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Bodo´s Power Systems™

Systems Design Motion and Conversion

August 2007

Power Modules for Hybrid Vehicles

Optimising Solar Installations

Extend Battery Lifetime

Design and Simulation

Multi-Phase Digital DC/DC

Bodo´s Power Systems

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Bodo´s Power Systems

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Events

Ansoft Design Seminars
http://www.ansoft.com/firstpass

National Power Seminars
www.national.com/see/powercourses

Fairchild Power Seminars
www.fairchildsemi.com/powerseminar07

EPE, September 2-5, Aalborg DK,
www.epe2007.com

Husum Wind, September 18-22, Husum D,
www.husumwind.com

Semicon Europa, Oct. 9-11, Stuttgart D,
www.semi.org/semiconeuropa

Electrical Power Quality and Utilisation, Oct. 9-11, Barcelona,
http://www.epqu2007.com

Digital Power Europe, Nov. 13-15, Munich,
www.dpfeurope.darnell.com

Productronica, Nov. 13-16, Munich,
www.productronica.com

SPS/IPC/DRIVES, Nov. 27-29, Nuremberg,
www.mesago.com

Wind is the Right Alternative Power

Wind is free and it's not (yet) taxable! Our grandfathers used wind power before steam engines replaced their sails. Now sailing is for leisure – to relax out on the waves with the wind moving the boat. But it is the nature of engineering to try and put wind to work. An innovative concept for large commercial ships uses a sail similar to a kite surfer to reduce fuel consumption. Windmills of the past processed wheat grain into flour for bread but today's windmills look a bit different and just generate electricity. They utilize modern inverter technology supported by efficient switches. Electricity is easy to distribute so wind power generators are popping up everywhere like mushrooms. And the wind is still free!

IGBTs are the workhorses in inverters. Invented over 20 years ago they are now the most popular and efficient switches for inverters. Power semiconductor material may change from silicon to silicon-carbide – a process that has been under discussion for just as long. SiC diodes are now in production and we are all looking forward to silicon carbide in active switches, MOSFETs and IGBTs. Just after the EPE conference in Copenhagen, ECPE will have a workshop on the usage and future perspectives of silicon carbide.

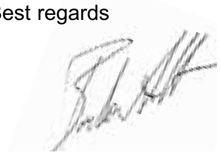
The higher operating temperature of SiC will be an advantage for power modules but module mounting technology is still a challenge with the necessity to migrate from solder technology to connections suitable for higher temperatures. Both the internal and external connections require a new class of products. Semikron has developed pressure contact modules which are also perfectly suited for electric hybrid vehicles. These trends reinforce more efficient green power applications.

We are looking forward to EPE in Aalborg in early September and HusumWind roughly two weeks later, both focussing on wind power. Denmark has the Baltic Sea on one side and the North Sea on the other. The wind there blows constantly and in many directions, some new. Schleswig-Holstein was once part of Denmark and the cultural influence is evident in Danish companies such as Danfoss Silicon Power with operations in Schleswig-Holstein. With no mountains to provide for waterpower Denmark started early to develop wind power as an alternative energy resource. It is nice to watch the big Danish trucks loaded with blades and towers driving south on the Autobahn for new installations in Europe. We see that California is using wind power and Pennsylvania is hard at work to become an expert in renewable energy by taking advantage of its wind power resources. The EPE and similar industry events will do their share to help move this technology forward.

My Green Power recommendation for August is to take a cold shower while the warm weather is still with us – it's both refreshing and helps get you awake in the morning. I tried it today.

See you in Aalborg, Copenhagen or Husum. They are all close to my home town.

Best regards



PROFIBUS Cracks the 20 Million Barrier

More than 20 million PROFIBUS nodes are now on the market around the world! The doubling of installed nodes from 10 to 20 million as announced by PI (PROFIBUS & PROFINET International) at the beginning of 2004 and predicted to occur by the end of 2007 was already achieved in April 2007, i.e. 8 months earlier than planned. This development impressively confirms the market leadership of PROFIBUS in all branches of industrial automation.

This figure demonstrates the significance of PROFIBUS for all companies that supply products and solutions for industrial automation. This also confirms the benefit of PROFIBUS as an important basis for the economic success of these companies on various markets.

Such a success is the occasion for a forecast of future trends. Edgar Küster, PI Chairman, predicts that PROFIBUS will enjoy uninterrupted growth: “We are continuing to attend to the constant growth of the world’s most accepted fieldbus system. At the same time, we are also smoothing the path for a simple changeover to PROFINET. With the simultaneous availability of PROFIBUS and PROFINET solutions, the customer can freely decide when the right point for him to change over has come.”

www.PROFIBUS.com

Miniaturized Energy Sources Solutions

STMicroelectronics and CEA, a French public technological research organisation, today signed an agreement to collaborate on the development of new miniaturized energy sources solutions. The two companies will establish a common laboratory in Tours and Grenoble, France, that will pursue advanced research in fields such as solid-state micro-batteries that promise longer life, greater safety and lower environmental burden than existing battery technologies, and micro-fuel cells for clean energy generation. Other promising energy generation, conversion and storage technologies that will be investigated include thermoelectric and mechanical scavenging techniques that convert, for example, physical motion into electrical power, always with a focus on low power applications.

ST, which has a major manufacturing facility in Tours, and CEA Liten (Laboratory of Innovation for New Energy Technologies and Nanomaterials), a research laboratory of CEA based in Grenoble, France, will collaborate on a four-year program to develop new miniaturized technologies for energy solutions with a particular emphasis on powering mobile phones, laptop computers and other portable electronic products. The collaboration will involve more than fifty researchers, distributed approximately between sites in Grenoble and Tours.

www.st.com

www.cea.fr

Magnet Systems for XFEL Pilot Project in DESY

VACUUMSCHMELZE is contributing VACODYM® magnets and VACOFLUX® components to the construction of a free electron laser (FEL) prototype at the DESY research centre in Hamburg. FELs have been built and operated for almost 25 years. Magnetic structures in the FELs in use today have a maximum length of a few metres. The DESY (German Electron Synchrotron) laboratory in Hamburg is currently the scene of a European project to design a superlative, revolutionary light source incorporating undulator structures several hundred metres in length.

This February, staff from VAC’s Hanau-based Systems Production Division installed the magnet systems in the first prototypes. The next step will be to “shim“ or adjust the completed structure on-site at DESY in Hamburg, where performance of the VAC components will be measured against the project’s high quality specifications. The findings and experience gained in the construction of the prototype structures will be incorporated into the design of the finished laser.

Work on the XFEL is likely to begin in the second half of 2007, with operation startup scheduled for 2013.

www.vacuumschmelze.com

Calls for Papers SENSOR+TEST 2008

Top-level conferences are on the agenda at the international SENSOR+TEST trade fair in Nürnberg. For the eighth time, the OPTO 2008 - International Conference on Optical Technologies for Sensing and Measurement - will again provide the forum for the experts. The IRS2 2008 - International Conference on Infrared Sensors and Systems - will take place next year for the tenth time. Calls for Papers have gone out for both of these conferences. Scientists and other professionals are asked to submit their contributions before 15 October 2007.

