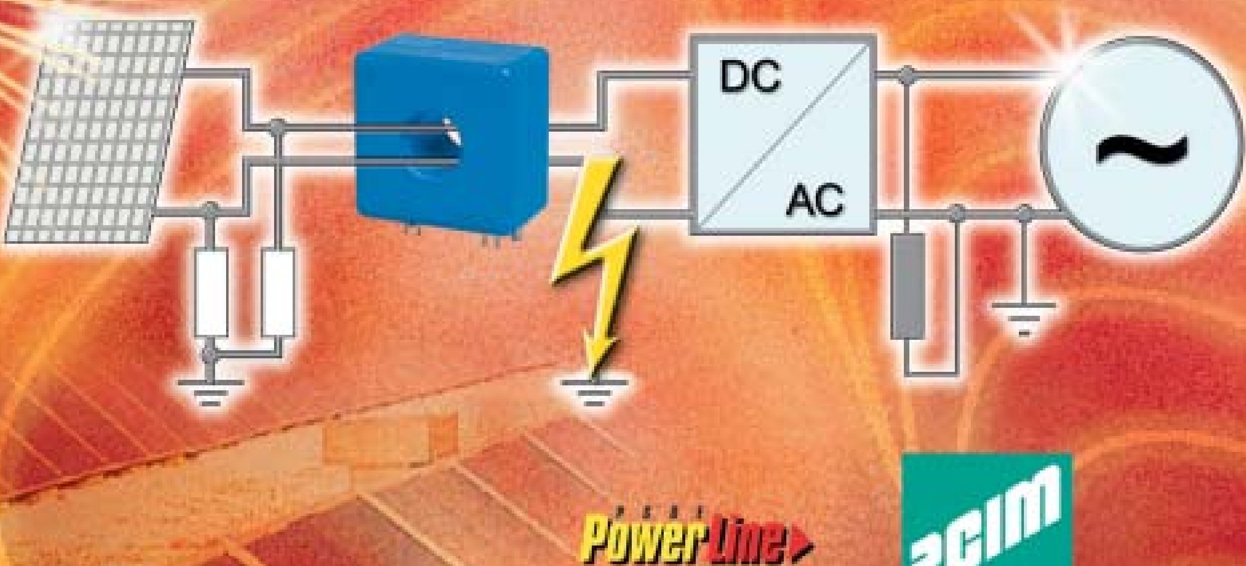
Power Systems Design EUROPE

Power Control Intelligent Motion

May 2005

Earth Leakage Control in Solar Inverters



PowerLine

Power Player

PCIM Europe 2005

Power Factor Correction

Passive Current Sharing

CONTENTS

Power Systems Design EUROPE

Power Systems Design EUROPE

AGS Media Group
Katzbek 17a
D-24235 Laboe, Germany
Phone: +49 4343 421790
Fax: +49 4343 421789
info@powersystemsdesign.com
www.powersystemsdesign.com

Editor-in-Chief
Bodo Arlt, Dipl.-Ing.
Bodo.Arlt@powersystemsdesign.com

Publishing Director
Jim Graham
Jim.Graham@powersystemsdesign.com

Associate Publisher
Julia Stocks
Julia.Stocks@powersystemsdesign.com

Creative Direction & Production
Eyemotive
beata@eyemotive.com
www.eyemotive.com

Circulation Management
circulation@powersystemsdesign.com

Advertising Rates, Sizes and Digital File Requirements available at:
www.powersystemsdesign.com

Your Free Subscription Request available at:
www.powersystemsdesign.com/psd/subslogn.htm

Registration of copyright: January 2004
ISSN number: 1613-6365
Issue print run: 20,000
Printing by: Central - Druck Trost GmbH & Co.
Heusenstamm, Germany

Send address changes to:
circulation@powersystemsdesign.com

Volume 2, Issue 4

Nuremberg the largest Power Electronics Show in Europe

The place to meet the power experts is Nuremberg with the PCIM Europe show celebrating it's 26th anniversary this year from June 6-9. All engineers are on their way to Nuremberg to participate in one of the most important events throughout Europe. Their interest is focused to power. Power is and has been the heartbeat of any electronics.

The world economy is still diverted but power electronics is not a lifestyle trend, it is essential to the support of today's technology. The show and conference are always busy, a success attributed to all the hard working conference board members. Of course, having had Gerd and Christine Zieroth driving the shows spirit for a quarter of a century has made a big difference, creating an environment similar to a big family event.

Becoming a tradition for the PCIM Exhibition in Nuremberg, I will moderate each days Podium discussions during the lunch break in the arena on the exhibitors floor. This year I expanded our topics to include more system level focused subjects for discussion between the experts.

- Tuesday: Power Management controlled by analog or digital.
- Wednesday: Portable Power, charging and optimizing operating time.
- Thursday: Thermal Management and the design and simulation tools.

The PCIM conference provides the platform for the future view into technology. The strength for us is that technology can conserve our rapidly depleting natural resources, improve lives and ensure our future. Progress is driven by innovation.

The technology for size and weight of a motor drive or of a power supply is influenced by other circuit requirements beside the power electronics. Power management starts at the device level with controller ICs that conserve energy by putting non-required functions to sleep or by slowing clock cycles, followed by the distributed power at the board level. Additionally, system solutions are being incorporated to boost the design to higher levels of performance.

In the center of this issue of Power Systems Design Europe, you will find the exhibitors booth layout, this should help you to get around the show floor.

I am always looking forward to seeing my friends at PCIM in Nuremberg, the place to meet the power experts. Stop by our booth 12-239 just across from the podiums discussion arena.

Best regards,

Bodo Arlt
Editorial Director
The Power Systems Design Franchise

ECPE Joint Booth with Competence Centers

At PCIM Europe (7 – 9 June 2005), ECPE European Center for Power Electronics e.V. organises a joint booth with leading European Competence Centers active in Power Electronics to present latest results from European Research. In this frame, the ECPE Demonstrator Programs will be presented as well.

The following university and research institutes are partners on the ECPE joint booth:

- Aalborg University, Institute of Energy Technology, Power Electronic Systems
- Delft University of Technology, Electrical Power Processing (EPP)
- ETH Zurich, Power Electronic Systems Laboratory (PES)
- FAU Erlangen-Nuremberg, Center for Power Electronics
- Fraunhofer Institutes IISB (Erlangen-Nuremberg) and ISIT (Itzehoe)
- RWTH Aachen, Institute for Power Electronics and Electrical Drives (ISEA)

In the forum program of the PCIM exhibition, ECPE will give a presentation on its Power Electronics Online Course (8 June 2005, 12.00 h) which is built up in cooperation with the Swiss Federal Institute of Technology (ETH) Zurich, Power Electronic Systems Laboratory. The course comprises interactive and animated Java applets as well as a script on fundamentals and theory of power electronics.

The Online Course is available on the ECPE web site www.ecpe.org, the use is free for ECPE Members as well as for universities and students.

You find the ECPE joint booth in hall 12, booth 551.

www.ecpe.org

Intelligent Motion at PCIM Europe

IPCIM Conference Directors for Intelligent Motion, Prof. Helmut Knöll, Fachhochschule Würzburg-Schweinfurt, Germany and Prof. Mario Pacas, University Siegen, Germany have their impressions for Nuremberg summarized. In Intelligent Motion we see a steady progress in all fields of drive technology. Only to point out some trends and highlights of our conference:

The trend of this year in motors and actuators are fault-tolerant systems, direct drives and improved design methods.

Concerning variable speed drives we concentrated on low power drives as they are today very important in automotive and in white goods applications. Vorwerk, Germany presents a high speed switched reluctance motor drive for kitchen machines. EBM-Papst, Germany reports on high speed PM drives for automotive applications.

Mechatronics continues to be one of the main driving forces for novel and improved drive technology. We observe an increase in both, applications as well as new solutions in machine building. Siemens, Germany reports on improved control of elastically coupled machine tool axis as well as compensation of structural oscillations of large gantry machines. ELAU, Germany presents flexible mechatronic machines in the packaging industry.

Furthermore, sensorless drives still represent a challenge to our engineers. We invited Prof. Holtz, Germany to report on perspectives and concrete solutions of sensorless ac drive technology. International Rectifier, Canada speaks on a novel position sensorless PMSM drive.

In the topics covering components for system integration as well as control and measurement you will find applications dedicated to all of our specialities.

www.pcim.de

Artesyn Launches Chinese Web-site

In a development that reflects the growing importance of the domestic power supply market in China, Artesyn Technologies has launched a Chinese version of its web site. Most of the navigation and search tools on the new site - http://www.artesyn.com/china/ - use Chinese nomenclature to help new and existing customers in the region find what they're looking for very quickly and easily. The site presents all top level information in Chinese, and effectively mirrors Artesyn's main English-language web site for detailed product information. The site also lists company job vacancies in China: Artesyn has a number of facilities in the country, including sales and support offices in Beijing and Shanghai, Asia-Pacific headquarters in Hong Kong, and a large manufacturing and R&D centre in Zhongshan City. The Chinese market for power conversion products has outperformed most other regions of the world over the past few years, and is currently growing at a rate in excess of 10%. It is being driven by a combination of increased domestic demand for electronics goods and services, especially in the telecoms sector, and by companies continuing to transfer electronics manufacturing from other parts of the world. Our new Chinese web site provides customers in the region with fast access to a fully-maintained information resource. The site is likely to prove extremely popular with design engineers, who need to be confident that they are referencing the most up-to-date data when specifying AC/DC power supplies and DC/DC converters for their products.

In order to support and further enhance growth in the Asia-Pacific, Artesyn is developing dedicated local language sites for other major countries within the region. These sites will be brought on-line during the course of 2005.

www.artesyn.com/china/

Fairchild Appoints Marketing Director, Europe

Fairchild Semiconductor announced that it has recruited Alfred Hesener to the newly-created position of Marketing Director, Europe. He will report to Ole-Petter Brusdal, Vice President of Sales and Marketing for Europe, and will be based in Fuerstenfeldbruck, Germany.

Hesener joins Fairchild from Infineon, where he was Senior Manager Technical Marketing for power semiconductors and control ICs for power conversion.

"Hesener brings to Fairchild a combination of a strong background in worldwide product marketing and definition and experience of the European market and customer base," commented Brusdal. "To have these two experience sets combined in one individual is rare, and Hesener will add considerable strength to our expanding presence in the European market. With a focus on automotive, industrial, consumer and communications segments, our European organisation provides strong design expertise and customer support, from design to delivery."

Alfred Hesener spent a total of over 9 years at Infineon and Siemens AG, Semiconductor Division in Technical Marketing and R&D. He started his career with Atmel, where he was a Field Applications Engineer. Hesener has a degree in Electrical Engineering from Darmstadt Technical University, with a specialisation in Microelectronics especially analogue and digital design, semiconductor physics and process technology.

www.fairchildsemi.com

Diehl Selects Maxwell Ultracapacitors

Maxwell announced today that Diehl Luftfahrt Elektronik GmbH, a leading producer of aerospace systems and controls, has selected Maxwell's BOOSTCAP ultracapacitors to power

emergency actuation systems for doors and evacuation slides in passenger aircraft, including the new Airbus 380 jumbo jet. These systems are designed to provide fail-safe backup power to open aircraft doors and deploy evacuation slides in an emergency, so Diehl thoroughly evaluated and tested all available energy storage alternatives before settling on ultracapacitors. Each of the 16 Door and Slide Management System (DSMS) actuators on the Airbus 380 incorporates ultracapacitor cells in a redundant configuration to ensure reliable operation even if individual cells should be damaged or fail for any reason.

Ultracapacitor-based systems are lighter than batteries and are more reliable because they remain fully charged off the main power system during normal operation, and they store up to eight hours of standby power to operate the actuators in the event of a main system failure.

www.diehl-gruppe.de

www.maxwell.com

Cree-Raytheon Team Awarded

Cree announced that a team led by Raytheon, as the prime contractor, and Cree as a subcontractor, has won a program award from the Defense Advanced Research Projects Agency (DARPA), under its Wide Bandgap Semiconductor Technology Initiative. The team will be developing next generation gallium nitride (GaN) semiconductors for military and commercial products. The program is focused on accelerating progress and targeting the insertion of GaN into military and commercial programs starting in 2006. The Cree-Raytheon team was formed to combine the efforts of two of the premier GaN RF teams in the United States to allow even faster development towards system needs.

John Palmour, Cree's Executive Vice President, Advanced Devices, stated, "This program is perfectly aligned with Cree's strategy to be a supplier not only to the military but also to a wide variety of commercial applications. The same improvements that will make GaN components viable for military systems insertion we believe will also make them viable for insertion into cellular infrastructure, as well as other burgeoning wireless applications. Combining our efforts with Raytheon is intended to accelerate the potential deployment of this important enabling technology." Cree has been developing GaN-on-silicon carbide (SiC) RF devices since 1996. The semiconductor work for this program will be conducted at Raytheon RF components (Raytheon's MMIC foundry) in Andover, Massachusetts and in the Wide Bandgap MMIC foundry of Cree, Inc. in Durham, North Carolina, as well as in Cree's Santa Barbara Technology Center in Goleta, California.

www.cree.com

Power Events

- ***PCIM Europe 2005**, June 7-9, Nuremberg, www.pcim.de*
- ***Automation Seminare**, June, Germany, www.mesago.de/automationseminare*
- ***GEMV Energietechnisches Forum**, June 14-15, Kiel, www.gemv.de*
- ***EPE 2005,** September 11-14, Dresden, www.epe2005.com*
- ***H2Expo 2005,** Aug. 31 - Sep. 1, Hamburg, www.h2expo.de*
- ***INTELEC2005,** September 18-22, Berlin, www.intelec.org*
- ***SPS/IPC/DRIVES,** 22-24 November, Nuremberg, www.mesago.de/sps*

Better Power MOSFETs for Greener Power

When examining power circuits, there is the need for increased efficiency due to better topologies, better magnetics and other passive components, superior control ICs and switching regulators as well as better discrete semiconductors. The majority of the power losses in power circuits occur in discrete power semiconductors and magnetics.

Fairchild recently introduced SuperFET™ MOSFETs, such as the FCP7N60. These new high voltage MOSFETs specifically address demanding high voltage fast switching applications requiring high efficiency such as Active Power Factor Correction (PFC), lighting and AC/DC power supplies. These devices allow applications to achieve a very impressive RDS(ON) and small die size resulting in increased efficiency in applications (Figure 1).

As you can see above, the orange bar represents the RDS(ON) of the SuperFET and the green bars represent conventional technology MOSFETs.

Fairchild's SuperFET technology (FCxxNxx) creates more efficient switches by changing the relationship between the $R_{DS(ON)}$ of the MOSFET and its breakdown voltage from an exponential relationship to a linear one. This solution is achieved through Fairchild's Super Junction FET process technology that grows pillars of P-type material (see Figure 2). The high break down voltage (600V) and industry leading Figure of Merit (FOM) parameters such as $R_{DS(ON)}$ per unit silicon area can significantly improve the efficiency and reliability of end applications like AC/DC power supplies, motor drives and lamp ballasts. As an example, a common 30W flyback AC/DC Switching Mode Power Supply (SMPS) with 110VAC input was tested in our lab. A maximum duty cycle of 0.77 was measured and at the system efficiency of 75%, the peak drain current was 1.22A. At this current, the difference in consumed power based on the $R_{DS(ON)}$ of the SuperFET and standard MOSFET was 0.97W. This change in wasted energy directly correlates to an increase in efficiency and a reduction of heat dissipation that could reduce the heat sink size, reducing weight and cost. The efficiency gained may seem to be small but the advantages of more efficient power supplies everywhere will save money in different ways. One has to only look at typical office building to see that it is populated with various electronic office equipment. Each of these has an AC/DC power supply and if every device dissipates 1 Watt less, that is one less Watt that the Air-conditioning system needs to remove.

As can be seen from Figure 1, the conventional MOSFETs have evolved into more rugged, faster switching, easier to drive and less expensive devices over time. The high voltage MOSFETs of today, with a breakdown voltage of 500-600V or higher have over 85% of the total $R_{DS(ON)}$ coming from the lightly doped epitaxial (Repi) region—a component that cannot be easily decreased since the epitaxial region of the mosfet is needed to block the high voltage in the off state. Knowing this, it is evident that the advances in conventional MOSFET technology are impressive and the conventional MOSFETs of today can compete in critical areas such as the specific $R_{DS(ON)}$ [Rds(on) per unit area] with super junction MOSFETs of three years ago at a very competitive price, due to its simpler structure.

By far, the most impressive new power MOSFET technology introduced in the last decade has been the Super Junction MOSFETs like Fairchild's SuperFETs. This modern family of MOSFETs has a structure distinctly different from that of the conventional MOSFETs. Figure 2 compares a cross-section of the conventional MOSFET

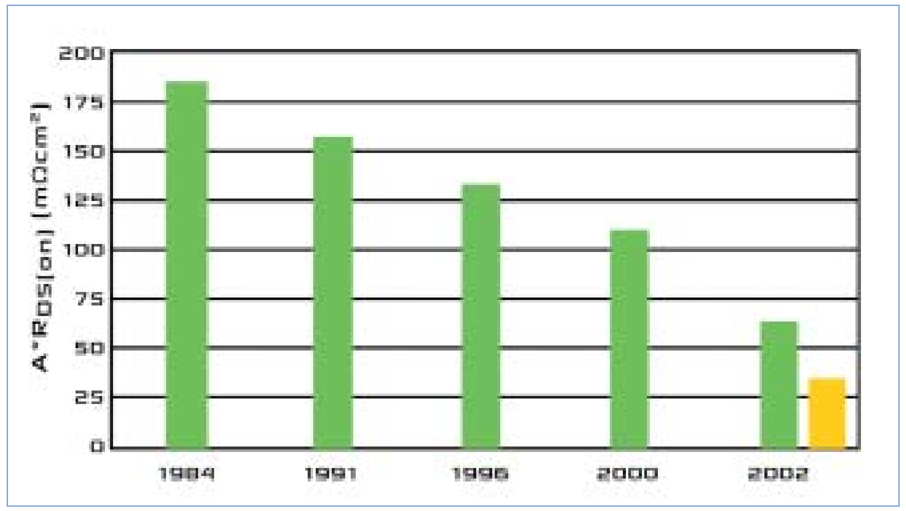


Fig. 1. Decrease of RDS(ON) of 600V MOSFETs Over Time.

with that of the SuperFET. Like all discrete MOSFETs, the SuperFET carries current vertically through the bulk of the silicon (see Figure 2).

