHS compliant) of the European Parliament.

The low isotropic coefficient of thermal expansion (CTE) value of AlSiC-9 (8 ppm/°C: 30 – 100°C) is compatible with the thermal expansion value of the die or substrate used in IGBT applications. The AlSiC CTE match reduces the mechanical stresses on IGBT die and substrates that is induced by thermal power cycling which improved reliability of substrate attachment and reduces die cracking failures.

The device compatible AlSiC CTE eliminates the need for stress compensation material layers that are required in Cu (CTE = 17ppm/°C) baseplate assemblies. Elimination of stress compensation materials simplifies assembly and reduces the thermal resistance for AlSiC systems so that AlSiC systems have equal or improved thermal dissipation over Cu baseplate assemblies.

In high power applications (>1200 V/ 400A) IGBT modules assembled with AlSiC baseplates are found to have a service reliability of many 10s of thousands of thermal power cycles over Cu equivalent systems.

AlSiC is a lightweight material (1/3 that of Cu), which makes it an ideal cooler material for the weight-sensitive IGBT applications. AlSiC also has higher strength and stiffness than Cu, which, combined with its lightweight nature, makes AlSiC assemblies more tolerant shock and vibration.

The CPS AlSiC near net-shape fabrication process both produces the composite material and fabricates the product geometry, allowing for the design of IGBT base plates with a dome profile. This geometry improves thermal interface contact with cold plates and coolers, adding to AlSiC's advanced thermal management qualities. CPS fabricates standard of 190 mm x 140mm, 140mm x 130mm and 140mm x 70mm base plate formats (shown) as well as custom formats.

www.alsic.com

New High Power LED Driver Optimized for Mid-Size LCD Panels

Catalyst Semiconductor has expanded its line of high-power LED drivers with a new device optimized for the rapidly growing mid-size LCD panel market. The new CAT4139 boost converter provides a switch current up to 750mA and drives LED strings up to 22V, making it an ideal choice for digital photo frames and backlighting applications where high LED counts up to 40 LEDs are emerging.

Many high voltage boost converters typically use a simple variable frequency switching scheme which results in a wide range of unwanted harmonics that are not easy to filter or eliminate. The CAT4139 uses fixed frequency, 1MHz switching architecture making it ideal for low noise applications. A high voltage CMOS output stage in the device allows 5 LED strings (up to 22V) to be accurately biased and regulated from a low voltage input supply while still delivering efficiency levels of up to 87%. The device follows Catalyst's CAT4240 high-power boost converter introduced earlier this year, which drives 10 LED strings up to 38V each.

To eliminate excessive inrush currents which can occur during initial power-up, the CAT4139 offers an integrated soft-start control. In the event of an open-LED fault condition, an internal over-voltage protection circuit will place the device into a low-power operating mode restricting the output voltage to safe levels without the need for external circuitry. Both of these features are fully integrated, eliminating the need for external components and the associated cost and board space overhead.

Designers have a choice of controlling LED dimming in the CAT4139 using a DC voltage, logic signal, or pulse width modulation (PWM) signal.

The CAT4139 is available in a 5-lead TSOT23 (1mm max height) package and is priced at $0.64 each in 10,000 piece quantities. Samples are available now. Projected lead-time for production quantities is currently 6 to 8 weeks ARO.

www.catsemi.com

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Power Systems Design Europe

Green Page

PSDE Green Power ENERGY EFFICIENCY

When Will We Get There?

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

The more I read, watch TV or listen to the radio, the more I hear the word 'green'. At PSDE, we saw this mushrooming and have tried to keep our readers abreast of what's going on.

I notice that Ericsson is running a green promotional campaign in conjunction with CNN, a big project, which started in summer and which has been a real success for the company in terms of visitors to the company's web; challenging, provoking and discussing how Ericsson is helping to contribute awareness to world sustainability.

Data centers and server farms, a hot topic for me, if you'll excuse the pun, are also getting much continued media coverage. IR just launched a high-efficiency part to lighten the load on the utility companies, hopefully to be followed by a complete revamp of the way we'll do things in the future. I do not hold out much hope in the near term; we are chipping away at the problem of the vast amounts of power consumed, but radical changes are necessary to make a significant impact here.

In an initiative to help achieve this, a consortium of IT giants like Microsoft, Dell, Sun, IBM et al, have set up The Green Grid - a platform for IT profes-

sionals who aim to cut power consumption in data centers. It offers solutions and consultation on the best practices available.

NanoSolar, a solar start-up claims to have the technology to make solar panels hundreds of times more cheaply and more efficient than anything the world has ever seen and is now ramping up production of its new invention in massive plants near San Jose, California and Berlin, Germany, NanoSolar says that its systems will achieve cost parity with the outdated electrical production systems of coal, oil and nuclear.

The company's main product is thin film solar panels that are printed with highly efficient semiconductors for converting sunlight into electricity on a massive scale. More on progress in a later issue.

In India, Philips Electronics India says that 18,000 MW power is used for lighting purposes alone annually. This is estimated to translate to around 2.2% of the gross output of the total industrial and service sectors.

Now, Philips India is in the process of creating an "ecosystem" comprising industry bodies, governments and NGOs and education institutes to break down the barriers against adoption of energy efficient lighting by promoting compact fluorescent lamps (CFL) that save energy by 80%.

It is reported that none of these initiatives will work unless there is collaboration by all concerned. For intelligent energy solutions to succeed there must be a concerted and collaborative effort by industry, government and consumers.

www.powersystemsdesign.com/greenpage.htm