The focal point of the OPTO Conference is on the various optical technologies applied in sensor and measuring systems. These technologies are becoming increasingly significant, as many measuring tasks, which used to be carried out with the aid of electronics, can be performed today more quickly and efficiently by using optical methods.

The focus of the IRS2 Conference is on the implementation of infrared technology in sensorics and measurement. This technology is also finding more and more applications in a broad industrial environment – including environmental engineering itself.

These two international conferences will be held in English.

www.sensor-test.de

Automotive Solutions Engineering Center

ON Semiconductor has established a Solutions Engineering Center (SEC) in Munich, Germany, to drive new automotive product initiatives and expand the company's local service capabilities by providing on-site technical expertise.

The Munich SEC will focus on development of advanced power management solutions for a variety of automotive applications including Body, HVAC, Powertrain, Safety and Infotainment. It will provide development platforms and local product support to better service customers who design and manufacture electronic automotive sub-systems in Europe.

www.onsemi.com

C&D to Sell Power Electronics Division to Murata

C&D Technologies has announced the signing of a definitive agreement to sell its Power Electronics Division (PED) to Murata Manufacturing Co., Ltd of Japan (Murata) for $85 million cash, subject to customary working capital adjustments. The transaction is subject to regulatory and other approvals.

With annual revenues of over $185 million, PED is a world-leading manufacturer of DC/DC converters, AC/DC power supplies, magnetics, data acquisition devices and panel meters. PED's global customer base includes many of the most respected Tier I electronics manufacturers.

www.cdtechno.com

Ultracapacitors for Hybrid Bus Powertrain

Maxwell Technologies announced that Azure Dynamics Corporation, a leading developer of hybrid-electric and electric powertrains for commercial vehicles, has selected Maxwell's BOOSTCAP(R) 390-volt heavy transportation ultracapacitor module (HTM) as the energy storage and power delivery component of its latest hybrid shuttle bus powertrain.

The HTM 390 incorporates integrated balancing and monitoring capabilities and highly efficient internal cooling to enable it to sustain continuous current of 200 amps with minimal temperature increase in high-temperature
environments that are typical with heavy transportation applications. The standard module is encased in a rugged, splash- and dust-proof, IP 65-compliant, aluminium chassis. Up to three modules may be linked in series to deliver a total of up to 1,170 volts.

www.maxwell.com

Distributor of the Year Award

Semiconductor Distribution specialist SILICA, an Avnet company, has achieved the top distributor status with International Rectifier and won the European Distribution Award for being the clear leader in various dimensions within International Rectifier's award criteria scorecard, amongst them the highest number of new design opportunities.

"While International Rectifier experienced strong performance throughout its distribution network, SILICA was notably the distributor, providing excellent POS growth and the highest number of design opportunities to our business in Europe," said Berthold Duecker, Vice President, European Sales for International Rectifier. "They have displayed tremendous commitment to delivering value to their customers and to helping International Rectifier build its business. Silica has achieved a great deal in the past year and thoroughly deserves this recognition of its efforts."

International Rectifier developed the awards program to recognize distributors that have contributed most to its business during the year. Silica carries and creates demand for the complete range of IR's analog, digital, and mixed signal ICs, and other advanced power management products throughout Europe

"By maintaining intimate knowledge of International Rectifier's technology and how it can best be utilized within target applications, SILICA differentiates itself by helping customers design products around IR devices", says Miguel Fernandez, Silica President, during the award reception. "We are extremely honored to have received an award of this magnitude. It underscores the strength of our relationship with International Rectifier, and this translates into real benefits for our customers," he adds.

www.silica.com

www.irf.com

Online Lighting Applications Design Centre

Microchip announces an online Lighting Applications Design Centre. This comprehensive Web site provides a wide range of technical tools and resources that designers can use to add intelligence to lighting designs — including information relating to Microchip's PIC microcontrollers, dsPIC Digital Signal Controllers (DSCs), analog and memory products, as well as development tools.

New lighting technologies, such as Light Emitting Diodes (LEDs), dimmable fluorescent ballasts and High Intensity Discharge (HID) lamp ballasts, demand increased performance with greater energy efficiency. The flexibility of Microchip's low-cost digital, analog and memory products enables designers to easily add intelligence to lighting applications. Benefits include energy savings, prolonged product life, improved safety and light quality, reduced component counts, remote control and diagnostic capabilities, and the ability to easily adapt existing lighting designs.

www.microchip.com/lighting

40 Microwatt from Micromachined Piezoelectric Energy Harvester

IMEC together with its sister company IMEC-NL at the Holst Centre has fabricated an energy harvester to generate energy from mechanical vibrations by using micromachining technology. The harvester comes together with a model which can be used to optimize the device during design. Output powers up to 40µW were obtained which are in range of the required power for wireless sensor applications.

Energy harvesters, transforming ambient energy into electrical energy, are of great value for situations in which batteries cannot be replaced easily. A typical example is autonomous sensor networks that are spread over large areas or placed in locations that are difficult to access. Vibration harvesters in general make use of electromagnetic, electrostatic or piezoelectric conversion to generate electrical power. IMEC and IMEC-NL developed, modeled and characterized a miniaturized vibration harvester based on a piezoelectric transducer.

For an input vibration with a resonance frequency of 1.8kHz and an amplitude of 180nm, a maximum experimental output power of 40µW was measured. This comes well in range of the amounts of power needed by wireless sensor applications, such as the pulse-oxymeter developed earlier by IMEC and IMEC-NL, operating from the Holst Centre in Eindhoven (The Netherlands).

www.imec.be

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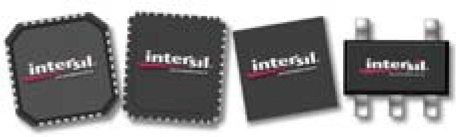

Battery Chargers

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- ISL6292
- ISL6292C
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Charging Safety

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- ISL9209C
- ISL9212
- ISL9212A
- ISL9212B

Authentication

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Analogue Technologies Drive Energy Efficient Handheld

Seven new display, audio and power management products from National Semiconductor enable energyefficient video in handheld devices such as mobile phones, portable media players and new converged devices that feature phone and media playback functions. The new products perform the “magic” of converting digital data into captivating real-world sights and sounds in the critical subsystems that enable video playback.

In-Stat anticipates growing demand for handheld multimedia devices. By 2011, the market research firm expects the video-enabled handheld device market to grow to 1 billion units from around 300 million in 2006.

Enhancing the display

The display is the centrepiece of the video experience. National’s low-power Mobile Pixel Link (MPL) family of products stream large quantities of data (seen by the user as images, video and graphics) to the display while maximising battery life. MPL serialises the data to reduce the wire count, which decreases the size of the connector and flexible printed circuit board (flex). MPL reduces electro-magnetic interference (EMI), and its power consumption is roughly half that of competing products. In addition, MPL handles the voltage-level translation between the host and the display, eliminating the need for an external level shifter. The newest member of National’s MPL family, the LM2512 is a high-speed serial host device.