As you can see, the most dramatic difference between the cross-section of the SuperFET and the conventional MOSFET is the deep P-type pillar in the body of the MOSFET. The effect of the deep P-type pillars is to confine the electric field in the lightly doped Epitaxial region of the mosfet.

To study the advantage of the confined electric fields of the SuperFET, let us look at the effect of the rise of the on-resistance of the MOSFETs as the breakdown voltage of the MOSFETs is increased. In standard MOSFETs, the $R_{DS(ON)}$ is directly proportional to the die size but the $R_{DS(ON)}$ increases exponentially as the breakdown voltage increases. In fact, as the breakdown voltage increases, the $R_{DS(ON)}$ increases with an exponent of roughly 2.5. The 1000V MOSFET, therefore, has a resistance of five times that of a 500V MOSFET of equivalent die size. In other words, a 1000V MOSFET should have roughly five times the die area as a 500V MOSFET in order to have the same $R_{DS(ON)}$. This means that higher voltage MOSFETs have very large die sizes that increases their cost and package size as well as decreasing manufacturing yield, etc. Hence, this presents a serious design challenge. The SuperFET replaces this exponential relationship between voltage and $R_{DS(ON)}$ with a linear one—that is the 1000V SuperFET shall only be about twice the area of a 500V SuperFET with the same $R_{DS(ON)}$.

The reduced specific on-resistance of the SuperFET, however, comes at the price of greater design complexity compared to the conventional MOSFET. The idea of the Super Junction MOSFET has been well known to designers for several decades but it is only recently that the costs of processing the deep P-type implants has decreased to make the SuperFET a viable option. Presently, the manufacture of the SuperFETs involves several additional epitaxial layers that comprise the P-type pillar.

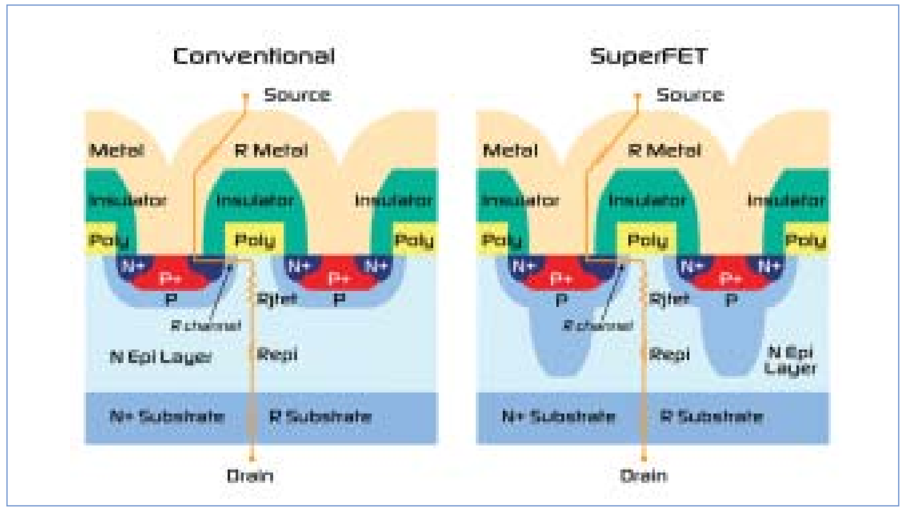


Fig. 2. Comparison.

This involves many masks approximately doubling the number of masks used in a 600V SuperFET compared to the conventional MOSFET. The number of masks and therefore, the complexity, manufacturing challenges and price of the SuperFET goes up as the breakdown voltage is increased. These processing challenges make the manufacture of say, a 1000V SuperFET much more difficult than the 600V SuperFET, even though the 1000V SuperFET has decidedly greater advantage in $R_{DS(ON)}$ over its conventional counterpart.

This design constraint can make the die size larger than the package at the same $R_{DS(ON)}$ and increases die cost. The package and cost constraints force standard MOSFET manufacturers to increase the $R_{DS(ON)}$ to produce a product at high breakdown voltages.

The real advantage of the Super Junction MOSFETs is the way they have increased the efficiency of power circuits not only in the high power applications, but the smaller die sizes of these Super Junction MOSFETs has resulted in smaller packages such as the DPAK being used in many lower power, higher volume applications such as lamp ballasts. The 600V, 600mW mosfet such as the FCP7N60 for example has become very popular in various applications replacing conventional 600V, 1.2 ohm TO-220 MOSFETs.

The manufacture of the SuperFET takes advantage of the various techniques developed over time to make the MOSFETs more rugged, better suited for bridge-type high power applications. As the power supply industry makes more area-efficient MOSFETs, the silicon area needed for the MOSFETs reduces. It is increasingly important for these modern mosfets to have avalanche energy and anti-parallel diode dV/dt ratings per unit silicon area to be higher than those of previous generations.

The SuperFET is also designed to handle a high rate of change of current (dI/dt) during switching. This ruggedness is important in many transient prone applications such as HID ballasts and plasma televisions. A guaranteed maximum gate source voltage of +/-30V helps the device withstand drive transients. Careful design of the cell structure also results in this newly released SuperFET family having a repetitive avalanche energy rating significantly higher than competitive solutions. The SuperFET manufacturing process also lends itself well to fast body diode versions that are optimized for use in bridge circuits.

www.fairchildsemi.com

Learning from the Customer for Success

By Peter Sontheimer, Tyco Electronics

Today's market for Power Modules is put at about US$ 800 million worldwide. High quantities are a characteristic of the lower power category, while in the medium to high power range you find greater focus on value added and high quality. Well-known market researchers expect to see continuing substantial growth for both ranges in the next ten years, an assumption supported by the general trend and the need to economize on energy. This is where producers of Power Modules make an extremely important contribution, though they pursue very different strategies.

A share of the innovative drive naturally comes from the R&D labs of the semiconductor producers. We have seen ground-breaking technologies like non-punch through (NPT) and trench field stop result in regular revamping if not complete redesign of Power Module generations from all suppliers. Voltage-controlled power MOSFETs, more of which are now being developed for high voltages too, are finding their way into new applications that call for very high switching frequencies for example. Zero-voltage-switching (ZVS) circuits can now be implemented in integrated Power Modules in a similar way to thyristor/diode combinations for very different applications.

In all cases the customer drives the development, and enables in particular the manufacturers of Power Modules, in effect mechatronic subsystems, to better meet the requirements. As a consequence we saw the appearance of two strong trends in the low-power drive technology segment between the middle and end of the 1990s. On the one hand there are cost-efficient solder modules like *flow*PIM modules, characterized by unique power flow-through. Then there are press-fit modules like MiniSKiiP modules, enabling the customer to dispense entirely with soldering, and thus, on the European market at least, creating cost advantages. CIB (converter inverter brake) topologies rule the roost in the industrial drive technology sector. Sixpacks round off the palette. Suppliers have an ongoing mandate to present modules that will cut the cost and BoM of customer's application design and speed up their production further. One approach is Power Modules whose direction of insertion is identical to that of other through hole components like relays or DC link capacitors. The best way is still to learn from the customer. The new product families of the *flow*90° PIM series from Tyco Electronics make a decisive contribution. Here too the fact was considered that the case not only functions as a shock-hazard guard but, through its molding, enables a definite mechanical attachment of the circuit board to the heatsink, as a cost-free extra as it were.

The customer expects even more – complete power range from one source. Seeing as the majority of customers do not concentrate solely on designing and marketing low-power devices, the supplier of Power Modules must respond by constantly expanding and improving his product portfolio. That also applies to Tyco Electronics of course. A major contribution was last year's launch of *flow*PHASE 0 modules, unique on the market in terms of power density and power cycle capability. The next move is *flow*PHASE 2 modules, extending the offered power spectrum up to an IGBT current of 300 A for 80°C heatsink temperature and 1200 V reverse voltage. This is a further important step towards high power, and certainly not the last. The high-power technologies needed for the purpose were already developed a while back for application-specific modules, and their reliability has been qualified and tested in the field.

The platforms on which these technologies set up allow the development of Power Module solutions tailored to specific applications. The resulting products are destined for applications worldwide in industrial drive technology, pump and fan controls, in welding and for soft starters.

Summarizing it can be said that the challenges of the market are exceptional, but its growth curves are too. Customers can only be offered the right solutions for their markets if one listens carefully to what their needs are. Generating standard products from custom solutions means letting all customers benefit from the latest chip and module technologies, true to the motto your success is our success.

Green products that meet RoHS directives will be qualified and available from Tyco from mid-2005.

http://em.tycoelectronics.com

"A Necessary Evil?"

By Chris Ambarian, iSuppli Corporation

The 20th annual Applied Power Electronics Conference and Exhibition (APEC) in Austin this year might well be remembered as the turning point for market recognition of the importance of power electronics.

I recently had the occasion to be hanging out with a couple thousand power electronics industry people in Texas, when I had an almost out-of-body observation of us as a group, and the observation has some pretty significant implications for us. So if you'll indulge me, I'll share it.

I was sitting in one of several technical sessions, when I realized that I'd heard something about 3 times at the conference already: "The power supply is a necessary evil." It was a power engineer, casually parroting the attitude(s) of his customer base—attitudes that fundamentally drove his activities. I thought about that. "A necessary evil." Hmm. It sounded like things I've heard for years in the consumer part of the motor drive market as well. "A necessary evil…"

How did we get to this point, a place where what we're working on is "a necessary evil" ? And by the way, who wants to work on a necessary evil??? How exciting is that?

I have developed products for and sold into this market for about two decades now, so I can certainly understand where this attitude was developed. We developed it in speaking with customers who knew little about power, and for whom it was not a critical function. In other words, they didn't value power. They told us that it was a necessary evil, and in the absence of any compelling evidence to the contrary, we believed it. Heck, it may have even been true.

Now mind you, I'm a realist. I'm not going to tell you that the emperor has some great clothes, and ask you to just believe. It probably hurts the brain just to imagine going to your customer(s) and saying anything other than "okay, here's what we're doing to drive cost out of our function." But in the same breath, I'd like to ask a question: How valuable can "a necessary evil" ever be?

Business is all about knowing what your value is, and then getting paid that value. You create value and articulate your value to your customers based on this self-image of what your value is – it's the basis of what we direct our R&D engineers to create, it's what drives our marketing and business management people, it's all that becomes available as tools and messages to drive our sales people. If you accept the notion that you are nothing more than "a necessary evil," what kind of conversation do you think you're going to be able to have with potential customers?

Ironically, an equipment system designer's freedom to design is now bounded by (or better, enabled by) the kind of power systems available to him or her. This is truer today than it has been for the last 20 years that I know of. One significant change is that power is now a critical function, a rate-determining step (or at least a cost- and space-determining one). Another fundamental change in the landscape is the set of possibilities created by the convergence of power, data processing, and communication. The competitiveness and differentiation of the end system are tightly interwoven with the power system. You can't easily design a smart network of drives to run your factory in a revolutionary way if your drives can't be communicated with easily. The more work that we do to facilitate new possibilities for the designer, the more they are going to be able to value our product. Of course, this requires that we seek out designers at a level above the "same thing for 10% less than last year" level.

I would propose that it would be much more powerful for us as suppliers (and for our customers as well) if we were to stop blindly accepting the "necessary evil" image as our own, and to adopt a new self-image: "Power supply as enabler." "Motor drive as enabler." "By using this product or this approach, you can make a much more valuable end product." This is a much broader perspective, where "value" is a subject to be explored between you and the customer, not just dictated to us as being "lower cost" (which is only one side of what's potentially valuable). Sure, "more valuable end product" could simply be one that costs 10% less next year – but it could also be a product that does things not possible before.

In the end, this is all just my conversation to create a new possibility for how our portion of the industry could work, and how we might become much more profitable. You don't have to accept it. You can continue to do business in the existing paradigm. At least we know what that's like.

www.iSuppli.com

Earth Leakage Control in Solar Inverters

Evolution of photovoltaic cell production

Kyoto protocol committed different national governments to increase the production of green energy and to make a grant to every initiative for this promotion.

By Stéphane Rollier, Bernard Richard, Martin Keller, Lem
In collaboration with Hans Welschen, Philips Lighting

Governments have decided to support every effort oriented for energy saving, and for sustainable energy. This can explain the revived interest in solar energy.

Solar energy had already been a source of interest some years ago due to profitability analysis. Indeed, the investments incurred were significantly higher, as compared to the usable energy generated. That was until this renewed commitment and today's electronic technologies, which made this energy source a more profitable one.

For instance, in Europe, 410.5 solar MWp have been installed during 2004 representing 69.2 % of growth vs. 2003. Photovoltaic market is led by Germany followed by Japan and USA. Spain confirms nevertheless, the increase in importance of its photovoltaic market (11.8 MWp installed in 2004 vs. 6.5 MWp in 2003).

Confirming this general trend is the evolution of the worldwide photovoltaic cell production. It has been produced 1194 MWp last year (representing about 400,000 systems with a mean capacity of 3 kWp), that is to say 450 MWp more than in 2003: A growth rate of more than 60%! More than half of the photovoltaic cell production has been realised in Japan, the remaining coming mainly from Europe (26%), USA (12 %) and rest of the world (12%) in 2004.

A solar panel is comprised of an array of solar cells, connected together in series and parallel. These cells are then encapsulated in glass and plastic. To allow for mounting on rooftops, usually the panels themselves are enclosed in aluminium or steel framing (Figure 1 and 2).

Figure 1. Cells.

Figure 2. Solar Panels.

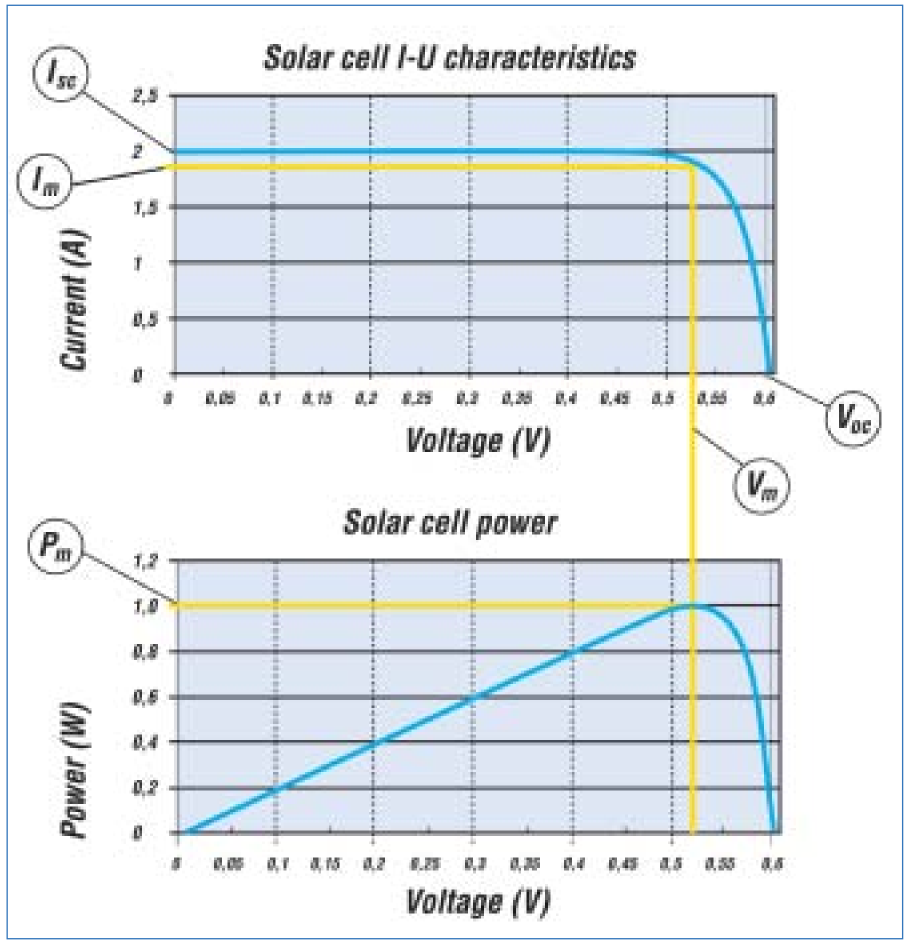


Figure 3.Cell I-U characteristics/Solar cell power.

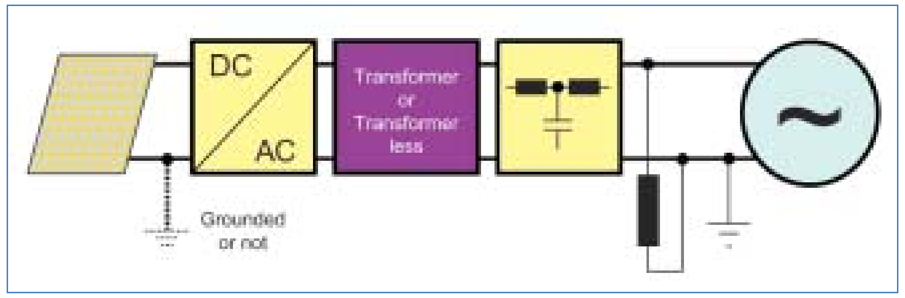


Figure 4. Solar panel system.

A variety of cells are available today, and in general today's panels generate DC current between 7 and 7.5 A. Other models also exist (Thin-film solar modules for example) generating different current levels. The maximum solar cell power is defined by the working point of the cells, which correspond to a certain voltage (Vm) and current (Im) (Figure 3).

When cells are short-circuited, a constant current is provided (with a value depending of the light intensity). A voltage expressed as Voc, approximately 0.6 Volt, is present when cells are open circuited. The total voltage Voc in a full solar panel is dependent on the number of cells used in the panel. Often used numbers are 36, 54 or 72 cells, resulting in 22, 33 or 44 Volts Voc.

Several panels can then be connected in series and/or parallel until reaching the required power and/or the maximum allowed voltage. A Voc of <120 V (at standard conditions +25°C) is considered as safe to touch.

During normal operation a special control routine keeps the solar panel in its maximum power operating point. A panel of e.g. 36 cells will then produce a voltage of approximately 14 -18 Volt, depending on the temperature.

To optimise the power delivered, it is common to use special software and dedicated electronics to control the operating point of the cells.

This generated electricity can then be used in 2 ways: For autonomous installations, remote from the distribution grid, charging a battery. This is commonly referred to as the off-Grid system (30 % of the market in 2002) For feeding back into the grid as green electricity. This "Grid connected" system will be described hereafter (70 % of the market in 2002).