Improving display backlighting and colour

To optimise the display, backlighting is critical. National’s new RGB LED drivers provide better colours on the display and lower power consumption compared to white LEDs. Available in a 25- bump micro SMD package, the LP5520 offers a small and simple solution without the need for optical feedback, producing a true white light over a wide temperature range while improving the colour gamut from 70 percent up to 100 percent of the National Television System Committee (NTSC) standard. In adaptive mode, the circuitry in the driver automatically adjusts the output voltage for the lowest possible power consumption. The LP5521, LP5522 and LP55281 colour management products feature an assortment of low-power colour LED drivers for a variety of handheld lighting applications.

Generating high-quality audio

Superior audio makes a great display even better. National’s new LM49100 audio subsystem allows routing of mono voice or stereo music signals to a mono speaker driver or stereo groundreferenced headphone amplifiers (or both) through simple selection of pre-set modes. In addition, it provides layout flexibility through its headphone ground-sensing function. The noise rejection improvement provided by this feature allows designers room to move in space-constrained systems. To maximise battery life, the LM49100 consumes the industry’s lowest quiescent current of devices in its class -- less than 5 mA, with all channels active.

Powering digital processors

Before video can be displayed, it must be decoded and processed by the application processor. Video processing consumes substantial energy, a major factor limiting battery life on mobile terminals. National’s innovative PowerWise® technology enables intelligent energy management of the processor using adaptive voltage scaling (AVS).

Supporting increased storage

The digital core processes data received from non-volatile storage, such as a secure digital card, FLASH or a micro hard drive. Each of these sources presents a unique energy consumption challenge in handheld devices. To power a micro-hard drive, National’s new LM3668 buck-boost regulator provides a 3.3V output voltage to power the driver motor.

Powering the wireless link

The demand to share video wirelessly is increasing, but sending data wirelessly consumes significant battery power. National’s new LM3207 DC-DC power supply, optimised for 3G RF power amplifiers, dynamically reduces energy consumption of the power amplifier by tightly regulating the RF power amplifier supply voltage to the lowest possible level while maintaining linearity in the power amplifier.

Engineering better systems

Whether for listening to high-fidelity audio, watching high-resolution video or capturing and sharing multimedia files, National provides all the differentiating analogue technology handheld devices need to minimise energy consumption and enhance users' experiences with longer battery life, better sound, sharper display images, smaller form factors, whiter lighting and streamlined interfaces.

www.national.com

The Need for a High Efficiency Linear Regulator

Novel Architecture Sets New Milestone in Power Density

By Ralf Muenster, Marketing Director, Power Products, Micrel, Inc.

With process technologies migrating to sub 100nm levels, supply voltages on many microprocessors, ASICs and FPGAs are now down to the 1Volt level, leading to decreasing margins for voltage fluctuations. The challenge that arises with these new low voltage requirements is that the tolerance on the supply voltages is remaining a fixed percentage of the supply voltage, instead of being an absolute value in volts. This means that as the core voltage goes down, the amount of tolerance that the processor can handle becomes smaller and smaller. For example, many high end ICs require supply voltages regulated to tighter +- 5 percent, which translates to only +-50mV at the 1V level.

Switching regulators seem the logical choice to power today's low voltage cores due to their good efficiency converting voltages downward from available 5Vand 3.3V rails. However, by their very nature, switch-mode converters create a significant amount of ripple voltage on their outputs. A synchronous single-phase DC-to-DC converter that is fully loaded can have anywhere from 10 mV to 100 mV of voltage ripple on the output. Relative to a 1-V output voltage, that is 1 percent to 10 percent of the regulator output voltage. On the other hand, linear regulators provide clean low noise outputs with good ripple rejection from the input.

Output ripple is not the only problem when supplying today's advanced process cores. With the lower geometries, the operating frequencies of these uPs, ASICs and FPGAs have risen to GHz levels at the very same time. Fast switching speeds can create dramatic dynamic load changes depending on the software code executed. In turn, these fast load changes can result in huge fluctuations on the supply voltage depending upon the response time of the voltage regulator that is used. The response of the regulator to load changes is sometimes referred to as transient performance.

Switch-mode converters in general have slower response times to load changes compared to linear regulators. The load transient response of a linear regulator can be made to be much higher than that of a DC-to-DC converter because it is a linear system. With the proper loop design, the output of the linear regulator can have gain-bandwidth loops as fast as 10 MHz. A typical DC-to-DC converter is limited by the switching frequency, which is generally around 1MHz. Moreover, in order to remain stable under all conditions, the DC-to-DC converter typically needs to roll off its gain and operate with a gain-bandwidth product of one-tenth to one-fifth of the switching frequency. This means that the transient voltage regulation of a switching regulator will be 10 to 100 times worse when compared to a linear regulator.

Linear regulators still have one essential drawback, their efficiency for a 5V to 1V or 3.3V to 1V conversion is very poor. This is due to the simple fact that they have to dissipate the energy of the voltage drop in the device. For example, the efficiency for the 3.3V to 1V conversion will be a mere 30 percent and 6.6W of power would have to be dissipated as heat to provide an output of 2A. This is too much for a conventional IC package and a large heat sink would be needed making the solution very large in size.

There is therefore a need for new type of voltage regulator, a high efficiency linear regulator that provides a low noise output, fast transient performance, good PSRR, small solution size while at the same time providing good efficiency.

To address this trend, Micrel recently introduced a new SuperLNR™ architecture that combines the "good" characteristics of a linear regulators with the efficiency of DC-to-DC converters to produce a new generation of easy-to-use Low Noise Regulators. Micrel's MIC38300, the first device with the SuperLNR™ name, is a 3A peak, 2.2A continuous output voltage regulator housed in a tiny 4mm x 6mm x 0.9mm MLF® package that produces less than 5mV of output noise. The novel architecture is a patented combination of a high performance LDO with over 70dB of PSRR at 1kHz supported by a fully integrated synchronous switcher. The new architecture allows the MIC38300 to achieve industry leading, ultra-fast dynamic performance, on par with the fastest LDOs on the market today. The device also maintains less than 30mV of output voltage deviation even during fast load transient while at the same time supporting efficiencies up to 85%. The MIC38300 features an input voltage range of 3.0V to 5.5V and adjustable output voltages as low as 1V.

Most impressive, the solution requires no external inductor and fits into a total footprint of less than 50mm² with a profile height of less than 1mm; about 1/15th the volume of a standard TO-263 or TO-220 LDO power package.

The device is targeted at applications that need an easy upgrade from LDOs as power dissipation becomes an issue or where low-noise performance, small size and fast transient performance are paramount. Target markets include point-of-load and digital IC power regulators for networking, servers, wireless base stations, industrial and RF applications.

With the SuperLNR™ technology a new architecture of voltage regulators has been born. It cannot be squarely placed in the linear regulator or the switching regulator camp. However it combines the advantages of both while at the same time setting a new milestone in power density.

Note: MLF is a registered trademark of Amkor Technology. SuperLNR is a trademark of Micrel, Inc.

www.micrel.com

Electronics Industry Digest

By Aubrey Dunford, Europartners

The European Commission adopted its proposal to launch a Europe-wide public-private research partnership in nanoelectronics, called ENIAC. With an expected budget of €3 billion from industry, Member States and the Commission, it will create a strong nanoelectronics research and manufacturing sector in Europe. Between 2008 and 2013, 60% of the expected €3 billion nanoelectronics research fund will come from industry.