The connection of the solar array through the inverter to the grid can be realized either by using a transformer or directly without transformer, so called transformer-less, meaning without galvanic isolation (Figure 4).

The transformer can be a conventional 50/60 Hz type between the inverter and the grid or a high frequency transformer on the DC part of the inverter. Transformer-less designs have become a general trend in such applications to enhance overall efficiency and lower cost.

High frequency transformers have the advantage of lower weight and a smaller volume. Compact and lightweight designs play an equally important role. There is also a question of power. Higher generated power requires large transformers, leading to larger installations and higher costs, and this explains the interest in transformer-less configuration.

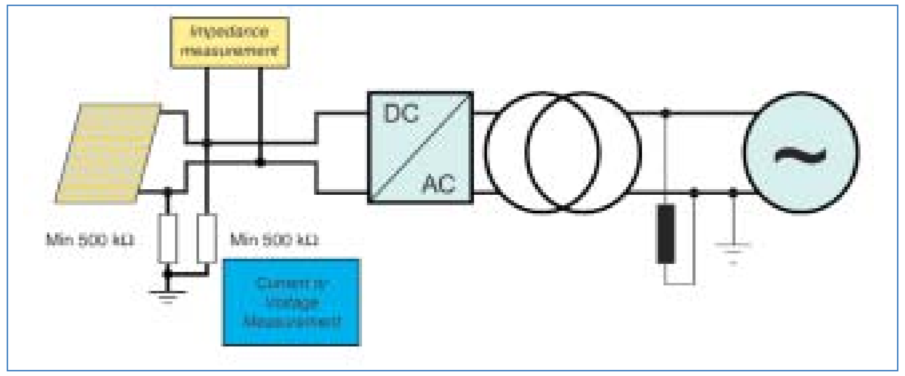


Figure 5. Photovoltaic (PV) array floating with transformer configuration.

Figure 6. LEM CT series of differential current transducers.

Whatever the system used, be it with transformer or transformer-less, the main concern is to ensure the safety of the entire system, and more importantly the safety of any human contact with the entire system.

As a starting point, the metal frame of the solar panel can be grounded. For larger systems that is mandatory from the building installation code but also useful in mountainous areas due to the likelihood of lightning strikes (Switzerland, Austria for example).

In the US, connection to ground for the DC part of the system is mandatory and when an electrical fault occurs, this connection must be interrupted as well as the entire installation disconnected from the grid. There is a chance that the ground connection will not be mandatory after the next installation code release.

In Europe it is free to connect or not the DC system to ground, however, with a transformer-less inverter the DC system will be connected to ground (via neutral of the grid) through the inverter electronics. The array may not have another connection to ground to avoid DC ground currents.

In Germany and some other countries, the insulation from ground must be tested before the inverter may connect to the grid and start operation. By having the solar panel DC voltage floating in respect to ground, a first layer of safety is insured; touching at a single point will not immediately create a hazard.

A system is defined as floating when its resistance to ground is > 1kOhm/Volt with a minimum of 500 kOhm (Figure 5).

Although the Photovoltaic (PV) array can be connected as floating, the whole system will be floating depending on the maximum possible voltage of the PV array (for a resistance to ground already installed).

Measuring a possible leakage to ground is not possible without closing the current path e.g. by means of a resistor. This is true for both, inverters with transformer and transformer-less inverters because the latter has to be disconnected from the grid (by means of relay contacts) during the measurement.

Building installation code requires a RCD (Residual Current Device) type B for transformer-less PV-systems. Type B, the version that is also sensitive to DC currents, is necessary because a ground fault in the PV array may generate a DC current. Disadvantage of such RCD is the high sensitivity for disturbing pulses and the fact that they have to be reset manually. Incorporating this function in the inverter will have some advantages.

1) The function can be combined with the required array insulation measurement. 2) The sensitive measurement of small DC currents can be done before the inverter starts operating and high frequency switching signals could disturb the measurement. 3) The function can be made with automatic reset after a nuisance trip. 4) Last but not least, the ac+dc ground current protection level can be set for person safety (30 mA) while accepting a larger stationary ac ground current due to the capacitance between the solar cells and a ground plane in the vicinity. This current is allowed to be as large as 300 mA. A sudden change of 30 mA can lead to disconnection. A differential current measurement can be used for this function.

Another requirement for the grid connection is not to supply DC current into the grid. The accepted level differs from country to country but often seen requirements are 0,5 % or 1 % of the nominal current output. Thusly, the DC offset of the current transducer used in the control loop of the inverter should be as low as possible. Also, DC offset as a result of the IGBT's switching delay in the inverter is then to be avoided or as small as possible.

The consequence of this DC offset can be a saturation of the network distribution transformers. To decrease this DC offset, new topologies of inverters are ongoing. Also, the Total Harmonic Distortion (THD) of the output current has to be limited to a value defined by the different utilities. This is different according to the country concerned as no real value has yet been agreed on.

When these problems occur, a circuit breaker is usually used to disconnect the solar installation from the grid.

LEM's CT range (Figure 6) has been specifically designed to meet those criteria in modern solar topologies, in response to increasing market demand in providing a compact, low cost and reliable solution based on a current transducer.

Traditionally used devices (such as RCD) are commonly known devices, but are rather bulky, and not really adapted to the new requirements in solar inverters. They also might fail, considering that both DC and AC currents must be monitored with spectral components up to 30 kHz induced by high speed IGBT switching.

Impedance measurement can also be a way to check the insulation level and to detect an earth fault in the solar panel. To achieve this, three measurements are mandatory; Impedance measurement, resistance ratio change + impedance measurement (to detect symmetrical fault to the earth in the solar panel), and voltage measurement. But this is not easy to do.

For a PV floating, and linked to the grid through a transformer, specific requirements do not yet exist. However, the impedance measurement between the PV array and the ground before start-up could be the tool to prove the real floating point (requirement is for 1 kOhm/V with a minimum of 500 kOhm/V). To measure this value, a voltage or current transducer can be used.

For a PV connected to earth, and linked to the grid through a transformer, impedance measurement and/or differential current measurement are possible to prove the ground connection.

The LEM CT series differential current transducers measure safely, currents with nominal values of 100mA, 200mA and 400mA, providing a linear voltage output of 5V at nominal current. Response time is better than 20ms at 80% and 60ms at 90% of peak current.

The use of a high technology ("flux-gate") has been the solution to these requirements, especially to achieve the accurate measurement of very small DC or AC currents.

DC and AC components up to 30 kHz can be measured. The CT products are PCB mountable, small size, lightweight components with an aperture for insertion of earth leakage wires.

Generally, the CT range is also suitable in other applications, including medium power inverter applications. Supported by international agreements to reduce the volume of carbon dioxide produced by fossil fuels, and by the grants allocated by the various governments, statistics forecast some 4500 MWp which could be produced by solar energy by 2010 in Europe. This assures electrical measurement requirements will be practiced more and more to ensure quality and safety.

www.lem.com

High Noise Immunity High-Side Gate Driver IC

The HVIC can replace pulse transformer

The monolithic high-side drive poses a fascinating challenge for system designers. Their goal is to find a way to drive the switching devices that is as simple as possible—without suffering from lack of speed or, wasting large device area—while maintaining low-voltage control capability. And they must do this using only the outputs of a micro controller or any other control circuits working in the 3.3V or 5V supply.

By Jong-Tae Hwang, Senior Engineering Manager, Fairchild Semiconductor

This article introduces a high-voltage process for the high-side gate driver IC, the conventional high-side driver topology, and addresses the driver's problems. Also, it will briefly explain a new proposed circuit technique that can solve common challenges faced by designers by the conventional high-side gate driver IC Such as critical malfunction of the HVIC. In addition to explaining how to solve such a malfunction, the robustness issue will be explored through the design and some experimental results will be presented.

High Voltage Junction Terminated Process

It is difficult, and not area-effective to the design, to make every device in the high-side gate driver circuit endure high voltage up to 600V. Actually, only few tens of volts are required to drive the gate of the power MOSFET and IGBT. Thus, the high-side driver itself does not require a full high-voltage range operation. The offset voltage of the high-side driver, however, must be guaranteed up to the maximum allowable voltage. To satisfy this high offset voltage constraint, the high-side circuit is incorporated in the cathode area of the high-voltage diode.

The high voltage diode of a device such as Fairchild's HDG4 625V rate high-voltage process is comprised by P-substrate, which has high resistivity, N-type buried layer and low doped N-type epitaxial layer. These layers are designed to meet the 625V break-down voltage requirement. To horizontally isolate this diode from other devices, some isolation layers are needed. Since the cathode of the diode is made of N-epitaxial layer, P-type isolation is required. Unfortunately, P-type isolation (PISO) layer cannot guarantee 625V isolation rate.

The HDG4 process uses additional high-voltage isolation (HVI) structure, which is based on the RESURF technique and N-epitaxial layer. Owing to the HVI structure, the PISO layer between high-side circuit region (the cathode of the high voltage diode) and the HVI structure is fully depleted and it is possible to prohibit a high electric field from forming in the PSIO layer. Of course, it is not an easy job to accomplish the high-voltage junction termination. This phenomenon depends on the N-buried layer concentration, on its location in the HVI, and on the depth and the resistivity of N-epitaxial layer.

Once this design difficulty is overcome, the process gives a good area-effective LDMOS. The HVI structure in this example can be the drain of the LDMOS, and the MOS channel can be implemented in the PISO layer. Since the drain of the LDMOS has the same structure with the HVI, LDMOS can be implemented without need for extra area. This is a dramatic leap of the modern high-side gate driver IC process since the conventional process requires an additional area for the LDMOS.

High-Side Driver Configuration

Figure 1 shows a conventional high-side gate driver circuit configuration. The conventional high-side gate driver IC typically is composed of following six parts:

Input detection logic

Edge pulse generator

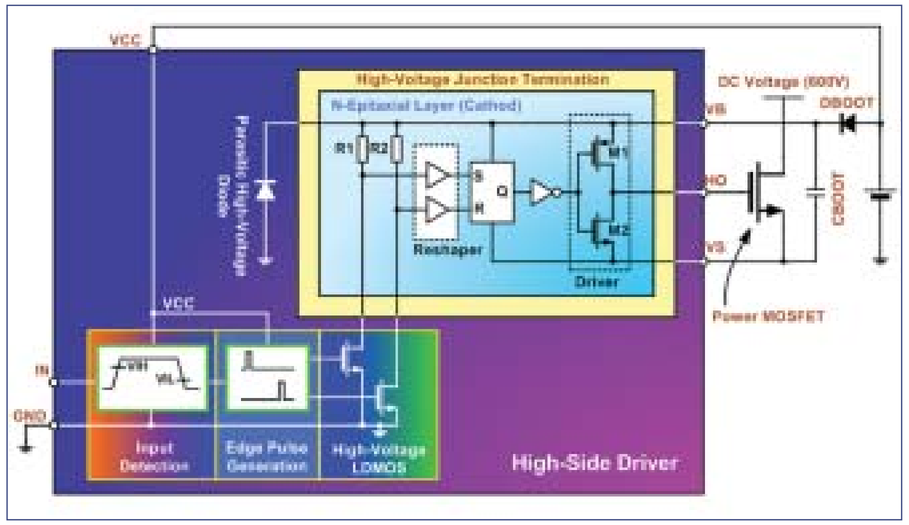


Figure 1. Conventional high-side driver configuration.

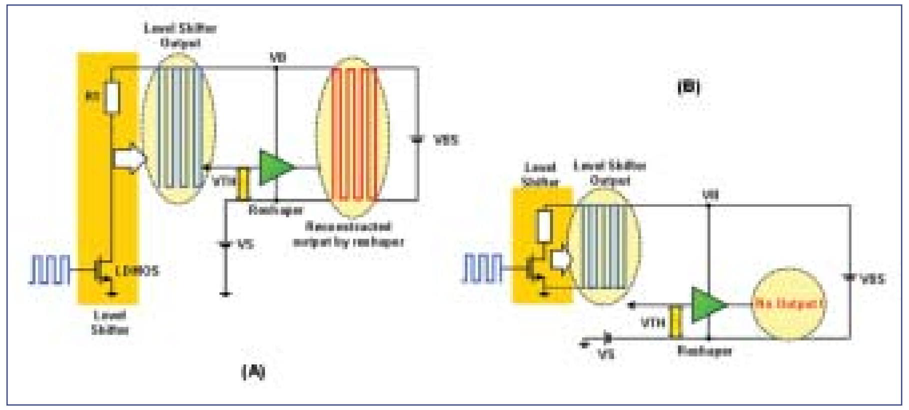


Figure 2. Allowable negative VS problem: (A) VS >0, and (B) VS < -VTH.

Level shifter
Reshaper
S-R latch
Gate driver

Before transferring the input signal to the high-side drive circuit, through the level shifter circuit by high-voltage LDMOSs with R1 and R2, the input detection circuit determines the input signal with the logic triggering levels, VIH and VIL. From this signal, two kinds of short pulses are generated by the edge pulse generation circuit with respect to the rising and falling edges. The high voltage LDMOSs converts these short-pulse voltage-signals to the current-signals, and R1 and R2; remaking short-pulse voltage-signals at the high-voltage region. The "reshapers," which are a type of a comparator with a given threshold level, amplify the signals to swing between VB and VS. These signals determine the state of the S-R latch. By virtue of the S-R latch, the low-side input command can be transferred to the high-side region with only edge information. Finally, the output driver composed by M1 and M2 drives an external high voltage power device with appropriate current driving capability.

High Dv/Dt Noise Warning

A pulsating noise, however, also affects the state of the S-R latch. High dv/dt noise, especially, is the most dangerous type for this kind of pulse driven HVIC. Assuming the parasitic capacitance, Cp, of the LDMOS seen at the drain is 2pF and a noise which has dv/dt of 50V/nsec is applied to the VS node. This noise is coupled to VB by the bootstrapping capacitor, CBOOT. For the LDMOS drain voltage to follow the fast changing VB voltage, Cp must be charged with large current. The current can be estimated using the following equation:

I=Cp*dv/dt

The charging peak current due to high dv/dt noise reaches 100mA. The large charging current makes enough voltage drop on R1 and R2 to abnormally trigger the S-R latch. If there is easy and effective method to remove this noise perfectly, that would be the best solution to make the HVIC free from the malfunction. However, it is impossible to suppress the noise to be coupled to the HVIC. Therefore, it is very challenging work to increase the immunity of the HVIC on the noise.

Allowable Negative Output Voltage

VB and VS are the highest and lowest voltage of the high-side driver, respectively. The voltage difference, VBS, is almost constant by the bootstrapping capacitor, CBOOT, and a bootstrapping technique. VS, however, depends on the half-bridge output, since VS is supposed to be connected to the source of the external MOSFET or the emitter of the external IGBT. An ideal HVIC must operate regardless of the VS voltage situation. For a real HVIC, however, VS heavily affects the operation. Some examples of the HVIC operation versus VB are depicted in Figure 2 as described in the following (A) and (B):

(A) VS > 0:

The reshaper has the threshold level, VTH. Thus, only when the level shifter's output swing is below this level, is the signal recognized by the reshaper. If Vs is higher than 0, the level shifter's output swings enough to touch VTH level. Consequently, there is no problem for normal HVIC's operation.

(B) VS<-VTH:

In this case, VS is negative. Accordingly, the absolute VB voltage is lower than case of (A). Therefore, the maximum output swing of the level shifter is limited within VB and ground and,as a result, the reshaper cannot catch the level shifter's output and the S-R latch state cannot be updated.

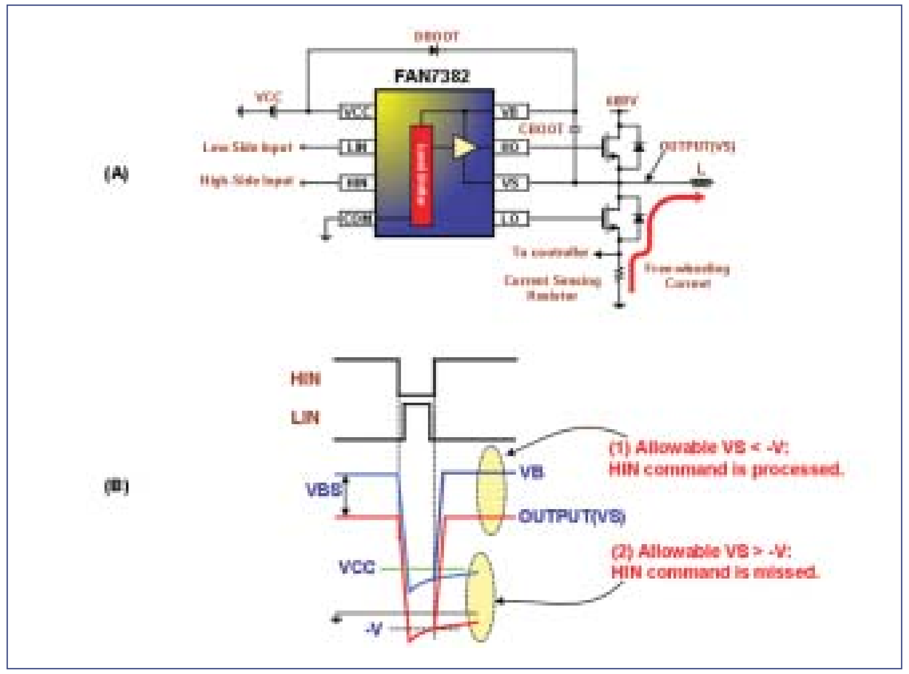


Figure 3. Allowable negative VS problem at Inductive Load Application: (A) A typical half-bridge configuration, and (B) Command missing due to the lack of allowable negative VS.