BASF and Bosch are to cooperate in the innovative field of organic photovoltaics (OPV) and are founding members of the technology initiative of Germany's Federal Ministry of Education and Research (BMBF). The BMBF will provide €60 million for research to develop this market, while the initiative's current industry partners – which include, alongside BASF and Bosch, Merck and Schott – plan to spend up to €300 million. Organic solar cells are flexible and both light and color tunable.

SEMICONDUCTORS

European semiconductor sales in May amounted to US$ 3.275 billion, down 0.5% versus the previous month, so WSTS. This corresponds to a 1.8% growth compared to the same month last year. On a YTD basis semiconductor sales increased by 4.0% versus the same period in the year 2006. **iSuppli** is remaining optimistic, with a prediction of a healthy 6 percent increase this year to $276.6 billion.

After increasing 18% in 2006, total semiconductor-industry capital spending is forecast to climb only 1% in 2007, so **IC Insights**.

The semiconductor industry in Germany was up only about 3% in May compared to last year. Incoming orders are likewise declining as compared to April, so **VdL/ZVEI**. However, sales for the first five months of the year grew 2 percent compared to the same period last year.

Members of France's **SITELESC** reported May 2007 sales down 6.7% sequentially (+8.9% for exports ; -14.4% for local sales). For the five first months in 2007, Sitelesc members sales decline 22.9% from January-May 2006.

The worldwide semiconductor materials market is expected to grow over 10 percent in 2007, and is forecast to grow another 10 percent in 2008, so **SEMI**. Growth in 2007 is expected for both the wafer fabrication materials and packaging sectors. Current estimates predict that the fab materials market will grow about 9% to reach $24.0B, and the packaging materials market will grow over 13% to reach $16.6B this year.

Worldwide semiconductor contract assembly and test services (SATS) market experienced double-digit growth in 2006 as revenue totaled $19.2 billion, a 26.5 percent increase from 2005, so **Gartner**. Outsourcing's share rose to 43.5 percent of the total semiconductor packaging market.

STMicroelectronics and CEA, a French public technological research organisation, have signed an agreement to collaborate on the development of new miniaturized energy sources solutions. The two companies will establish a common laboratory in Tours and Grenoble, France, that will pursue advanced research in fields such as solid-state micro-batteries and micro-fuel cells for clean energy generation.

Infineon Technologies announced the planned acquisition of Texas Instruments DSL Customer Premises Equipment (CPE) business. The transaction is expected to close in the summer of 2007.

Tyco Electronics officially becomes an independent, publicly-traded company, completing its split from Tyco International.

OTHER COMPONENTS

C&D Technologies announced the signing of a definitive agreement to sell its Power Electronics Division (PED) to Murata for $85 million cash.

Spectris has sold its in-line instrumentation business Ircon to **Fluke** Electronics for $ 33 M. Ircon manufactures noncontact infrared thermometers.

Aeroflex announced its decision to divest its radar systems development and manufacturing business located in Powell, Ohio and to seek a strategic buyer. The two other divisions, synthetic test systems and broadband test equipment, will be retained.

Umicore and **Hydro** will join forces in the production of solar-grade silicon used in the production of solar cells. The new company, based in Norway, will be named HyCore.

DISTRIBUTION

Future Electronics reported strong Q1 2007 EMEA sales of $165 M, up 18% on Q1 2006, and 19 % up on calendar Q4 2006. Best performing regions include Germany (+33%) Benelux (+27%) Eastern Europe (+19%) Spain (+17%) and Nordics (+15%). Q2 07 runrates are flat on Q1 07. Recent additions to the management team include George Hiltrop (France, Benelux) and Gary Oliver, Financial Director, formerly of Ingram Micro.

This is the comprehensive power related extract from the «Electronics Industry Digest», the successor of The Lennox Report. For a full subscription of the report contact: eid@europartners.eu.comor by fax 44/1494 563503.

www.europartners.eu.com/services/digest.htm

EPSMA Leads Charge Against IPC Standard

By Douglas Bess, Editor, PowerPulse.Net

Scott Strand, Ph.D., Senior Technical Staff Member, Integrated Technology Delivery Quality, IBM, and Chairman of the IPC-9592, **Requirements for Power Conversion Devices for the Computing and Telecommunications Industries**, subcommittee recently said, "I am extremely satisfied with the results of the [June 27] meeting. There was a tremendous amount of cooperation and this combined team will continue working to create a very useful document for the entire industry. " (You can see video interviews of Dr. Strand as well as Lars Thorsell, chairman of the European Power Supply Manufacturers Association's (EPSMA) Technical Committee, and other participants in the IPC-9592 meeting at: http://www.powerpulse.net/conferenceVideo.php)

Dr. Strand's statement on Wednesday afternoon, 27 June, followed two days of intense discussions. The events leading up to that pivotal meeting began on 20 April when PowerPulse.Net uncovered the 'secret' efforts to launch the nearly 100-page proposal for the IPC-9592 standard.

In the April article, Dr. Strand was quoted, "This is a comprehensive document that will be of significant value to both customer and supplier. We started developing the document in September 2006 and I am confident we can finalize this consensus standard by the third quarter of 2007. This is not only a testament to the process, but to the hard work of the IPC subcommittee members."

About a week after that exclusive article appeared in PowerPulse.Net, the European Power Supply Manufacturers Association (EPSMA), issued an open letter stating it was "very concerned" about the draft document. The EPSMA letter continued, "The draft has the content of a guideline, but the language of a standard."

A week later, EPSMA issued a further statement. Lars Thorsell, who chairs the EPSMA's Technical Committee, commented: "A guideline of this type is useful but the document should look very different. At the moment it feels like a standard. The documentation required by IPC-9592 is excessive, and makes it impossible to protect suppliers' confidential information. Furthermore the extensive testing specified would significantly increase cost and time-to-market, which runs completely counter to market demands."

Also at that time, the EPSMA "offered its expertise to produce a new document, leading to feasible and economically viable requirements."

In commenting on the EPSMA concerns, a representative of the IPC Power Conversion Subcommittee responded in part, "The purpose of the IPC-9592 is to put forth a minimum set of acceptable requirements for power supply specifications. The IPC subcommittee members all agree that FMEA is a very important process to develop a design that meets requirements for function, quality, and reliability as early in the process as possible. I am not in total agreement that FMEA will cost a lot of money."

In announcing the June meeting, Tony Hilvers, Vice President of Industry Programs with IPC, stated, "We welcome all comments and suggestions. If you don't like the draft, I challenge you to get involved in the process and make constructive comments. Only the first draft has been released. We may go though multiple drafts before reaching a consensus on the document."

During that interview, Hilvers indicated that between 15 and 20 companies sent in over 70 pages of comments to the current Draft. From the beginning, the public comments over IPC-9592 have grown more and more strident and various parties established increasingly hardened positions for and against the draft.

The EPSMA responded to Hilvers'challenge to get involved' and issued a letter to IPC, highlighting a number of concerns. The IPC draft was considered too broad, attempting to address too many products and applications. In addition, the document was considered to be overly prescriptive in its attempts to secure quality and does not leverage existing standards from JEDEC, IEC, IEEE and ISO.