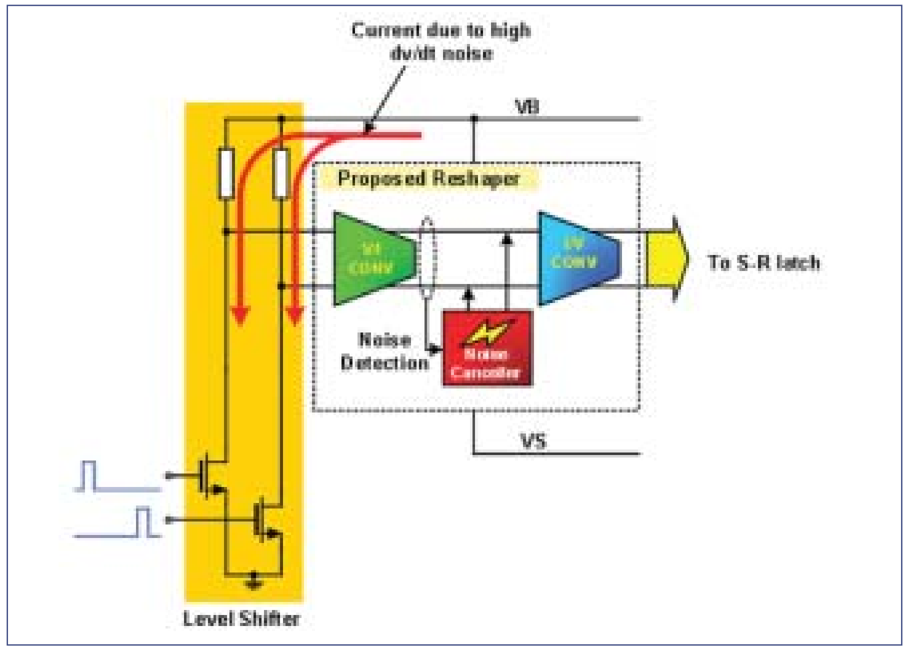


Figure 4. Proposed reshaper configuration which provides a noise-canceling function and enhances allowable negative VS range.

In the case (B), the allowable negative VS voltage is –VTH since the HVIC does not respond below this level. This malfunction can be frequently observed in the real application since there are so many chances for the HVIC to drive inductive loads. Figure 3(A) is very familiar half-bridge circuit using HVIC (where FAN7382 is a HVIC, which has a low-side driving circuit as well).

This circuit drives an inductive load, L, and also has a current-sensing resistor. The switching inputs are shown in Figure 3(B). When HIN is high, a high-side external power MOSFET, whose drain is connected to 600V line, is turned on and supplies current to the inductor load. Even if LIN is high, and the low-side MOS is turned on some times later, the current flows from ground level to the load. Accordingly, output voltage (VS) becomes negative. Furthermore, the sensing resistor makes the output into a deep negative voltage. Following this, HIN becomes high again. What is wanted from the HVIC is to make the output become high. The HVIC, however, misses the command if the allowable negative VS voltage is higher than –V, as depicted in the figure.

Proposed HVIC Circuit

Today there are two goals to achieve with the HVIC: (1) to enhance the noise immunity for the high dv/dt noise, and (2) to extend allowable negative VS voltage. To achieve these goals, a new reshaper circuit is proposed (as shown Figure 4.)As explained previously, the allowable negative VS limitation comes from the predetermined threshold level of the reshaper. It is needless to say that it is possible to increase that limitation by increasing VTH level.

Such design, however, makes HVIC too sensitive to the noise.The output of the level shifter swings from VB to ground direction, whereas the conventional reshaper is operating in the VBS supply voltage. Accordingly, the detection of the level shifter's output by the reshaper is determined by the VB voltage level and VTH of the reshaper.In this new approach, a V/I (Voltage-to-Current) converter is used to detour around the VTH problem. The V/I converter converts the level shifter's outputs to the current information. Since the only role of this circuit is conversion, VTH is not considered. Next, an I/V converter reconstructs the voltage signal, which swings between VB and VS supply rails from the current outputs of the V/I converter. After these sequences, the amplified signal is sent to the S-R latch. Owing to the V/I converter, the allowable negative VS voltage is no longer governed by the threshold level, VTH, of the reshaper. As long as VB voltages are large enough to meet the requirement

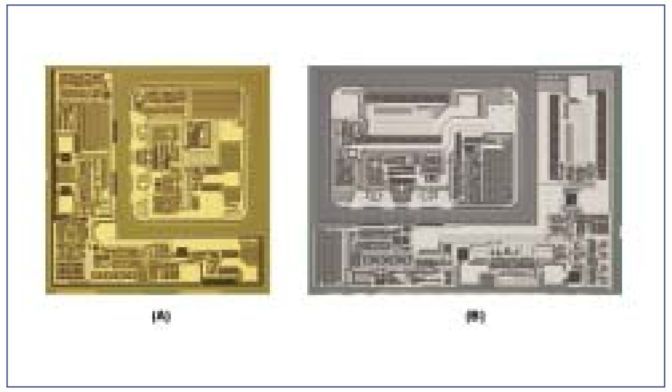


Figure 5. Micro-photo of the designed half-bridge driver: (A) FAN8380 which provides internally fixed 100nsec dead-time and is suitable for the ballast and low frequency PWM based half-bridge control, and (B) FAN7382 whose current driving capability is 350mA/650mA (sourcing/sinking current) is a general purpose high/low-side gate driver IC.

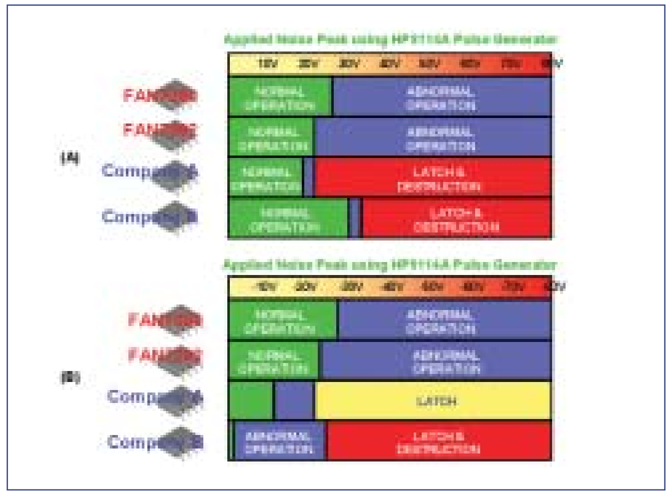


Figure 6. Robustness test results: (A) Positive Pulse Noise Test, and (B) Negative Pulsating Noise Test.

voltage for the V/I converter and to make the level shifter to work, HIN input is never lost.

Another merit of V/I and I/V conversion is that it is easy to sense noise and to attach a noise canceling circuit. Because high dv/dt noise is added on to VB line via the CBOOT, noise is commonly applied to all the elements attached to the VB line. Thus, for the common-mode noise, which has high dv/dt, the V/I converter gives same outputs. Whereas, the V/I converter outputs are different from each other for normal operation, as only one of two LDMOSs operates at a normal level shifter operation. Thus, it is not difficult to determine whether the V/I converter output is due to noise or not. Once the noise canceller recognizes a common-mode noise intrusion, it absorbs the current outputs of the V/I converter.

Owing to its unique topology, Fairchild HVIC demonstrates good noise immunity against high dv/dt noise up to 50V/nsec and guarantees an extended negative operation. At VBS=VCC=15V, the proposed method satisfies approximately –10V operation. Figure 5 shows the micro-photos of two new HVICs also from Fairchild: the FAN7380 and FAN7382, which are designed using the HDG4 process.

Robustness

In general, the HVIC drives high-voltage and high-current switching devices. Resulting high-voltage peaks, noise and EMI can cause the HVIC to malfunction, sometimes leading to destruction. Therefore, considering the actual usage of the HVIC, the robustness is the key issue.

To test the robustness of the designed HVIC, positively pulsating noise is added to VBS in series and negative pulse is applied to VB line using the HP8114A's pulse generator. During the test, VBS is constantly biased to 15V. The test was performed by changing the output of an HP8114A programmable pulse generator from 0V to 80V. The HVIC responses for the applied noise power can be sorted into the following four categories:

(1) Normal Operation: The HVIC is normally controlled by the command as a user intends.

(2) Abnormal Operation: The HVIC skips and misses the input command in a medium noise peak. For a high noise peak, the HVIC output is fixed to the lowest level.

(3) Latch Operation: The HVIC output is fixed to the lowest level and large current flows toward the HVIC. But, if reducing the applied noise power, the HVIC is recovered and works normally.

(4) Destruction: The HVIC is damaged permanently. The HVIC is never recovered; in a worse situation, the package gets cracked or explodes.

As shown in Figure 6, the FAN7380 and FAN7382 show an abnormal operation at high-voltage peak. However, the test vehicles are not destroyed and do not fall into the latch state. This means that the designed of these two devices is very robust for high-energy pulsating noise.

The HVIC design based the new technique presented in this article demonstrates good noise immunity and extended allowable negative VS voltage swing. Furthermore, this effective HVIC process offers a robustness which can overcome even difficult situations.

The HVIC itself is significance because it can replace the bulky pulse transformer using silicon technology. But the more important factor to remember is that a power-system-on-a-package is possible with HVIC because it is built on a cheap familiar silicon wafer. For the success of the power-system-on-a-package such as SPM (Smart Power Module) and IPM (Intelligent Power Module), the high-side and low-side gates driver IC's role is very important and the proposed HVIC offers a workable solution for designers.

www.fairchildsemi.com

International Exhibition & Conference for
POWER ELECTRONICS
INTELLIGENT MOTION
POWER QUALITY
07 - 09 June 2005
Exibition Center Nuremberg

ABB Switzerland Ltd., CH
Booth 12-408 / 12-503
URL: *www.abb.com/semiconductors*
IGBT modules

Advanced Power Technology, USA; Europe, F
Booth 12-416
URL: *www.advancedpower.com*
MOSFETs, IGBTs, Rectifier

Ansoft GmbH & Co. KG, D
Booth 12-308
URL: *www.ansoft.com*
Simulation software

Apex Microtechnology Corporation, USA
Booth 12-526
URL: *www.apexmicrotech.com*
Power Operational Amplifiers, PWM Amplifiers

Coilcraft Europe Ltd. GB
Booth 12-111
URL : *www.coilcraft.com*
Inductors, Transformer, surface mount

CT Concept Technologie AG, CH
Booth 12-102
URL: *www.IGBT-Driver.com*
IGBT driver boards

curamik electronics gmbh, D
Booth 12-118
URL: *www.curamik.com*
Ceramic substrates

Danfoss Silicon Power GmbH, D
Booth 12-120
URL: *www.danfoss.com/siliconpower*
Customized Power Modules

EPCOS AG, D
Booth 12-436
URL: *www.epcos.com*
Capacitors, Inductors, Varistors, Passives

Eupec, D
Booth 12-501
URL: *www.eupec.com*
MOSFET Modules, IGBT, GTO, Power Solutions

Eurocomp Electronik GmbH, D
Booth 12-416
URL: *www.eurocomp.de*
Distributor for APT and Microsemi

Fairchild Semiconductor, USA
Booth 12-601
URL: *www.fairchildsemi.com*
MOSFET, IGBT, ICs, Opto

Ferraz Shawmut, F
Booth 12-230
URL: *www.ferrazshawmut.com*
Protection, Cooling

Floeth Electronic GmbH, D
Booth 12-324
URL: *www.floeth-electronic.com*
IGBT-Driver-Controller

Fuji Electric GmbH, D
Booth 12-304
URL: *www.fujielectric.com*
IGBT Modules

Infineon Technologies AG, D
Booth 12-501
URL: *www.infineon.com/power*
MOSFET, IGBT, ICs,

International Rectifier, GB
Booth 12-201
URL: *www.irf.com*
MOSFET, IGBT, ICs, Modules, Power Solutions

Isabellenhütte Heusler GmbH, D
Booth 12-627
URL: *www.isabellenhüette.com*
Precision Resistors, ASIC for monitoring

IXYS Semiconductor GmbH, D
Booth 12-302
URL: *www.ixys.com*
MOSFET, IGBT, ICs, Modules

LEM SA, CH
Booth 12-401
URL: *www.lem.com*
Current/Voltage Transducers

Microsemi Corp., USA
Booth 12-416
URL: *www.microsemi.com*
ICs for power control

MITSUBISHI ELECTRIC EUROPE B.V., D
Booth 12-320
URL: *www.mitsubishichips.com*
IGBT Modules; GTO

National Semiconductor, D
Booth 12-349
URL: *www.national.com*
Power Management ICs

NEC Electronics (Europe) GmbH, D
Booth 12-411
URL: *www.ee.nec.de*
MOSFETs

Ohmite Manufacturing Co., USA
Booth 12-606
URL: *www.ohmite.com*
High Voltage Resistors

Power Electronic Measurement, GB
Booth 12-546
URL: *www.pemuk.com*
Rogowski Current Transducers

Power Integrations, USA
Booth 12-345
URL: *www.powerint.com*
Power Management ICs

Powersem GmbH, D
Booth 12-218
URL: *www.powersem.de*
Power Modules

Power Systems Design Magazines
Booth 12-239,
URL: *www.powersystemsdesign.com*
The European Power Magazine

SanRex Europe GmbH, D
Booth 12-429 / 12-237
URL: *www.sanrex.com*
Power Modules

SEMIKRON International GmbH, D
Booth 12-310
URL: *www.semikron.com*
MOSFET, IGBT, GTO, Modules, ICs, Power Solutions

Spoerle, D
Booth 12-424
URL: *www.spoerle.de*
Distributor

STMicroelectronics GmbH, D
Booth 12-106
URL: *www.st.com*
MOSFETs, Rectifiers, IGBTs

Texas Instruments, F
Booth 12-229
URL: *www.ti.com*
ICs, Power Management, Modules

Thermacore Europe Ltd., GB
Booth 12-622
URL: *www.thermacore-europe.com*
Thermal Management

Transim Technology Corporation, USA
Booth 12-444
URL: *www.transim.com*
Design and Simulation Software

Tyco Electronics, D
Booth 12-421
URL: *http://em.tycoelectronics.com*
Power Supply, Power Modules

Vishay Electronic GmbH, D
Booth 12-547
URL: *www.vishay.com*
MOSFETs, Ceramic Components

Würth Elektronik eiSos GmbH & Co. KG, D
Booth 12-628
URL: *www.we-online.de*
EMC and Inductive Components

Zetex PLC, GB
Booth 12-208
URL: *www.zetex.com*
ICs, MOSFET, Power Management

Power Factor Correction-on-a-Chip

Saving board space and reducing component count

A new power factor correction IC that can help designers to halve the size of their control boards in applications with power ratings from 75W to 4kW

By Stephen Oliver, International Rectifier

From industrial applications to consumer electronics, and from home appliances to office equipment, designers of modern AC-DC SMPS circuits are under pressure to develop high performance, high power density circuits. And with commercial, legislative and environmental issues placing power factor correction (PFC) implementation at the top of the agenda, these designers are looking for solutions that will minimise component count, simplify board layout, and reduce board space. It is in the context of these demands that International Rectifier has developed its new IR1150 family of µPFC (microPFC) devices for AC-DC power factor correction (PFC) circuits.

The concept of the IR1150 is to provide an integrated PFC controller, on a single, compact SO-8 IC, that can be used across a wide application voltage range. The key to the new device is the One Cycle Control (OCC) technique employed. OCC is a patented technique designed to combine the performance of the continuous conduction mode (CCM) technologies traditionally employed in higher power PFC designs with the simplicity, reliability and low component count of the discontinuous current mode (DCM) approach conventionally used with lower power applications. Power factor is the relationship between AC voltage and current waveforms and is a measure of "power quality" that affects the efficiency of electrical transmission networks. With unity PF as the ultimate goal, the IR1150 is designed to deliver a 0.999 power factor with only 4% total harmonic distortion.

IR1150 Overview

Figure 1 shows a schematic diagram of the new IR1150 IC, which is intended for boost converters for PFC operating at fixed frequency in continuous current mode. By using the OCC method, the need for an analogue multiplier, AC input voltage sensing or a fixed oscillator

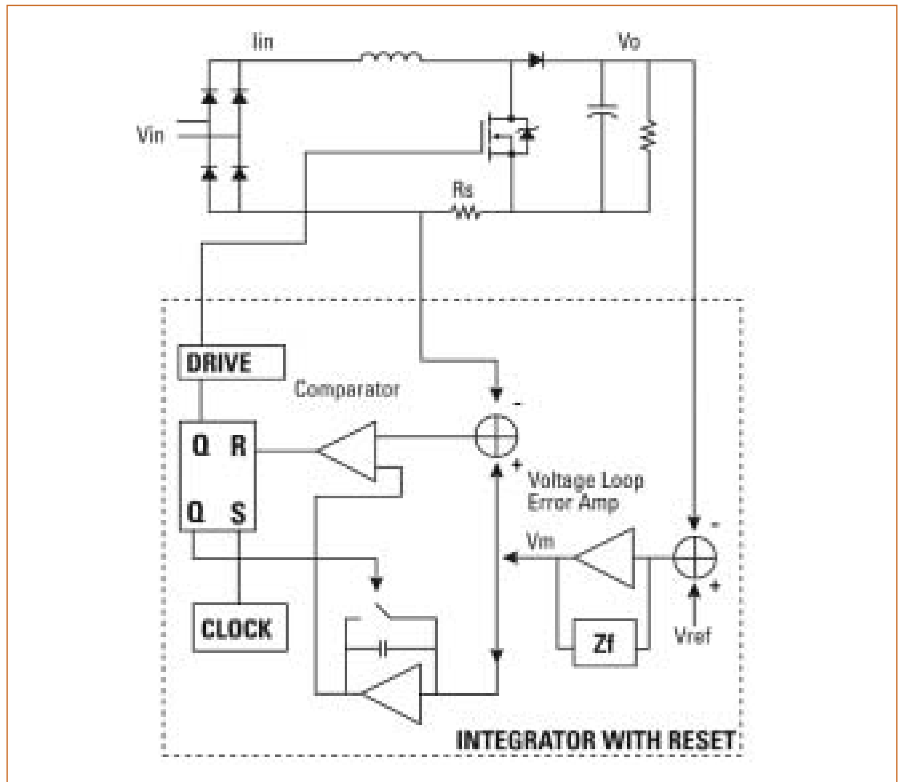


Figure 1. Shemaţic diagram of the IR1150 IC.

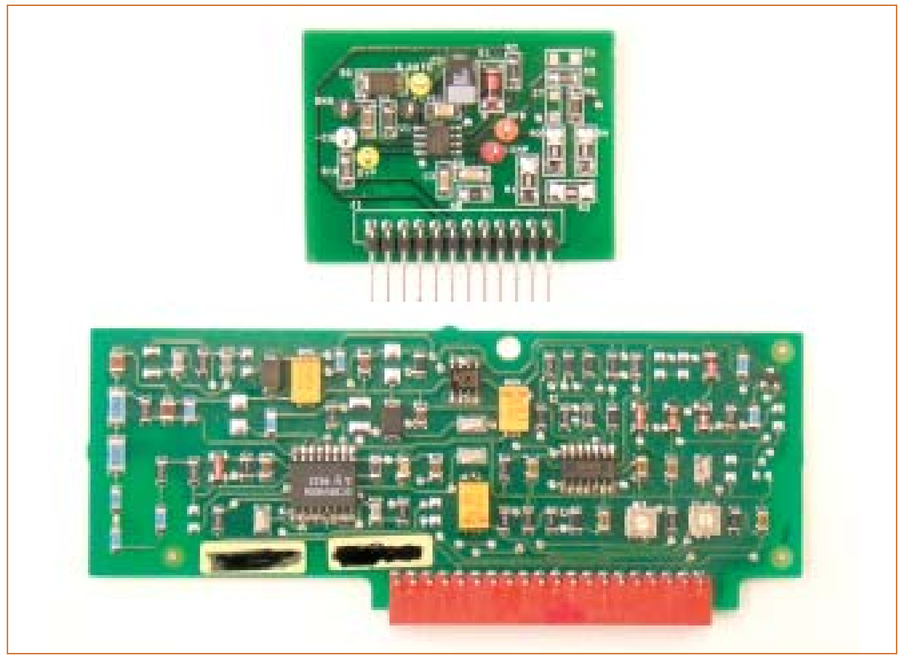


Figure 2. IR1150 implementation for a 1kW PFC compared to the traditional multiplier-based solution.

ramp (as used in conventional CCM-based designs) is completely eliminated.

Instead, IR's OCC uses a proprietary 'integrator with reset' circuit. In this case, the output of the error amplifier is integrated over each clock cycle to generate a variable-slope ramp. This ramp is then compared with the error voltage and subtracted from the current sense signal to generate the PWM gate drive. In a 1kW example, this control method requires 40% fewer resistors and 50% fewer capacitors than traditional multiplier techniques and delivers a unified control solution that is adaptable to various topologies for both leading and trailing edge modulation.

Figure 2 shows the new IR1150 implementation for a 1kW PFC compared to the traditional multiplier-based solution. The IC operates with essentially two loops, an inner current loop and an outer voltage loop. The inner current loop sustains the sinusoidal profile of the average input current based on the dependency of the pulse width modulator duty cycle on the input line voltage, to determine the analogous input line current.

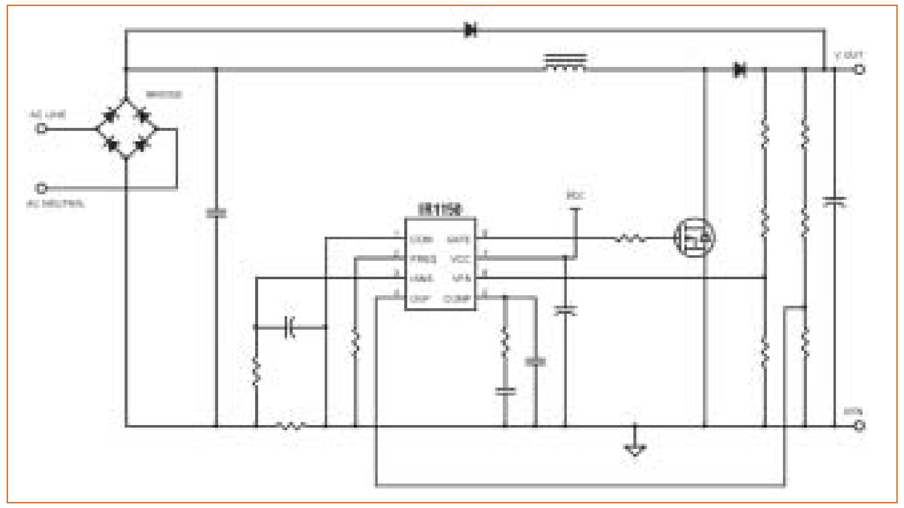


Figure 3. IThe IR1150 IC being used in a typical PFC circuit.

Thus, the current loop exploits the embedded input voltage signal to command the average input current following the input voltage. This is true so long as operation in continuous conduction mode is maintained.

The outer voltage loop controls the output voltage of the boost converter and the output voltage error amplifier produces a voltage at its output. This voltage directly controls the slope of the integrator ramp, and therefore the amplitude of the average input current. The combination of the two control elements controls the amplitude and shape of the input current so as to be proportional to and in phase with the input voltage.

Integrated protection and sleep functions

In any PFC design, implementing protection must be a design priority, and in the case of the 1150, much of the required protection has been integrated into the IC. This integrated functionality includes protection from system level overcurrent, overvoltage, undervoltage, and brownout conditions.

Open Loop Protection (OLP), for example, prevents the controller from operating if the voltage on the feedback pin has not exceeded 20% of its nominal value. If for some reason the voltage control loop is open, the IC will not start, avoiding a potentially catastrophic failure. As soon as the VCC voltage exceeds this threshold, provided that the VFB pin voltage is greater than 20%VREF, the gate drive will begin switching. In the event that the voltage at the VCC pin should drop below that of the UVLO turn off threshold, VCCUVLO , the IC then turns off, gate drive is terminated, and the turn on threshold must again be exceeded in order to re start the process.

A dedicated programmable Over Voltage Protection pin (OVP) is available to protect the output from overvoltage. If the output voltage exceeds the set OVP limit, the gate drive will be disabled until the output voltage again approaches its nominal value.

Finally an Output Under Voltage protection OUV is provided. In the case of overload or brown out, the converter will automatically limit the current: as a result the output voltage will drop. If the drop exceeds 50% of the nominal output voltage, the controller will shut down and restart.

An additional feature of the IR1150 is the ability to force the IC into a "sleep" mode. In the sleep mode, the internal blocks of the IC are disabled and the IC draws a very low quiescent current of 120µA (typ.). This is a desirable feature designed to reduce system power dissipation to an absolute minimum during standby, or to shut down the converter at the discretion of the system designer. The sleep mode is activated any time the OVP pin is at a voltage lower than 0.62V.

Designing PFC applications with the new ICs

Figure 3 shows an IR1150 IC being used in a typical PFC circuit. Despite its small size, the IR1150 still provides a fast, 1.5A gate drive. For applications with higher powers (over and above 1.5kW, depending on switching frequency), the only major addition needed to the application design is the substitution of this gate drive for large, paralleled power semiconductors (FETs or IGBTs).

In order to further simplify the implementation of PFC designs based on the new IC, IR has also developed a number of support materials and tools, including application notes and a demonstration board. In addition to the IR1150 device itself, this demo board incorporates a high-efficiency power switch, a hyper fast recovery boost diode, and all of the other components needed to evaluate the performance of the IR1150 control IC in a 300W continuous conduction mode boost converter design. Using the board, designers can program frequency (between 50kHz and 100kHz), evaluate input, output and power factor performance for different load and line conditions, identify component requirements for their specific applications, and conduct a range of other tests including EMI measurement.

www.irf.com/eu

Passive Current Sharing

A low cost solution for increasing deliverable power

Passive current sharing can also improve the reliability of N+1 power module configurations, by reducing the stress on each converter in the system without the need for any additional active circuitry.

By Barry Ehrman, Artesyn Technologies

Connecting two or more DC/DC converter modules in parallel to increase current availability is a perfectly reasonable design aim. But few low-cost converters offer current sharing facilities, so designers need to implement their own circuits. One option is to add active circuitry to the output of each converter, but this tends to be expensive and takes up valuable board space. Another approach is to use passive current sharing, which involves putting droop resistance in series with the converters' outputs to equalise their voltages. This is much simpler to implement, costs next to nothing, and takes up hardly any space. This article is intended to clear up the mysteries of passive current sharing, using a fully worked real-life example to show the advantages and disadvantages of the technique.

Although passive current sharing cannot be used to obtain double the current output you would get from a single converter (because one of the converters will always try to output more than half the total load current, and therefore exceed its maximum rating), it provides a highly scalable means of accommodating demands for more power, which typically result from increases in system size or functionality over time. Passive current sharing can also improve the reliability of N+1 power module configurations, by reducing the stress on each converter in the system without the need for any additional active circuitry.

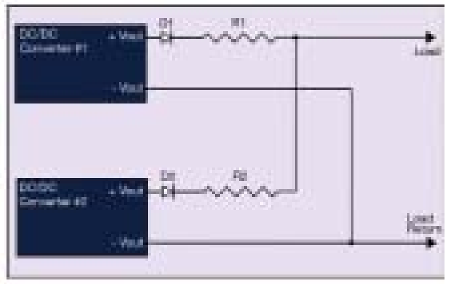


Figure 1. Typical N+1 Redundant Passive Current Share Configuration.

Unfortunately, the simplicity of this method of paralleling is not without its tradeoffs – the biggest being loss of system efficiency and load regulation. Whether these tradeoffs are acceptable is obviously a design decision, and to a large degree depend upon the application. In the example presented in this article, load regulation is less of an issue, because the paralleled converters are feeding an on-board intermediate bus, to supply multiple point-of-load (POL) converters which provide further down-conversion and regulation for their various silicon loads.

We have chosen to illustrate the advantages and disadvantages by paralleling two Artesyn TQW14A-48S12 intermediate bus converters (IBCs). These are wide-input 168 Watt DC/DC converters, primarily intended for telecom applications, which convert a nominal 48V DC input into 12V DC output. TQW14A-48S12 IBCs can output up to 14A with a typical efficiency of 95%, and are not equipped with active current sharing facilities. For the purposes of illustration all calculations are based on worst-case component tolerances. Figure 1 shows the two IBCs in an N+1 redundant passive current share configuration.

In addition to the two converters, there are two Schottky ORing diodes, D1 and D2, to decouple the outputs. These are assumed to have a forward drop of 0.2V, plus a resistive component equivalent to 7 milliOhms, which models the datasheet curves for the STPS20L15 devices manufactured by STMicroelectronics.

In order to implement current sharing between the two converters using Oring diodes, their output voltages ideally need to be adjusted to be perfectly matched under all conditions. However, in the real world it is nearly always impossible to achieve this degree of trim accuracy; furthermore, in the example we are using, for reasons of economy the IBCs are only designed to produce loosely regulated outputs, and do not offer a voltage trim facility. Consequently, there are two options. One is to implement an active circuit on the output of the converters, to force them to current share: this is relatively expensive, and takes up valuable board space. The second option is to employ passive current sharing, which involves putting droop resistance in series with the outputs. This droop resistance will create enough voltage drop under load to cause the two converters' voltages to equalise, and the converters will consequently current share.

To complete the circuit in Figure 1, we need to determine the value of the droop resistors R1 and R2. The major tradeoffs are the following: if the droop resistors are too small then there will not be enough voltage drop under load to cause the converters to share the load. Conversely, if the droop resistors are too large, the final voltage under full load will drop too low to be useful. To determine the ideal value, we need to determine the maximum variation allowed in the voltage to the load.

The first consideration is the minimum voltage the TQW14A IBCs will output under worst-case conditions. This will occur when their input voltage is at the bottom end of its permissible range, i.e., 36V. According to the datasheet, the output voltage could then be as low as 12V minus 10%, which is 10.8V.

The second consideration is the minimum voltage which the load can tolerate. The TQW14A IBC is primarily designed to drive POL converters, so we'll assume that these constitute the load in this case. The nominally 12V input POL converters that Artesyn produces fall into three groups, with input ranges of 10.8 to 13.2V, 10.2 to 13.2V, and 10 to 14V. Obviously we cannot drive the POL converters with a 10.8 to 13.2V input range, because there's no margin. So for the purposes of example, we'll use the second group, and limit the droop to 600mV.

To determine the value of R1 and R2, we first need to subtract the voltage

Output current to load	Iout 1 (Amps)	Iout 2 (Amps)	Vout	Power loss due to resistance (Watts)	Power loss due to diode drop (Watts)	Total current share circuit power loss (Watts)	Typical efficiency of each converter drawing half the load	Total power dissipated (Watts)	Efficiency with passive current share circuit
0	0.00	0.00	11.90	0.00	0.00	0.00	0.0%	4.32	0.0%
1	1.00	0.00	11.87	0.02	0.21	0.23	73.0%	4.70	71.63%
3	3.00	0.00	11.82	0.18	0.66	0.84	88.0%	5.79	85.96%
5	5.00	0.00	11.76	0.50	1.18	1.67	92.0%	6.93	89.46%
7	6.14	0.86	11.73	0.76	1.67	2.43	93.5%	8.31	90.81%
9	7.14	1.86	11.71	1.08	2.18	3.26	94.5%	9.58	91.66%
11	8.15	2.85	11.68	1.48	2.72	4.20	95.0%	11.18	91.99%
13	9.16	3.84	11.65	1.96	3.29	5.25	95.0%	13.50	91.82%
15	10.17	4.83	11.63	2.52	3.89	6.41	95.0%	15.92	91.63%
17	11.17	5.83	11.60	3.16	4.51	7.67	95.0%	18.45	91.44%
19	12.18	6.82	11.57	3.88	5.16	9.04	95.0%	21.09	91.25%
21	13.19	7.81	11.54	4.68	5.84	10.52	95.0%	23.83	91.05%
22	13.69	8.31	11.53	5.11	6.20	11.30	95.0%	25.25	90.95%
23	14.20	8.80	11.52	5.56	6.55	12.11	94.8%	27.46	90.61%
25	15.20	9.80	11.49	6.52	7.29	13.81	94.5%	31.33	90.17%
27	16.21	10.79	11.46	7.55	8.05	15.61	94.5%	34.53	89.96%
28	16.71	11.29	11.45	8.10	8.45	16.55	94.5%	36.17	89.86%

Table 1. Worst-case current sharing scenario for two TQW14A IBCs fitted with 0.02 Ohm droop resistors.

drop caused by the isolating diodes from the 600mV, as shown below: 600mV - 200mV - ((14 Amps x 0.007 Ohms) x 1000) = 302mV

By using Ohms law: voltage = current x resistance

R1 = R2 = 0.302 Volts / 14 Amps = 0.0215 Ohms or 21.5 milliohms.

For the circuit we will choose the next lowest standard value, which is 0.020 Ohms. Assuming 1% tolerance resistors, the minimum value will be 0.0198 Ohms, and the maximum will be 0.0202 Ohms.

The circuit is now designed. The questions are: how well does it work, and what is the theoretical loss of efficiency? We also need to bear in mind that the resistance of the PCB conductor traces will affect the results. Because this resistance varies from application to application, we will assume a value of zero Ohms for the purposes of this example. The resistance of the PCB traces will tend to improve current sharing while decreasing system efficiency.

Through circuit analysis the output voltage = Vout1 - Iout1 x R1 = Vout2 - Iout2 x R2, and the load current = Ioutload = Iout1 and Iout2.

The individual output currents Iout1 and Iout2 can be calculated by the following formulae:

Iout1 = (Vout1 - Vout2 + (R2 x Ioutload)) / (R1+R2)

Iout2 = Ioutload - Iout1

Vout = Vout1- (Iout1 x R1)

Table 1 shows Iout1 and Iout2 under various load current conditions:

Note that the formulae for Iout1 and Iout2 indicate a negative current for Iout2 for load currents of 5 Amps or less. Because of the ORing diodes, negative currents are blocked, which results in 0 Amps for Iout2. At the other end of the current output scale, note that passive current sharing can only be used up to 22A – beyond this the maximum output capability of one of the IBCs is exceeded, as shown in red.

In addition, Table 1 shows the power loss due to the resistors and the ORing diodes, together with the overall effect on efficiency. As can be seen from the table, passive current sharing is far from perfect. With the circuit constraints conveyed by the load and 1% standard parts, the worst case load sharing is theoretically 24.4% (based on the 0.02 Ohm droop resistors) with a 22A load shared between the two converters. However, this load sharing is achieved with an efficiency loss of only 4.05%.

It is important to note that we are using worst-case figures to illustrate passive current sharing. Based on actual Cpk (Process Capability Index) sample measured data, using extreme values, the worst case output voltage values for the TQW14A IBC are 12.098V maximum and 11.957V minimum. After allowing for the voltage drop of the

ORing diode, these reduce to 11.898V and 11.757V respectively. A more reasonable scenario would be to use the actual Cpk sample measured data, but with values equivalent to the Standard Deviation from the average. This would produce converter output voltages of 12.076V maximum and 12.006V minimum, giving post ORing diode values of 11.876V and 11.806V respectively. Although overall efficiencies remain largely unchanged, the effect of using the more reasonable output voltage figures is an improvement in current sharing accuracy to 11%, and the paralleled IBCs will now deliver up to 25A before the output rating of a converter is exceeded.

Passive current sharing offers an inexpensive means of accommodating increased on-board power demands without major redesign, provided the slight loss in conversion efficiency can be tolerated. Although we have chosen to illustrate the technique using two IBCs feeding POL converters via an intermediate bus, the approach is also suitable for use with conventional brick type converters with tightly regulated outputs.

Eliminating the ORing diodes would obviously increase overall efficiency, but it would be necessary to guarantee a fairly high minimum load at all times. However, this approach is not without risk, because the FETs used by the converters' synchronous rectification stages can sink or source current when active, and power could consequently circulate between the two converters.

Other reasons for adopting passive current sharing are to increase reliability of N+1 power module configurations, and to secure better performance on boards that do not use an intermediate voltage bus and point-of-load converters. If the board contains widely distributed loads, better voltage regulation will be achieved by placing the converters as closely as possible to the loads—perhaps using both sides of the board—and the amount of copper can be reduced because the board traces will be carrying less current.

About the author:
Barry Ehrman is Marketing Application Engineer for Artesyn Technologies' Power Group. He is based at the company's facilities in Tucson, Arizona, and can be contacted via email at barry.ehrman@artesyn.com.

Company contact:
Jackie Day, Marketing Communications Manager
Artesyn Technologies, Springfield Industrial Estate, Youghal, Co. Cork, Ireland.

Tel: +353 24 25388
Fax: +353 24 25407
Email: jackie.day@artesyn.com

www.artesyn.com

Networking in Overdrive

International centers for complete power sub-assemblies

The modern power electronics solution for markets such as wind, solar, traction, welding, elevators and electric vehicles is a complete sub-assembly. The decision to select an all-round solution which includes a complete sub-assembly, the specification and design, production, arduous testing and after-sales support and service is time-saving, cost-effective and so simple with an experienced partner.

By Fréderic Sargos, International Coordinator Solution Centers Network and Paul Newman, Managing Director, Solution Center United Kingdom

Semikron combined the expertise of nine Solution Centers from each continent in South Korea, Australia, South Africa, USA, France, United Kingdom, Brazil, India and Slovenia into a unique Solution Centers Network. The main goal is the development of cost-effective platform products which are marketed in high quantities in the global network. Additionally the capacities in production, purchase, engineering and logistics are united. The hands-on organization makes the network even more competitive. Specifically global customers profit from the local service and support as well as the swiftness with which the network operates. The speciality of over 40 design and application engineers is to find the best possible solution for a specific customer inquiry.