Bernhard Erdl, Chairman of the EPSMA, added, "The EPSMA have already supported the High Density Packaging User Group (HDPUG) which represents a large number of companies from the communication and system integrator industries. It has done a lot of work in producing guidelines for board-mounted power supplies (BMPS) over the last two years, working closely with the user community. This work has resulted in a comprehensive document of nearly 150 pages, aimed at a mature and bilateral understanding between users and manufacturers of such products. The BMPS Applications Guidelines was published and released by HDPUG in late March this year."

The EPSMA again stated it would be happy to share its expertise with IPC, as it did previously with its collaborative work with HDPUG. It proposed to work closely with IPC to develop a document with collective input from both users and manufacturers.

Members of the IPC's Power Conversion Subcommittee, leading power supply associations and power supply manufacturers from around the world converged on Chicago, Illinois, June 26-27, to discuss the draft of IPC-9592, and make plans for its continuing development and publication.

The companies that comprise the proposed standard's originating subcommittee (of the IPC OEM Critical Components Council Steering Committee) – **Dell**, **IBM**, **Lenovo**, **Hewlett Packard**, **Cisco Systems**, **Alcatel Lucent** and **Apple** – organized the meeting. Representatives from the **EPSMA**, the **Power Sources Manufacturers Association** (PSMA) and the **Distributed-power Open Standards Alliance** (DOSA) joined in the discussion, along with individuals from **Astec/Artesyn** (U.S.), **Astec Power** (Philippines), **Astrodyne** (U.S.), **C&D Technologies** (U.S.), **Lite-on** (U.S.), **Lite-on Technology** (Taiwan), and **Tyco Electronics Power Systems** (U.S.).

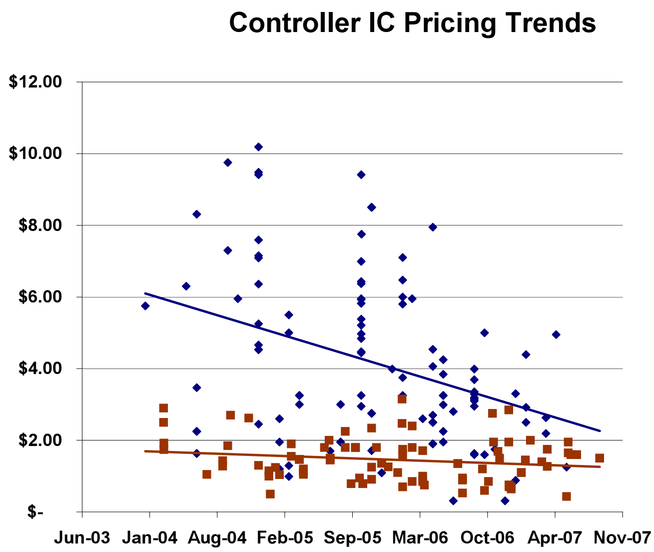
Although the meeting was preceded by serious concern from associations representing power suppliers, those points were addressed and the organizations (as well as other companies in attendance) have agreed to serve on the IPC-9592 subcommittee. Without the leadership of EPSMA, the result may not have been nearly as positive. Complete coverage of the events leading up to the June IPC meeting as well as video interviews with several of the key participants can be found at: http://www.powerpulse.net/conferenceVideo.php

Darnell Predicts Price Parity for Digital Power ICs

By Jeff Shepard, President, Darnell Group

Based on a comprehensive analysis of pricing trends over the past 42 months, Darnell Group has determined that digital power controller ICs will reach pricing parity with existing analog devices in the first quarter of 2008. This prediction is based on an analysis of the pricing of over 250 switch-mode controller ICs between January 2004 and June 2007. In a little over 3 years (early 2004 to June 2007), average prices for digital power ICs have dropped from about $6 to under $3 today. Prices for digital controller ICs will continue to drop and are predicted to be under $2 by the first quarter of 2008.

"Moore's Law" is driving the inevitability of digital over analog solutions. Analog IC technology follows its own version of Moore's Law, which means the die size of analog is shrinking by 30% every generation, and the cost is cut in half every 4-8 years. In the case of digital ICs, the die size of digital is shrinking by 2X every new generation. A new generation is 18-24 months. Since the cost of every new generation is 10-20% higher, it takes approximately 2-3 years for digital to reduce the cost by 2X. The fabrication nodes to make digital controllers less costly than analog controllers already exist and are being used to make the latest generation of microcontrollers. In the very near future (early 2008), it will become cost-effective for use in commodity parts like power supply controller ICs.



But Moore's Law is only one factor that has contributed to the rapid drop in prices for digital controllers. At the same time that digital process technology is moving forward, the designs of digital controllers are evolving. The new IC designs are a major factor contributing to the falling prices for digital control ICs. Darnell Group has completed a detailed study of the commercial roll-out of digital controller ICs. This pricing study is only one aspect of the overall research effort that also included detailed analysis of the integration levels and features included in successive generations of digital power ICs. Complete details on this study can be found at

www.Darnell.Com

Interview on Power Management

with Dave Bell, President and COO Intersil

By Bodo Arlt, Editor BPS

Bodo Arlt:
What end markets will drive Intersil power management growth?

Dave Bell: Much of Intersil's power management growth comes from its dominant position in the computing power market. This technological leadership is directly applicable to processor power requirements in a growing number of automotive, communications and industrial applications. We see broad growth in these sectors as well as continued expansion in our computing and consumer products.

Bodo Arlt: What is Intersil's position besides the wide range of ICs?
Dave Bell: In almost every end-market, we bring unique leadership positions. Intersil's computing power business has been the market leader in motherboard power management for seven years and has more recently emerged as the market leader for notebook core power as well. And, in the industrial and communications power markets, Intersil delivers complete telecom/datacom base station solutions, from bus converters, FET controllers, voltage sequencers and voltage monitors.

Bodo Arlt: What are the technologies that Intersil offers innovation leadership?

Dave Bell: Intersil's latest generation of computing power PWMs utilize our newest architecture to deliver the industry's fastest transient response. Our patented R3 TechnologyTM, which stands for Robust Ripple Regulation, monitors a transient current and then adjusts the switching frequency accordingly. We will also will be leveraging this technology across a wider range of power management ICs, including powering processors for the automotive market.

Bodo Arlt: What impact will digital power have?

Dave Bell: The impact of digital power will be in greater programmability and system telemetry, which is the ability to read back parameters such as power consumption and temperature. This diagnostic functionality will greatly increase the reliability and performance of products, which is why Intersil's first offerings in digital power will be geared toward the high-end computing and infrastructure markets. This is a market where the power efficiency and enhanced telemetry provide an immediate technological advantage.

Bodo Arlt: Is power management more in silicon, or is it also part software design?

Dave Bell: There are really three elements to power management: the actual silicon design and manufacturing processes, the power converter architectures which can be analog or digital, and then the software design that runs at the system level. This system level software allows the end designer more programmability and enhanced telemetry. Intersil is a proven leader in chip level design and processes as well as power system architectures.

Bodo Arlt:
What makes Intersil different from traditional IC suppliers?

Dave Bell: One key differentiator is our unique manufacturing structure. Intersil uses a "fab light" strategy which has two key benefits: accelerated introduction of new fab processes through foundry partnerships, and the continued use of unique, proprietary processes in internal fabs. Intersil's internal fabs run specialized analog processes that cannot be obtained from external foundries.