Figure 1. Solution Center Network.

Joined forces

Over 5 decades ago Semikron started integrating semiconductors into power assemblies, called SEMISTACK® . These completely tested systems consist of diode/thyristor, MOSFET or IGBT modules with gate driver, protection, cooling, DC link capacitors and sensorics. More than 15 000 different designs have been successfully implemented in the industry. Semikron specializes in the most arduous applications such as wind plants or traffic engineering and produce customized as well as standard SEMISTACK`s ranging from simple press fit diode plates for battery chargers to specific solutions for elevators, wind, solar plants, traction electric vehicles and marine. For example, 57% of globally installed power capacity in variable speed generators is powered by Semikron, a significant part of it being made of assemblies.

The customer benefits

Global support for local service is the philosophy of the Semikron Solution Centers by providing development and production capabilities as close as possible to the customers' applications. Wherever the intended application, the customer is offered local expertise and highly qualified service of one of the Solution Centers' team of application engineers, as well as local development and production, for a high quality product and support.

Every Solution Center has its own team of application engineers, expertise as well as knowledge transfer within the network. This allows tried-and-tested systems from one center to be transferred to another, closer to its market, for manufacture. Semikron is the only company in this market to offer such a uniform worldwide design, support and build network, combining global design resources and local customer support. The development, design and experiences of different projects are shared in the network. Customer specific designs are handled with the utmost confidentiality and loyalty.

The testing policy of the Solution Centers is a quest for zero defect rates in the field. All SEMISTACK`s are visually and electrically checked. The inverter units are tested under full load and short-circuit conditions.

The first platform solution

The SEMIKUBE B6CI is a power electronics platform solution meeting market demands for a standardized, compact, maintainable, flexible and above all cost-effective system for forced air-cooled inverters from 300A up to 1550A.

Figure 2. SEMITOP inverter for elevators. SEMITOP is based on base plate-free technology and offers the best reliability in very high cycling applications such as elevators in the lower kW range.

Figure 3. SEMIKUBE B6CI, the cubic design realizes the most efficient modularity.

Figure 4. SEMISTACK intelligent modular solution incorporating SEMiX IGBT half-bridge modules and SKYPER half-bridge driver core.

It is the first standard platform solution developed by the Semikron Solution Centers Network and is the result of 45 years of experience in the stack business.

The ground-breaking cubic form with a low inductivity connector for 220kW – 900 kW drives allows for similar SEMIKUBE blocks to be connected in various mechanical and electrical arrangements to achieve the desired electrical and mechanical performance. The low inductive connector makes a fast connection and disconnection possible. The cubic form of the blocks also offers the possibility to install the products horizontally or vertically into the cabinet.

To achieve the most cost-effective industrial platform, parts used within the range from 385A – 1550A, (at 3kHz switching frequency) are reduced to the minimum, the whole range can be covered with only one reference of IGBT module, capacitor, heat sink, fan, and current sensor. The SEMITRANS module family with the latest IGBT chip generation is optimal for the SEMIKUBE range. The Semikron SKHI gate driver family along with patented close protection scheme gate boards protect the devices with electrical isolation, Vce monitoring, short pulse suppression, under-voltage monitoring and interlocking.

The SEMIKUBE range has forced air-cooling of the capacitors guaranteeing a long lifetime expectancy and avoiding the occurrence of hot spots. The excellent symmetry of the busbar system between the capacitor blocks and the IGBT modules ensure a current sharing between the modules and between the capacitors. All five sizes use the same spare parts. This ensures easy integration, plug and play and easy maintenance. Three of these sizes have a half controlled rectifier with a pre-charge system included.

All removable parts weigh less than 30 kg and all screwing points are accessible from the front side. For a large installation with multiple power ratings less spares are required due to the modularity of the SEMIKUBE. The same parts are used through the whole range, which simplifies training of the after-sales team and allows an improved availability of the parts.

All technical performances result in a power/volume ratio, which was previously only achievable through water-cooling. Although SEMIKUBE B6CI was designed as a standard platform it was also designed to allow customization, such as changing the power modules, the capacitors length or the type and orientation of the fans without changing the whole concept.

The customer specific configurable "black box" solution

The SEMISTACK range is further expanded with an intelligent power solution, integrating the SEMiX IGBT half-bridge modules and SKYPER half-bridge driver core containing all basic driver functions. It takes the form of an off-the-shelf or configurable "black box" that offers all the functionality that is needed for a wide range of applications —all the user needs to do is provide a control scheme. This SEMISTACK solution can be expanded as a platform with built-in intelligence, incorporating the newest advances in power electronics while using common piece parts wherever possible. It can be based on SEMiX 2, 3 or 4 IGBT half-bridge modules. These are the latest-generation, lowest-loss, highest efficiency IGBT modules, which are housed in a very low inductance, 17mm high package. A range of current ratings is available within each SEMiX family, providing an overall choice ranging from 250 to 1300A. Therefore, the stack can be configured for low, through medium, to high power to suit a wide range of applications including motor drives, inverters, uninterruptible power supplies and renewable energy generation. This SEMISTACK platform is believed to be the most compact and volumetric-efficient solution on the market. It is fully protected by the incorporation of the SKYPER intelligent gate driver circuits which, in addition to basic driver functions and electrical isolation, also include V_{CE} monitoring, short pulse suppression, under-voltage monitoring and interlocking.

Other features of this SEMISTACK with SEMIX and SKYPER include low-inductance co-planar bus barring; DC-linked voltage monitoring; highly-accurate, closed-loop current sensors and thermal measurement; high-frequency snubber capacitors; and DC-linked bulk capacitance.

The units have been designed to be plug-and-play and are fully electrically and thermally tested. They are available in air-cooled and, for even more compact solutions, water-cooled variants.

www.semikron.com

Powering the Heart of the LCD Display

The wLEDs visible spectrum appears white

Thanks to liquid crystals, electronic displays continue to shrink in size. Wrist watches, cell phones, PDAs and laptop computers have LCD-based displays. LCD and other, smaller display technologies are also slowly replacing the cathrode-ray tube (CRT) based desktop monitors and televisions.

By Jeff Falin, Texas Instruments

The electronics behind an LCD are very different than those of a CRT. A CRT has three rear-mounted electron guns whose beams converge on a material at the front of the display that emits light. However, regardless of whether an LCD display is the older dual-scan twisted nematic (DSTN) type or the high-image quality thin film transistor (TFT) type, LCD is a transmissive technology. As shown in Figure 1, an LCD works by varying the amount of fixed-intensity white “backlight” as it passes through an active filter.

The actual liquid crystals are placed between two finely grooved surfaces: the alignment layers and polarizing filters. Since the two alignment layers are perpendicular to each other, the crystals begin with the orientation of one layer and then twist to accommodate the perpendicular orientation of the other layer. Light follows the alignment of the liquid crystals as it passes through. However, if a voltage is applied across the liquid crystals, they rearrange themselves vertically. This forces the light to pass through vertically, only to be stopped by the second polarizing filter.

For small- to medium-sized displays, this backlight is provided from white-light emitting diodes (wLEDs). Larger LCD displays, like those found in a laptop computer, typically use cold cathode fluorescent lamps (CCFL) to provide the backlight. This first article of the three part series details what to consider when powering wLEDs and provides example circuits for powering them. The second article explains the requirements and gives examples of how to provide the various voltage and currents used in thin-film-transistor (TFT)-based active matrix displays. The last article in the series explains the options available for and complexities of powering CCFLs.

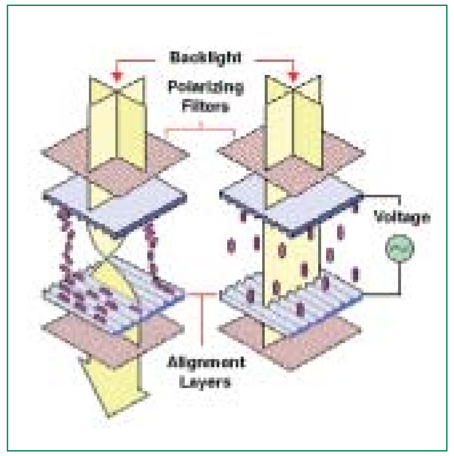


Figure 1. Simplified LCD cell.

wLED

An LED is a semiconductor diode with an inorganic chemical compound that gives off light when an electric current passes from the diode’s anode to its cathode. LEDs emit light proportional to the amount of current being driven through them. For wLEDs, the emitted light covers the entire visible spectrum so the light appears white. All LEDs have a non-linear V-I curve, so even the smallest change in the forward voltage of the wLED creates a change in the wLED current. In addition, the forward voltage tolerance can vary by 1V or more. Usually, multiple wLEDs configured in parallel or in series are necessary to produce a uniform intensity over the display. A forward current for wLEDs can be generated by either a constant voltage source (Figure 2) or constant current source (Figure 3).

Constant Voltage vs. Constant Current

Using a constant voltage source to drive multiple, parallel wLEDs as shown in Figure 2 is perhaps the simplest and least expensive solution. The ballast resistors are required to promote even current sharing among the diodes in parallel as well as to provide over-current protection. The primary weakness of this method is that the feedback loop regulates the voltage across both the series ballast resistor and wLED instead of the current through the wLED. In this configuration, the actual voltage drop across each wLED, and therefore each individual wLED’s light intensity may vary.

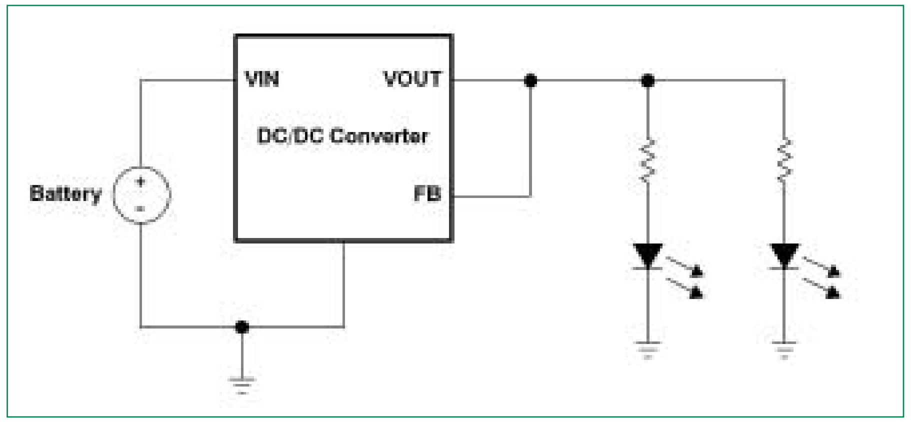


Figure 2. Constant voltage source powering wLEDs in parallel with ballast resistors.

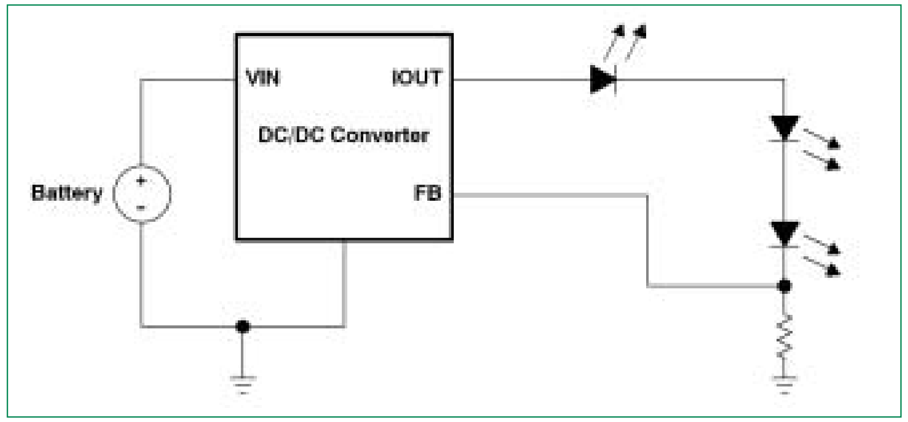


Figure 3. Constant current source powering wLEDs in series.

So, wLED-1 may provide light intensity at V_F = 3.6V and I_F = 20mA while wLED-2 might require V_F = 3.8V to provide the same light intensity with I_F = 20mA. In addition, the ballast resistors waste power, thereby lowering the overall efficiency of the system and decreasing battery life. This is unacceptable for many applications.

The preferred method for driving wLEDs is from a constant current source as shown in Figure 3. The constant current source eliminates changes in current due to variations in the wLED's forward voltage. A constant, controllable forward current delivers constant, controllable display brightness. Rather than regulating the output voltage of a supply, the controller regulates the voltage across a single current sense resistor as shown in Figure 3. The converter varies its output voltage until the wLED current being sensed reaches regulation. The converter's reference voltage and the current sense resistor value determine the wLED current. Most displays require more than one wLED. The wLEDs should be connected in a manner that ensures identical current flow through each to provide balanced brightness between them.

Special Requirements when Driving wLEDs

Many applications using a display panel require a backlight dimming function. With products such as PDAs, the user adjusts the brightness for ambient light conditions. With other products, such as cell phones, the processor automatically dims and turns off the backlight after a period of inactivity. Two methods are used for implementing a dimming function: analog and PWM. With analog dimming, the display is dimmed to 50 percent brightness by applying 50 percent of the maximum current to the wLEDs. Drawbacks to this method include a wLED color shift and the need for an analog control signal, which is not usually readily available. PWM dimming is achieved by applying full current to the wLED at a reduced duty cycle. For 50 percent brightness, full current is applied at a 50 percent duty cycle. The PWM signal frequency must be above 100Hz to ensure that the pulsing is not visible to the human eye. The maximum PWM frequency depends on the power supply start-up and response times. For maximum flexibility and ease of integration, the wLED driver should be able to accept PWM frequencies as high as 50kHz. The dimming signal is usually derived from a GPIO on the system processor.

Constant current wLED drivers require over-voltage protection in the event of an open circuit fault condition. The wLEDs are often on a separate PWM than their driver; therefore, an open circuit condition is created if the connector pins become dislodged. Another fault condition exists if a wLED fails and becomes an open circuit. In either case, the driver increases its output voltage in an attempt to provide a constant current. Without protection, the output voltage can raise high enough to damage the IC or output capacitors. The easiest way to protect the driver is to choose an IC that has a built-in over-voltage comparator that limits the maximum output voltage. Alternatively, a Zener diode can be used to clamp the maximum output voltage; however, this is very inefficient because the maximum programmed current flows through the Zener diode during a fault condition.

An often overlooked feature in a wLED driver supply is load disconnect, which electrically removes the wLEDs from the input source when the supply is disabled. This feature is important in two situations: shutdown and PWM dimming. Even when an inductive boost DC/DC converter is turned off, the load is still connected to the input through the inductor and catch diode. Since the input voltage is still connected to the wLEDs, a small current continues to

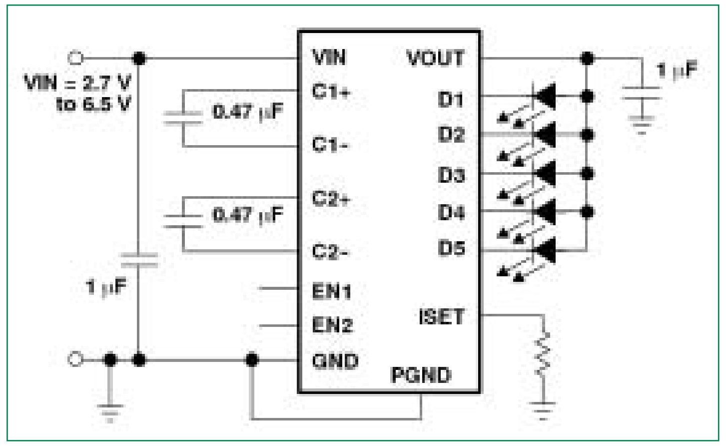


Figure 4. Typical wLED driver circuit using the TPS60230.

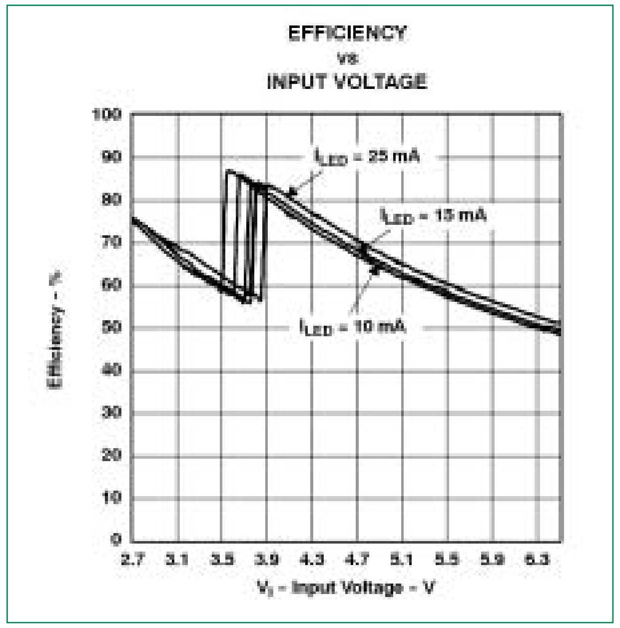


Figure 5. Fractional Charge Pump Efficiency Curve Showing 1x to 1.5x Mode Change.

flow even when the supply is disabled. Portable products may spend more than 95 percent of their time in stand-by mode, so even small leakage currents significantly reduce battery life. Load disconnect is also important while the PWM is dimming. During the dimming period off-time, the supply is disabled but the output capacitor is still connected across the wLEDs.

Without load disconnect, the output capacitor discharges through the wLEDs until the dimming pulse turns the supply on again. Since the capacitor is partially discharged at the beginning of each dimming cycle, the supply must charge up the output capacitor at the start of each cycle. This creates a spike of inrush current each cycle, which lowers system efficiency and creates voltage transients on the input bus. With load disconnect, the wLEDs are electrically removed from the circuit, so there is no leakage current when the supply is disabled and the output capacitor remains fully charged between intervals of PWM dimming. A load disconnect circuit is best implemented by placing a MOSFET between the wLEDs and the current sense resistor. Alternatively, placing the MOSFET between the current sense resistor and ground provides load disconnect but inadvertently creates an additional voltage drop that appears as an error in the output current set-point.

wLEDs in Parallel

All ICs designed specifically to drive wLEDs provide a constant current. Most solutions are either inductive-based or charge-pump-based. The primary advantage of a charge pump, or switched capacitor, solution is that this does not require an inductor. Power is transferred from the input to the output by discrete capacitors. Charge pump power supplies are easy to design since the component selection is usually limited to choosing the correct capacitor from a datasheet list. The main disadvantage of a charge pump solution is its limited output voltage. Most charge pump ICs can only provide an output voltage up to twice the input voltage. Therefore, driving more than one wLED with a charge pump requires them to be driven in parallel. When driving multiple wLEDs with a charge pump that only regulates the output voltage, ballast resistors are required to improve current matching.

However, the latest charge pump ICs that are specifically designed to drive wLEDs have incorporated current sharing circuitry directly into the IC. As shown in Figure 4, the TPS60230 is a charge pump solution that generates a voltage in parallel across the anode of multiple LEDs. The resistor to ground from the ISET pin determines the current.

Each wLED cathode is directly connected to a different pin on the IC. Internal circuitry regulates the forward current through each wLED to within 0.3 percent without the need for external resistors. The device has over-voltage protection and being a charge pump, has inherent load disconnect. The EN2 pin is used to implement PWM dimming. Analog dimming is implemented by applying an analog signal through a series resistor to ISET instead of tying it to ground through a resistor. Most charge pump based solutions have an acceptable efficiency between 60 to 85 percent. The more advanced charge pump ICs have fractional conversion modes that automatically switch to the most efficient conversion mode as the input voltage changes. Figure 5 shows the efficiency graph of a fractional conversion charge pump as it switches from one mode to another.

wLEDs in Series

With their small size and high efficiency, inductive DC/DC converter solutions are ideally suited for most portable consumer products to provide longer battery life. Through careful selection of a boost converter's inductor and catch diode, the designer can tailor an inductive converter's efficiency to optimize the trade-off between size and efficiency. Because boost converters are capable of providing an output voltage much larger than their input voltage, they can drive many wLEDs in series.

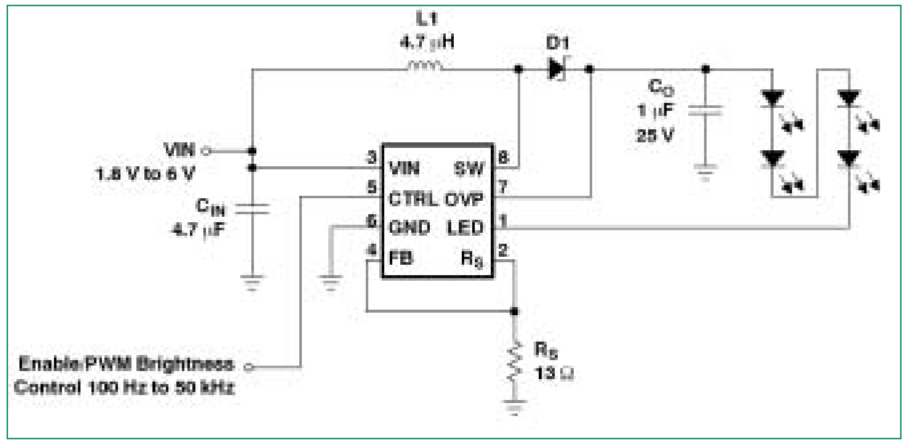


Figure 6. Typical wLED Driver Circuit Using the TPS61043.

The backlight driver is often on a different PWM than the actual LEDs themselves, so power must be routed from one board to another. Driving four wLEDs in parallel requires a total of six connector pins, while driving them in series requires only two pins.

The TPS61043 wLED driver shown in Figure 6 is ideally suited to meet these requirements. It is a fully-integrated inductive mode boost converter with an integrated power FET that has been customized to operate as a wLED driver. The TPS61043 has built-in load disconnect, over-voltage protection and PWM dimming in a 3x3 mm QFN package. Its 1 MHz switching frequency minimizes the size of the inductor. In a typical application, the TPS61043 can drive four wLEDs in series with 15 mA from a Li-Ion battery at 83 percent efficiency. The datasheet provides several typical application circuits and recommended components as a starting point for this design.

Because LCD is a transmissive technology, wLEDs are critical components in today's small to medium LCD displays. While wLEDs can be powered from any DC/DC converter configured as a constant voltage source, powering them from a constant current source provides the most uniform light intensity. Features, such as over-voltage protection, load disconnect and dimming, not found in many DC/DC converters are also desirable when powering wLEDs. The TPS62030 charge pump and TPS61043 boost converter are constant current power solutions with the additional features needed to power wLEDs.

www.ti.com

TRANSIENT PROTECTION

Micro-Packaged ESD and EMI Solutions

Low-cost for portable applications

Designers are being challenged to develop reliable systems that meet stringent Electrostatic Discharge (ESD) and Electromagnetic Interference (EMI) standards, while reducing the size and cost of their designs.

By Jim Lepkowski, ON Semiconductor

A new series of Transient Voltage Suppressors (TVS) avalanche diodes have been developed to protect sensitive electronic components from the surge pulses that arise from ESD and EMI. The low cost, low clamping voltage, fast response time, and small SOD-523 package of the ESD5Z2.5T1 family of TVS diodes makes this an ideal device for ESD and EMI protection in space constrained products. Keypad and panel switches interface circuits are examples of applications that can benefit from the features of the ESD5Z2.5T1.

ESD and conducted EMI surge voltages are a major design concern for designers because the surges can disturb the operation of the system, produce permanent damage, or cause latent damage that will eventually cause a failure. In particular, the latent damage of surge pulses is difficult to detect because the circuit may continue to operate for an extended period of time before a complete failure occurs. Electronic products are typically connected to other systems through input/output (I/O) cables; thus, the I/O interface has become a major source and entry point for both ESD and EMI. TVS devices are an effective tool to reduce field failures and improve the reliability of a system by suppressing high voltage surge pulses at the I/O connector.

ESD Protection

The ESD immunity level can be specified by several different tests including the Human Body Model (HBM) and Machine Model (MM) specifications. The majority of IC bus transceivers have a HBM rating of 2 to 6 kV and MM rating of 100 to 200 V. In contrast, the ESD5Z2.5T1 has a 16 kV HBM and a 400 V MM specification. Although the HBM and MM tests provide a good representation of the typical ESD energy levels that occur during the assembly and handling of the printed circuit board (PCB), the energy level of the test pulses is often too low to simulate ESD events that occur in normal product usage.

The International Electromechanical Commission (IEC) 61000-4-2 specification is emerging as the preferred system level test to measure the ESD immunity of a product. The IEC 61000-4-2 and HBM ESD specifications are designed to simulate the direct contact of a person to an object such as the I/O pin of a connector; however, the IEC test is more severe than the HBM test. The IEC test is defined by the discharge of a 150 pF capacitor through a 330 Ω resistor, while the HBM uses a 100 pF capacitor and 1500 Ohm resistor. The ESD5Z2.5T1 TVS diodes have a 30 kV rating for both the contact and non-contact (air) IEC 61000-4-2 ESD tests. In contrast, most IC data sheets provide only a HBM and MM rating, and do not list a rating for the IEC 61000-4-2 test. Figure 1 shows the low clamping voltage output of the ESD5Z5.0T1 diode for the IEC 61000-4-2 ESD test.

The surge ability of a diode is directly related to its size. External TVS devices are typically a factor of at least ten times larger than the size of IC ESD diodes. Since it is typically not practical for an IC to have large ESD diodes, the TVS diodes will provide a higher level of protection. Internal IC protection circuits function well at preventing assembly failures; however, they often are inadequate for ESD events that occur in normal product usage. In addition, many ICs have an internal ESD protection circuit that is designed to handle only a few transient events while TVS devices such as the ESD5Z2.5T1 provide immunity for an indefinite amount of surges.

EMI Protection

EMI protection is important because products must function in close proximity to a wide range of other electronic devices. These products must be capable of operating without either becoming effected by or adversely effecting the operation of electronic devices. EMI's common entry points are the power supply and data lines. The power source is typically shared by a number of modules and some of these modules may have load switching or inductive devices such as motors that can create surge pulses and high frequency noise on the power lines. Furthermore, noise on the power lines is easily coupled into data line signals because the power and data lines are often located inside the same wire bundle. The coupled noise produced on the data lines can produce a surge voltage that can permanently damage an IC.

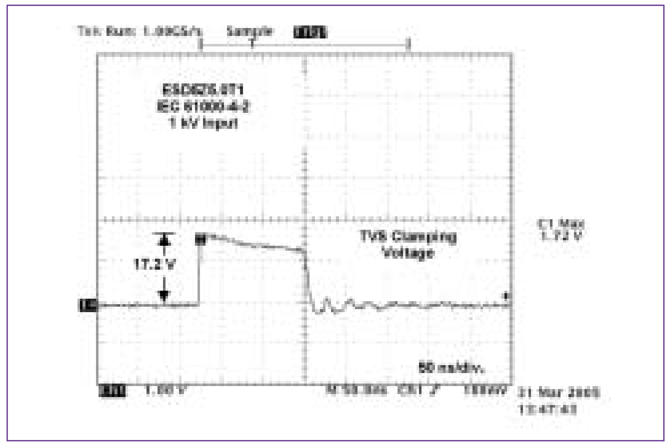


Figure 1. EC 61000-4-2 ESD Test.

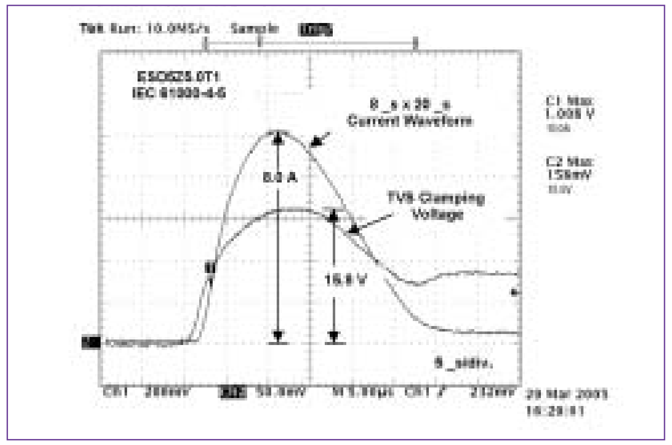


Figure 2. IEC 61000-4-5 8µ x 20µ Surge Test.

The immunity level of a module to repetitive high frequency voltage EMI surges, also known as electrical fast transients (EFT), can be measured with the IEC 61000-4-4 test. Repetitive surges are modeled by a recurring pattern of high voltage spikes of 50 ns transient pulses in bursts of 15 to 300 ms long. This test is used to verify a module's immunity from noise sources such as inductive load switching and relay contact chatter. The switching transients are coupled into the data line cables because of the parasitic capacitance and inductance inherent in the wiring harness. The ESD5Z5.0T1 TVS diodes provide an IEC 61000-4-4 rating of 50 A.

The IEC 61000_4_5 test serves as a standard test to verify the immunity of a system to a non-repetitive surge. The surge voltage waveform is defined by a double exponential pulse with a rise time of 8 µs and duration of 20 µs. The 8 µs x 20 µs test is often used to quantify the power rating of a TVS device and is representative of a single surge event such as the voltage induced by lightning. An ESD5Z5.0T1 TVS diode with a break down voltage of 6.2 V has an IEC 61000-4-5 rating of 9.4 A and 174 W. Figure 2 shows the ESD5Z5.0T1's response to the 8 x 20 µs surge test.

TVS Selection and PCB Guidelines

TVS diodes provide a simple, low cost solution for surge protection. Listed below are recommendations on selecting an appropriate TVS device, along with PCB layout suggestions that maximize the effectiveness of the protection circuit.

TVS Selection Guidelines

Select a device with a working voltage that is greater than the maximum bus voltage. Select a device with a clamping voltage less than the maximum specified voltage for the protected circuit. Verify that the TVS device's power rating can dissipate the energy of the surge pulses. The capacitance of the TVS device should be minimized for high speed circuits.

PCB Recommendations

Protect all I/O signals entering or leaving the PCB with a TVS device. Locate the protection devices as close as possible to the I/O connector. This allows the devices to absorb the energy of the transient voltage before the surge pulse can arc and propagate between adjacent PCB traces.

Minimize the loop area for the high-speed data lines, as well as the power and ground lines, to reduce the radiated emissions and the susceptibility to RF noise.

Use ground planes to reduce the parasitic capacitance and inductance. This will prevent voltage overshoot and ringing on high speed data lines. Minimize the PCB trace lengths for the ground return connection.

www.onsemi.com

Options for Secondary Post-regulation

Conventional DC-DC converters represent the highest performance

The increasing number and complexity of loads poses a problem to the power supply engineer. Traditionally an off-line power supply would have one main high current output supplying the core voltage to the microprocessor or microcontroller and auxiliary outputs supplying I/O circuits and peripherals.

By Paul Greenland, National Semiconductor

The control loop would be closed around the main high current output and auxiliary outputs would be loosely regulated by means of a weighted-sum feedback network at the input of a programmable shunt regulator. This approach is simple but the regulation of the auxiliary outputs is poor, particularly if the secondary windings are not tightly coupled to each other and the main regulated output winding. Furthermore, there are cases where a secondary load is significant compared to the main output and has a switching current waveform, for example, a hard disk drive. In such cases some form of secondary regulator is required. Fortunately there is a choice of post-regulator; each form has its merits and sweet-spot of applicability.

Linear post-regulation

Linear regulators are the simplest option for post-regulation. However, they are rarely employed at load currents greater than 2 A due to the impact on the overall efficiency of the power supply. For many years, a simple linear regulator such as the LM317 was employed with the secondary winding delivering approximately 2.5 V of headroom at maximum load and minimum line. Additional high frequency rejection was afforded by bypassing the adjust pin with a 10uF tantalum capacitor to return. Recently linear regulators such as the LP38843, shown in figure 1, with an additional bias rail have been introduced.

These regulators are capable of very low dropout provided an auxiliary or bias rail is available to power the drive for the pass transistor. Furthermore, they are stable with multi-layer ceramic capacitors, which are favored for filtering high switching frequency. Generally speaking, linear post-regulation offers a fast load transient response, together with excellent high frequency rejection. Also a typical monolithic linear post-regulator usually includes overload and short-circuit protection. These advantages have to be traded off against efficiency and the provision of heat sinks or printed circuit board copper area for heat removal.

Magnetic Amplifier Post-regulation

Magnetic amplifiers, shown in figure 2, became popular in the 1980s for high power post-regulation. A magnetic amplifier is a coil wound on a core with a relatively square B-H characteristic. This assembly has two distinct operating states. When the core is saturated, the impedance of the winding drops close to zero allowing high current to flow unimpeded. In the unsaturated state, the coil acts as a high inductance capable of supporting a high voltage with negligible current flow.

In essence we have a “magnetic switch”. Regulation is achieved by either passing current back through the magnetic amplifier winding while the secondary is not conducting, or applying a voltage to a second winding on the magnetic amplifier core during the same portion of the main converter’s switching period. Each technique programs the volt*seconds that the magnetic amplifier will block when the secondary next starts conducting. Magnetic amplifiers utilize leading edge modulation, this technique is particularly beneficial in current-mode regulated power supplies, it ensures that no matter how the individual output loading varies, the maximum peak current seen in the primary always occurs as the pulse is terminated. Magnetic amplifiers are accurate and efficient post-regulators. However, the extra inductive components, limited operating frequency, slow dynamic response, cumbersome short-circuit protection and

POWER SUPPLY

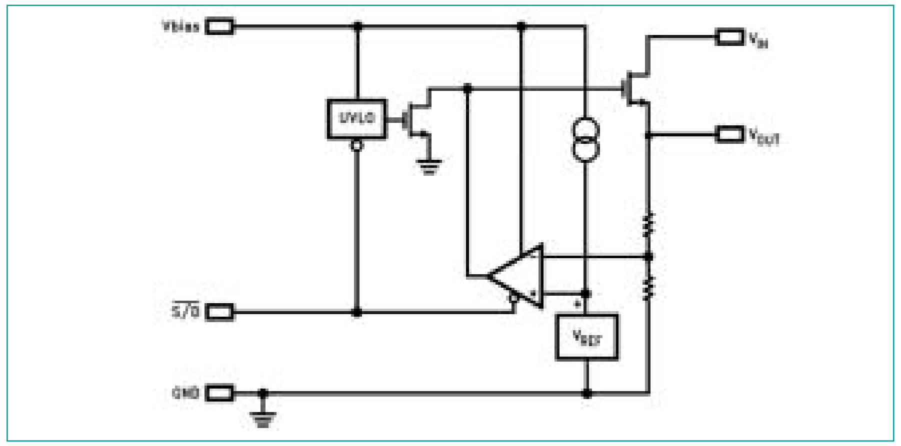


Figure 1. LP38843 Internal Schematic.

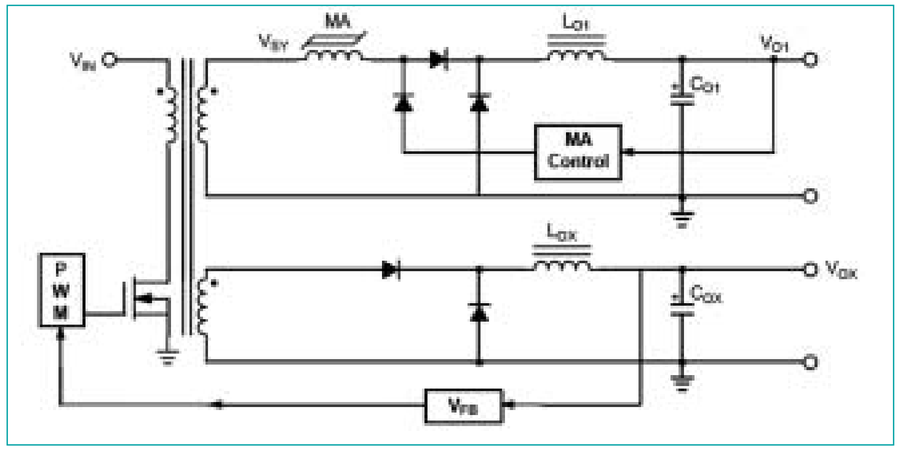


Figure 2. Magnetic Amplifier Post-regulator.