Bodo Arlt: How much is Intersil involved in the end customer's application?

Dave Bell: There is a gap emerging within the electronics industry due to the fact that analog solutions are growing more complex and there are fewer experienced analog engineers. Because of this, our Field Application Engineers play an increasing role in helping our customers understand their systems. Our FAEs are essential in helping our customers get their products to market quickly. Because of our many years as a leading application specific IC supplier, we can take on this responsibility and commit to meeting our customers' needs.

Bodo Arlt:
How much is Intersil involved in ICs for automotive applications?

Dave Bell: This has become a focus market for Intersil. With the increase in infotainment electronics, Intersil will be an even bigger player in both analog mixed signal and power management applications. Intersil is a proven leader in high-reliability ICs for military and space, and we're now leveraging that expertise and company culture for automotive products. As a sign of our commitment, Intersil has created an entire business unit to specifically address the development and marketing needs of the automotive industry.

Bodo Arlt: What will be the future for LED driver technology?

Dave Bell: Intersil has established a leadership position in white LED backlighting drivers for notebook computers and displays. These products are directly applicable to the LED lighting solutions in automobiles, including lighting for navigation displays, heads up displays, instrument cluster displays and internal/external lighting systems. Apart from the automotive market, this leadership position will help Intersil capitalize across the board as the desire to eliminate CCFL heavy metals expands white LED usage in notebooks, monitors and TVs.

Bodo Arlt: Do we expect only monolithic components in power management?

Dave Bell: We anticipate that in the future, finer line-width processes will enable higher current monolithic solutions that will reduce the size and complexity of ICs. This, in turn, will enable the creation of higher current and high voltage monolithic power management products. We also expect module level solutions to become more popular, utilizing both integrated functions and discrete components.

Bodo Arlt: Do we expect to see more digital power IC technology from Intersil?

Dave Bell: Intersil will utilize digital power where it makes practical sense for our customers. Given the current technology, digital power brings little benefit to handheld consumer products. This is why our first offering will be specifically geared for the datacom/telecom infrastructure market where the slight increase in efficiency along with enhanced telemetry will deliver cost savings and improved reliability. The ISL8601 will be the first IC to combine a PMBus compliant digital interface with the performance of an analog control loop. Intersil will continue to focus on devices that offer immediate market impact and improved functionality.

Bodo Arlt: Which of your competitors do you believe will stimulate the race for leadership in digital power?

Dave Bell: It is not surprising that all of the top power management companies will invest in digital power research and development. However, we believe that Intersil's unique process capability, along with its superior analog power architecture knowledge, will enable us to emerge as a top performer in these technologies.

Bodo Arlt: Thank you Dave for the time. We look forward to a successful future for power management IC development.

David B. Bell
President, Chief Operating Officer, and Director, Intersil Corporation
Mr. Bell was named President, Chief Operating Officer, and Director of the Company in April 2007. Prior to joining the Company, Mr. Bell spent 12 years with Linear Technology Corporation ("LTC"), most recently, from June 2003 to January 2007, as its President. Prior to becoming President of LTC, from January 2002 to June 2003, Mr. Bell served as LTC's Vice President and General Manager of Power Products and, from February 1999 to January 2002, as LTC's General Manager of Power Products. From June 1994 to January 1999, he held the position of LTC's Manager of Strategic Product Development. Mr. Bell has a B.S. degree in Electrical Engineering from the Massachusetts Institute of Technology.

HUSUMwind

September 18th to 22nd

The HUSUMwind continues to grow. The anniversary event of the HUSUMwind, held from 18 – 22 September 2007, will be no exception. Organised for the tenth time, the HUSUMwind follows the tradition of its predecessor to accommodate even more exhibitors on further extended exhibition grounds.

This has been verified by reliable figures revealed at the second meeting of the Advisory Board on 25th of April: This year Husum Wind is offering 14% more exhibitors, including an increasing supplier presence. We estimate that over 30% of the exhibitors will be from abroad, the exhibition area has been increased by 20%

A minimum of six countries are presumed to be represented at International Pavilions: Denmark, Great Britain, France, Taiwan, the USA, and Canada. In addition, there will also be eight joint exhibitors from Germany. It may be presumed that approx. 600 exhibitors will be presenting their products and services to the 16,000 visitors currently expected for late summer 2007.
The central entrance will be located at the shuttle bus stop for Schwesing airport as a P+R car park, for Hamburg airport, the Husum train station, and the Husum town centre.

HUSUMwind Congress: "Develop the future!...of wind energy"
The trade fair will be accompanied by an international congress that is being held on the exhibition site directly adjacent to Entrance Hall 4. There are three conference rooms, one with 120 seats and two with 50 seats, where over 25 wind energy companies and institutions will be holding interesting events throughout the trade fair.

The great interest already shown in these events indicate that there will be a great run for them. Make sure you get a seat by registering at www.husumwind.com / congress.

Picture: The Fairground

windcareer: "See your future! – Meet your new employee"
This the motto of this year's windcareer job fair at HUSUMwind, to be held on Saturday 22nd September in all congress areas. windcareer is the opportunity for qualified applicants to meet possible future employers. A large number of training and educational institutions will be presenting information about apprenticeships and study courses suitable for career opportunities in this globally booming industry.

There is no better opportunity to find out about qualifications needed, and to bring together prospective employers and employees, than at the largest wind trade fair in the world, HUSUMwind.

Come to meet the wind energy family
Husum's charm really is that of a small town that combines history and modernity.
No other place demonstrates this as clearly as the harbour area. Wind turbines and fishing boats make up a picturesque ensemble. Ships are no longer built here, but wind turbines are built in their place:
The former wharf area on the south side of the harbour is one of the locations of the wind turbine manufacturer "REpower Systems AG".

From building ships - to building rotor blades:
Wind energy is the business sector that Husum is backing in a big way. Besides „REpower", "Vestas Deutschland", one of the leading German manufacturers is also represented. The "Training Centre for Renewable Energies" (BZEE) educates service technicians for the wind energy sector and in the House of Future Energies renewable energy is programme.

The town has sharpened its profile through consistent development since the beginning of the HUSUMwind at the end of the Eighties. An up-to-date exhibition hall has been built that meets modern standards, and the necessary infrastructure.

Our strong point is that everything is within easy reach:
This is what makes Husum something special as a tradefair location. Our strength is in the relaxed atmosphere, the fact that everything is close at hand. In Husum the wind energy scene meets as a family, and you are always at the heart of things in the wind energy sector. HUSUMwind has never tried to copy what larger cities can offer. Far more we have always cultivated our own charm, while keeping an attentive eye on the demands of this innovative sector.

Extend an invitation to the wind world!
The wind world meets in Husum – extend an invitation to them! Bring in your own ideas to the HUSUMwind 2007 and together with us make reality of something you've always wanted to do!
Bring in your own ideas! Demonstrate your success to the world of wind!

www.husumwind.com

Reliable IGBT Power Semiconductor Modules for Hybrid Electrical Vehicles

Hybrid drives today have the potential to save energy in the automobile.