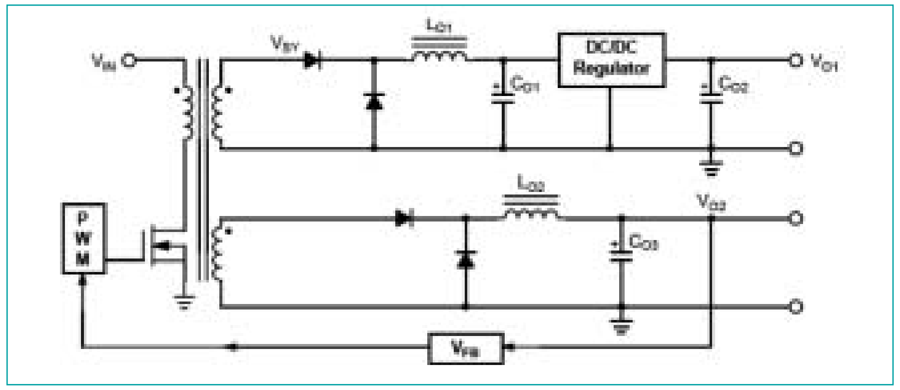


Figure 3. DC-DC Post-regulation.

no load operation limit useful application. The European power supply manufacturer Lambda, formerly called Coutant, manufactured an innovative modular AC-DC converter series that employed magnetic amplifier post-regulation before its re-emergence when square loop cobalt-enriched cores entered the market. The Coutant technique consisted of a constant volt*second primary converter feeding an array of secondary regulators with an input voltage head-room of approximately 20%. There was no feedback across the primary-secondary isolation barrier, only fault/diagnostic signals. This approach led to a significantly faster time-to-market for semi-custom AC-DC converters.

Switching Post-regulation

Switching regulation on the secondary takes two forms, conventional switching regulators and synchronous switching post-regulators. The former is usually a DC-DC converter with its own free-wheeling diode and LC output filter. This approach, illustrated in figure 3, has high efficiency and accuracy. Output voltage regulation is independent of the pre-converter's duty ratio.

DC-DC converters often have independent protection against output over-voltage and short-circuit, which will apply to the post-regulated secondary. On the downside, if steps are not taken to synchronize the switching frequency of the post-regulator with the main supply, beating or interference may occur. The component count is higher with the additional filter, synchronization circuitry and the extra rectifier.

The synchronous secondary side post -regulator (SSPR), shown in figure 4 is considered to be the best secondary regulator for high power auxiliary outputs.

Its behavior is not unlike the magnetic amplifier; consequently it is often called a "solid state mag amp". The LM5115-based SSPR is synchronized to the primary converter. It uses leading-edge pulse width modulation and is compatible with either current or voltage mode controlled primary power source. Synchronization of the LM5115 comes from the main secondary winding of the power transformer. A resistor divider samples the pulsating power voltage waveform creating a synchronization signal and setting an internal current source to create the PWM ramp. This affects input voltage feed-forward, regulating against line voltage variation. The LM5115 controls the buck power stage with leading edge pulse width modulation holding off the high side driver until the necessary volt*seconds is established for regulation. Representative waveforms are shown in Figure 5.

Bias to the part comes from a rectified pulse signal. Adaptive dead time control delays the top and bottom drivers to avoid efficiency-sapping shoot through currents.

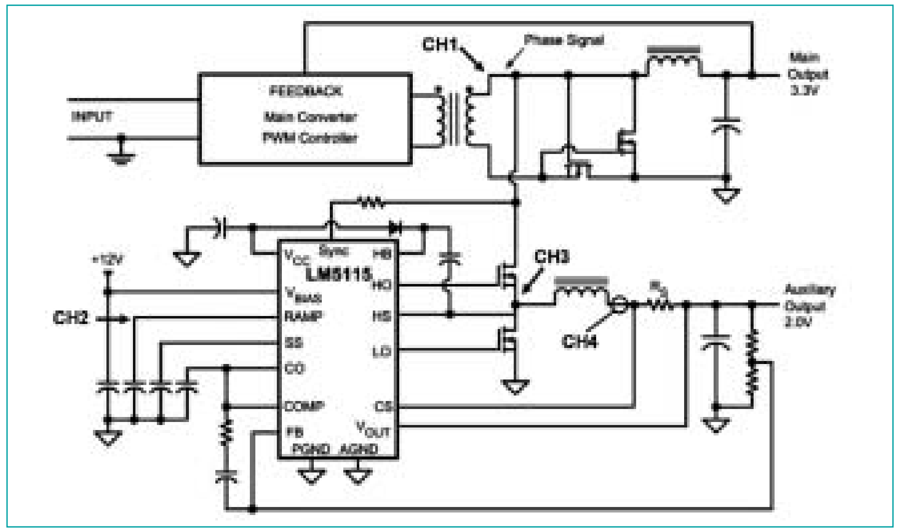


Figure 4. Synchronous Secondary Side Post Regulation.

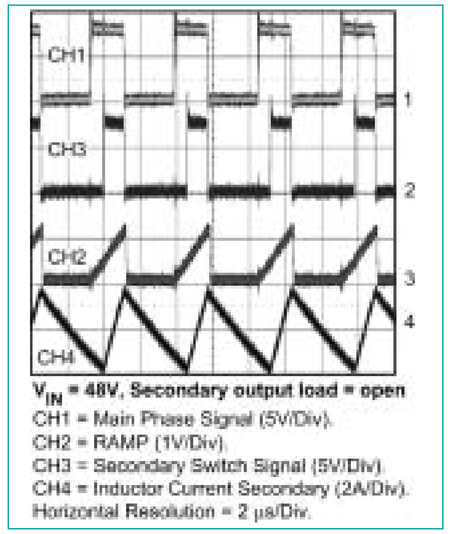
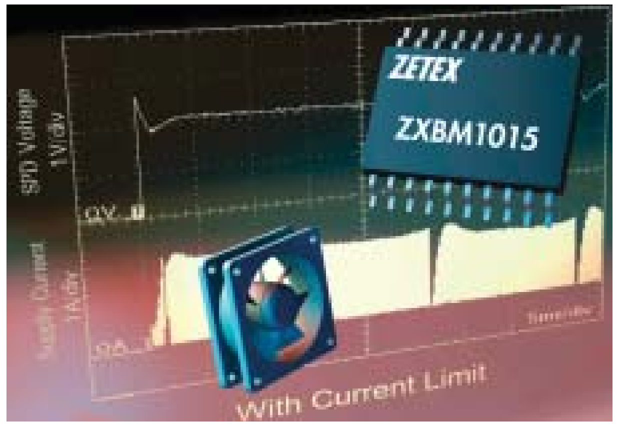


Figure 5. SSPR Representative Waveforms.

Multiple output power supplies are challenging to design, particularly if the auxiliary rails represent a significant portion of the throughput power. Traditional low current post-regulation techniques, such as master-slave and conventional linear regulation are limited due to inefficiency or poor load regulation. Magnetic amplifiers scale with the volt*second blocking capability rather than current and are complex to protect under overload and short circuit conditions. Conventional DC-DC converters represent the highest performance, at the expense of component count. The synchronous secondary side switching post-regulator is the optimum solution for efficient high power auxiliary regulation.

www.national.com

Single-Phase Motor Pre-Driver



For variable or fixed speed control of single-phase brushless DC fans, blowers and pumps, the ZXBM1015 pre-driver from Zetex Semiconductors includes a current monitor that enables supply current on start-up and stall to be kept permanently within OEM specifications.

The ZXBM1015 produces a PWM output to drive an external H-bridge that in turn drives the motor windings. Its integral current monitoring circuit measures the voltage across a low value external resistor in the low side of the H-bridge and deduces how much current the motor is taking during each PWM cycle. If it takes too much, the pre-driver backs off the PWM drive to reduce the current drawn.

The pre-driver IC is also the first of its kind to offer a configurable phase commutation delay, which allows OEMs to accurately meet the requirements of different motor sizes and so further optimise efficiency. The ZXBM1015 has a fixed internal commutation delay of 100µs, which can be easily extended
or reduced by the simple addition of an external resistor.

The flexibility of the ZXBM1015 solution is demonstrated by its compatibility with thermistor, voltage and PWM control inputs, which support fully adjustable motor speed control in a wide range of equipment, from desktop computers to central heating systems.

With a built-in Hall amplifier, the pre-driver is compatible with any type of Hall-effect sensor and can provide as a result, pulsed rotor speed and locked rotor alarm outputs. For a locked rotor condition, the ZXBM1015 puts motor drive outputs into a safe operating mode to protect the H-bridge and motor windings.

Visit Zetex at PCIM Europe Booth 12- 208

For further information and reader enquiries: Lin Collier
Zetex Semiconductors plc
Lansdowne Road
Chadderton
Oldham OL9 9TY
United Kingdom

Tel: +44 (0)161 622 4444
Fax: +44 (0)161 622 4469
E-mail: lcollier@zetex.com

www.zetex.com

Power Input Modules

Tyco Electronics Power Systems announced the PIM200, the industry's first power input modules designed to comply with the Advanced Telecom Computing Architecture (AdvancedTCA) specifications, providing Telecom Equipment Manufacturers a complete power solution for their AdvancedTCA boards. As a packaged solution, these standard, off-the-shelf modules greatly reduce product time to market, thus meeting the needs of telecom service providers in a more efficient manner. The packaged solution also reduces product complexity as a "one-stop shop" for managing all functions required by AdvancedTCA standards.

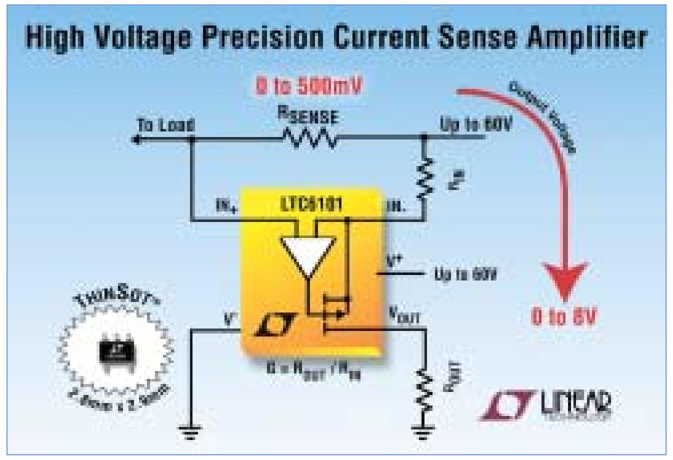
PIM modules are rated for 200W of maximum output power with a wide input voltage range of –38Vdc to -75Vdc, suitable for both –48Vdc and –60Vdc power distribution. The PIM modules incorporate all of the power management features required by the AdvancedTCA PICMG 3.0 specification. Some features of the modules are: Inrush Current Protection; ORing Functionality with MOSFETs; EMI filtering meeting Class B CISPR Limits; Hot Plug capabilities; A/B Feed loss alarm; 8W of Auxiliary power for IPMI and house keeping functions and Input undervoltage, overvoltage, overcurrent and thermal protections

In addition, the PIM200 modules provide a charging current at 72Vdc for external holdup/energy storage bulk capacitors to reduce real estate on telecom boards. Sized at 2.78 in x 1.45 in x 0.5 in (70.6 mm x 36.8 mm x 12.7 mm), the modules have a high efficiency of 97% at –48Vdc. When combined with Tyco Electronics' isolated DC/DC and bus converters and point of load modules, the PIM200 modules provide elegant powering solutions while complying with AdvancedTCA board power requirements, thus enabling automated and highly efficient board-level management capabilities.

Visit Tyco at PCIM Europe Booth 12- 421

www.power.tycoelectronics.com

60V High Side Current Sense Amplifier



Linear Technology's LTC6101 high side current sense amplifier combines very quick response times with an input voltage range of 4V to 60V. The LTC6101 can withstand voltages up to 70V, a valuable feature when power supply failures or catastrophic load changes can lead to transient overvoltage. With a response time under 1us, the LTC6101 is ideal for automatic power shutdown under fault conditions.

The LTC6101 is designed to extract a small differential signal from a high common mode voltage, and then amplify and translate this into a ground-referenced signal. Achieving this functionality with precision has typically required a combination of discrete components and op-amps, differential amplifiers or instrumentation amplifiers. The LTC6101 simplifies this task by requiring only the LTC6101 ThinSOT package and two resistors. Not only is this part much smaller and simpler, it consumes only 250uA.

The LTC6101 includes outstanding performance: input bias current is 170nA Max and input offset voltage is 300uV Max. Better than 1% accuracy can be achieved using precision gain resistors, allowing for excellent measurement resolution and the ability to accommodate inputs with large dynamic range.

For more information, contact:
Doug Dickinson, Media Relations Manager
Linear Technology Corporation
1630 McCarthy Boulevard
Milpitas, CA 95035-7417
ddickinson@linear.com

www.linear.com

Universal Active ORing Controller IC

International Rectifier introduced the IR5001S universal high-speed controller/N-channel power MOSFET driver for high-performance, active ORing circuits. The active ORing IC, housed in an SO-8 package, is used with an external MOSFET, replacing traditional diode ORing to increase efficiency and reduce power dissipation. Active ORing is a key requirement for many high-end systems requiring maximum up-time, such as carrier-class communication equipment and telecom and datacom system servers.

Active ORing combines two or more power sources to create a redundant power source, preserving the input power supply in case one of the input sources fails. In the event of an input power failure, the active ORing circuit disconnects the non-functioning power source as quickly as possible to prevent the system bus voltage from falling, and to prevent large peak reverse currents.

Technical highlights

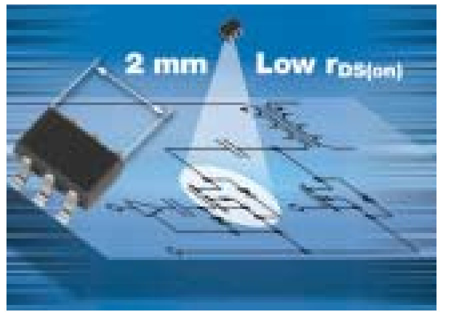
The IR5001S active ORing controller IC is suitable for a wide range of active ORing circuits, including -48V/-24V input active ORing for carrier-class communication equipment, 24V/48V output active ORing for redundant AC-DC rectifiers, 12V output active ORing for multiple-output DC-DC and AC-DC power, and for low voltage output redundant VRM DC-DC processor power. In 12V output systems, ORing circuits capable of handling currents of 100A can be made using four IRF6609 DirectFET MOSFETs in parallel. The IR5001S can also be used in reverse polarity applications for 48V/24V systems, replacing large D²Pak style diodes and an expensive relay.

Visit IR at PCIM Europe Booth 12- 201

http://www.irf.com
IR response management:
Mike Wigg, International Rectifier Co Ltd,
European Regional Centre
439/445 Godstone Road
Whyteleafe
Surrey. CR3 0BL
Tel: +44 (0)20 8645 8003
Fax: +44 (0)20 8645 8077
e-mail: mwigg1@irf.com

www.irf.com

150-V and -200-V p-channel Power MOSFETs



Unlike traditional packaging materials, A family of -150-V and -200-V p-channel power MOSFETs that offers space-saving solutions for active clamp configurations were released by Siliconix / Vishay .

While p-channel MOSFETs for active clamps offer a simpler alternative to n-channel clamp implementations, until now the majority of devices suitable for this application were available only in larger packages such as the SO-8 and DPAK. With the new devices in the SOT-23 and SC-70, Siliconix brings together small size and on-resistance values at least 80% better than the nearest competing devices.

Built on Siliconix's advanced p-channel TrenchFET technology, the compact dimensions of these new p-channel power MOSFETs reduce board space requirements to enable smaller overall product design without sacrificing performance. Because p-channel drive circuitry is less complicated than that of n-channel solutions, these new devices also allow designers to implement smaller, lower-cost active clamp designs in small and intermediate-sized power converters.

The power MOSFETs released today are intended for primary-side active clamp circuits in dc-to-dc converters for telecom, datacom, and industrial products. With on-resistance values ranging from 1.2 ohms to 2.35 ohms, these power MOSFETs represent industry-best on-resistance for their respective footprints.

The Company's facilities include a company-owned Class 1 wafer fab dedicated to the manufacture of power products in Santa Clara, California, and a Class 1 wafer fab located in Itzehoe, Germany utilized under a lease arrangement. Vishay is headquartered in Malvern, Pennsylvania, and has operations in 17 countries employing over 25,000 people.

Visit Vishay at PCIM Europe Booth 12- 547

www.vishay.com

High-Precision Industrial Op Amp

Texas Instruments introduced a 4mm x 4mm DFN package version of the high-precision OPA277 operational amplifier from the company's Burr-Brown product line. The OPA277 features an excellent combination of offset, drift and noise characteristics. This leadless, near-chip-scale package is less than 1mm thick and features contacts on only two sides, thereby minimizing board space requirements and enhancing thermal characteristics through an exposed pad. The DFN package can be easily mounted using standard PCB assembly techniques. (See www.ti.com/sc05093)

The OPA277's reduced package size allows compact designs in a variety of applications including industrial electronics, temperature measurement, battery-powered instruments and test equipment, and helps preserve precision by keeping the chip temperature low as the power is easily dissipated through the exposed pad. Additionally, the OPA277 features ultra low offset voltage (35uV typical) and drift, low bias current, high common-mode rejection and higher power supply rejection. The device also offers high open-loop gain and a wide supply range (to +/-18V).

For more information on TI´s complete analog design support, and to download the latest Amplifier Selection Guide, visit www.ti.com/analog.

Visit Texas Instruments at PCIM Europe Booth 12- 229

www.ti.com

Lead-Free Fuses

To meet the growing needs of manufacturers who must meet worldwide lead-free manufacturing requirements, Littelfuse has introduced lead-free versions of its 2AG, 3AG, 3AB and 5 x 20mm form factor fuses.

The company's goal is to allow end-product manufacturers to comply with emerging worldwide lead-free initiatives such as Europe's Restriction of the use of Certain Hazardous Substances in Electronic and Electronic Equipment, (RoHS) and the Japanese Electronics Industry Development Association lead-free product roadmap.

The new fuses also comply with electronic industry manufacturing standards for lead-free circuit board content including IEC 60068-2-20 as well as the EIA-IS-722 (Low Voltage Supplemental Fuse Qualification Specification), CSA and UL approvals.

Designed to withstand the higher temperatures associated with lead-free wave soldering, the new fuses offer the same performance specifications as the company's conventional 5 x 20mm, 2AG, 3AG and 3AB fuses, but in a lead-free package.

5 x 20mm series are currently available in full production quantities. 2AG, 3AG, and 3AB series are available for sampling and will be available June 2005.

www.littelfuse.com

Companies in this issue

Please note: **Bold**—companies advertising in this issue