A main component of the hybrid system is the electric drive combined with the internal combustion engine. Significant attention needs to be given to the design of the power electronics according to the requirements arising from the various operating conditions as well as with regard to the ambient conditions in the vehicle.

By Ingo Graf, Infineon Technologies

Contrary to industrial applications, integration into the vehicle leads to other partially higher requirements. Ambient and system conditions such as strong vibrations, high temperatures, transient loads, high power density or a high number of load cycles impact significantly on the design and application of possible semiconductor concepts. Only one limiting factor here is the restricted space available in the vehicle.

Conditional on the various installation positions in the vehicle suitable semiconductor concepts such as power semiconductor modules need to be developed. Figure 1 shows the typical construction of a power semiconductor module.

Quality level and lifetime of the components used are the same for the hybrid system, while the ambient conditions for the various components can be very different. Hence the requirements for temperature and load cycle robustness of the power electronics are different. Cooling system and installation position can be simplified and categorized according to table 1.

High demands with regard to reliability are placed on the bond wire connections in the components. The operating load changes in the aluminium wire (power cycles) and the differing coefficients of expansion of silicon and aluminium result in micro-movements in the material. This may lead to small cracks in the connection points, the so called "Bond Wire Lift Off". In effect the component may fail.

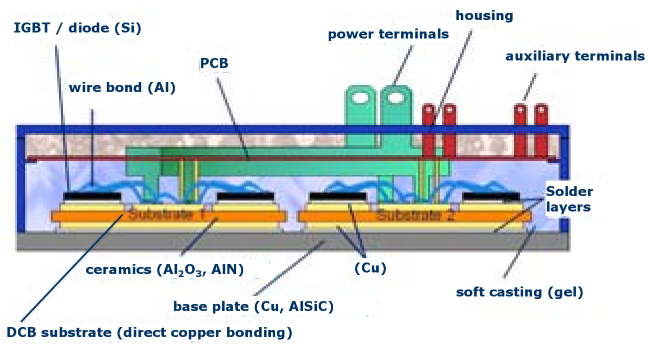


Figure 1: Construction of a power semiconductor module with DCB technology

During its lifetime the connection point between silicon and bond wire will endure several million load cycles. Depending on the temperature rise ΔT taking effect on the semiconductor, a number of power cycles will be achieved accordingly. Generally, the number of possible load cycles reduces with increasing ΔT.

	Ambient temp.	Coolant temp.	Thermal cycles	Power cycles	Vibration	Shock
Trunk mounted with forced air cooling	- 40 °C – 85 °C	- 40 °C – 65 °C	medium	medium	5 g	50 g
Engine compartment with seperate liquid cooling	- 40 °C – 105 °C	- 40 °C – 85 °C	high	high	10 g	100 g
Engine mounted with engine coolant	- 40 °C – 105 °C	- 40 °C – 125 °C	high	high	10 g	100 g
Transmission mounted with transmission coolant	- 40 °C – 140 °C	- 40 °C – 150 °C	very high	high	20 g	400 g

Table 1: Requirements on the power electronics depending on installation position.

A significant influence on the load cycle capability is the temperature level of the component. Fluid cooled power electronics in hybrid drives will, other than air-cooled systems, reach heatsink temperatures of more than 100 °C. For semiconductors with a permissible junction temperature of Tj = 125 °C (continuous operation) this will only leave little headroom for temperature rise. Thus semiconductors with higher junction temperatures are required for hybrid systems.

An increase of the junction temperature by 25 K reduces the possible load cycles by a factor of two. When introducing the Infineon designed 600V IGBT³ and the EmCon3 diode, measures had to be taken both in chip design as well as in packaging of the semiconductor module, to achieve the same cycling capability at the increased junction temperature of 150 °C.

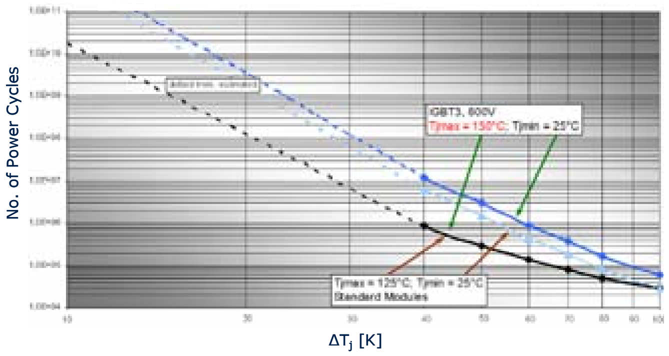


Figure 2: Power cycling graphs for power semiconductor modules, 600V IGBT³ vs 600V IGBT²

Figure 2 shows the possible number of cycles (power cycling graphs) for various temperature levels (T_j: junction temperature of the semiconductor) at various temperature fluctuations ΔT_j. The number of load cycles of the 150 °C curve (600V IGBT³) achieves the same number of possible load cycles at the same temperature rise as the 125 °C graphs (600V IGBT²). In other words, this equates to an improvement of the load cycle capability for the 600V IGBT³ chip by a factor of two, referenced to a junction temperature of 125 °C.

Over the lifetime of direct copper bonding (DCB) modules the layers are prone to recurring mechanical stress, due to the ongoing thermal cycles. Caused by the current flow in the semiconductor and the resulting heat up, the materials used such as copper, ceramics, silicon and aluminium expand with their different coefficients of expansion

This may lead to premature solder fatigue between the DCB substrate and the baseplate. The result is delamination of the solder layer and the increase of the thermal resistance caused by this. Finally, the component fails due to overheating.

For industrial applications usually modules with a standard DCB (Al_2O_3) in conjunction with a copper baseplate are used, as the requirements for thermal cycling capability are much lower here than in traction applications for example. For these often a combination of materials is used consisting of an AlN DCB and an AlSiC baseplate.

An important qualification test for semiconductor modules is the so called thermal shock test (TST). In this two chamber test the module is permanently exposed to temperature fluctuations of -40 °C to 125 °C (or 150 °C) and from 125 °C (or 150 °C) to -40 °C. After the test with a predetermined number of cycles the degree of solder layer delamination between baseplate and DCB is evaluated.

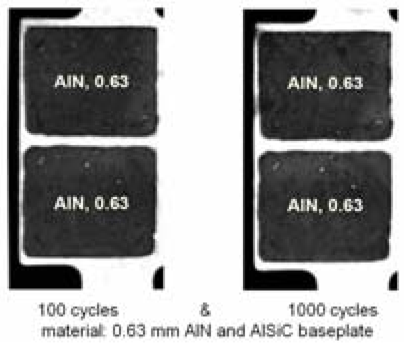


Figure 3: Ultrasonic scan of solder delamination after TST for AlN DCB and AlSiC baseplate

Power semiconductors for hybrid drives bear requirements of up to 1000 cycles of thermal shock. This requirement can not possibly be achieved with a standard DCB module construction. One solution would be the use of the material combination mentioned above – AlN DCB with AlSiC baseplate. This approach, however, results in added material cost and is suitable primarily where the heatsink temperature is already at a very high level. As can be seen in Figure 3, the degree of solder layer delamination is unchanged even after 1000 cycles for this combination of materials.

Considering the temperature fluctuations and number of required thermal cycles during the lifetime, a cost optimised solution has to be found for the power semiconductor concept. One solution is the use of a so called “improved” Al_2O_3-DCB in conjunction with a copper baseplate. This combination of materials is mainly suitable for mild hybrid systems and some full hybrid systems.
Figure 4 shows clearly that an “improved” DCB contributes to a much advanced thermal cycling capability.

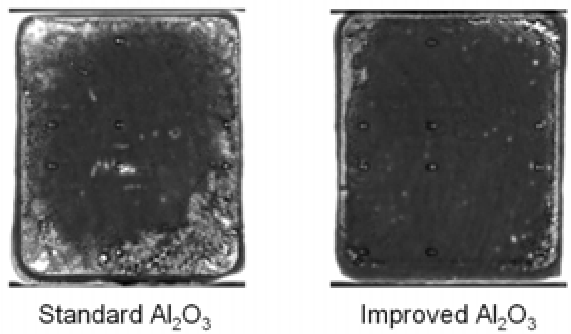


Figure 4: Ultrasonic scan of solder delamination after TST for Al_2O_3 - DCB on copper baseplate

When designing the power semiconductor module particular consideration needs to be given to the load profile during the lifetime of the hybrid vehicle. Once the required profiles are available detailed in passive temperature fluctuations and current profiles, a suitable combination of materials substrate (DCB) / baseplate can be determined.

The following hypothetical example (Table 2) depicts, for a supposed annual temperature profile, what influence different combinations of materials and/or construction techniques will have on the thermal cycling capability, considering various cooling conditions. The assumed temperature rise delta Tc (temperature rise of the baseplate) is the reference value for the lifetime consideration. Assuming that the percentage of used available lifetime can be accumulated, the final value is then determined. If the final value exceeds 100%, the selected module solution (combination of materials / construction techniques) is insufficient for the assumed conditions in this application. Failure of the power electronics will occur before the required lifetime has expired.

It can be shown that in water cooled systems with high temperature levels the use of high-end combinations of materials / construction techniques can satisfy the requirements for the lifetime expectation (Table 2b).

a) air cooled system

T_heat sink max [°C]	65	65	65	65	65	65	65	65	65	65	65	65		
T_air_ambient_min = Tc_min [°C]	-25	-20	-15	-10	-5	0	5	10	15	20	25	30		
T_h [°C]	80	80	80	80	80	80	80	80	80	80	80	80		
T_c_max [°C]	89	89	89	89	89	89	89	89	89	89	89	89		
delta Tc [K]	**114**	**109**	**104**	**99**	**94**	**89**	**84**	**79**	**74**	**69**	**64**	**59**		
Cycles per day	2	2	2	2	2	2	2	2	2	2	2	2		
days per year	5	10	10	20	25	30	45	50	50	50	35	35	**365**	
Cycles per year	10	20	20	40	50	60	90	100	100	100	70	70		
Cycles per lifetime	**150**	**300**	**300**	**600**	**750**	**900**	**1350**	**1500**	**1500**	**1500**	**1050**	**1050**	**15 years**	
virtual no. of possible cycles (lifetime)	568	804	1136	1607	2272	3213	4544	6426	9087	12850	18172	25697	**total [%]**	
x % of possible lifetime used @ module solution **1** (cost efficient)	26,4	37,3	26,4	37,3	33,0	28,0	29,7	23,3	16,5	11,7	5,8	4,1	**280**	**not sufficient > 100 %**
virtual no. of possible cycles (lifetime)	1705	2411	3409	4821	6817	9640	13633	19278	27261	38551	54515	77090		
x % of possible lifetime used @ module solution **2** (increased costs)	8,8	12,4	8,8	12,4	11,0	9,3	9,9	7,8	5,5	3,9	1,9	1,4	**93**	**sufficient < 100 %**
virtual no. of possible cycles (lifetime)	5797	8206	11616	16442	23274	32945	46635	66012	93442	132270	187231	265030		
x % of possible lifetime used @ module solution **3** (distinct increased costs)	2,6	3,7	2,6	3,6	3,2	2,7	2,9	2,3	1,6	1,1	0,6	0,4	**27**	**sufficient < 100 %**

b) liquid cooled system

T_liquid_max [°C]	90	90	90	90	90	90	90	90	90	90	90	90		
T_water_min = Tc_min [°C]	-25	-20	-15	-10	-5	0	5	10	15	20	25	30		
T_h [°C]	90	90	90	90	90	90	90	90	90	90	90	90		
T_c_max [°C]	105	105	105	105	105	105	105	105	105	105	105	105		
delta Tc [K]	**130**	**125**	**120**	**115**	**110**	**105**	**100**	**95**	**90**	**85**	**80**	**75**		
Cycles per day	2	2	2	2	2	2	2	2	2	2	2	2		
days per year	5	10	10	20	25	30	45	50	50	50	35	35	**365**	
Cycles per year	10	20	20	40	50	60	90	100	100	100	70	70		
Cycles per lifetime	**150**	**300**	**300**	**600**	**750**	**900**	**1350**	**1500**	**1500**	**1500**	**1050**	**1050**	**15 years**	
virtual no. of possible cycles (lifetime)	197	279	395	558	789	1116	1578	2232	3156	4463	6311	8925	**total [%]**	
x % of possible lifetime used @ module solution **1** (cost efficient)	76,0	107,5	76,0	107,5	95,0	80,6	85,5	67,2	47,5	33,6	16,8	11,8	**805**	**not sufficient > 100 %**
virtual no. of possible cycles (lifetime)	592	837	1184	1674	2368	3348	4735	6696	9468	13389	18934	26775		
x % of possible lifetime used @ module solution **2** (increased costs)	25,3	35,8	25,3	35,8	31,7	26,9	28,5	22,4	15,8	11,2	5,5	3,9	**268**	**not sufficient > 100 %**
virtual no. of possible cycles (lifetime)	1907	2699	3820	5408	7655	10836	15338	21712	30733	43504	61580	87169		
x % of possible lifetime used @ module solution **3** (distinct increased costs)	7,9	11,1	7,9	11,1	9,8	8,3	8,8	6,9	4,9	3,4	1,7	1,2	**83**	**sufficient < 100 %**

Table 2: Hypothetical scenario "thermal cycling capability" for
a) air cooling,
b) fluid cooling and the use of different combinations of materials / construction techniques

Infineon has developed new power semiconductor modules for mild and full hybrids. The modules are equipped with the latest 600V IGBT³ chip technology for a Tvjop = 150 °C and an improved bond process is used. The load connections feature screw terminals. The auxiliary connections are brought out as solder terminals and moulded into the plastic case.

The cost optimized HybridPACK™1 module (FS400R06A1E3) has been developed for 20 kW applications. This module features a SixPACK configuration with 400A / 600V switches and is intended for the use in mild hybrid with forced air-cooling. The module is equipped with an NTC (temperature monitoring) and is constructed with an "improved" Al_2O_3 -DCB and a 3 mm copper baseplate. The size of the baseplate is 139 mm x 72 mm.

Another development is the HybridPACK™2 module (FS800R06A2E3) for the power range above 50 kW. This module has been specifically developed for fluid cooled systems (full hybrid) and is equipped with an AlSiC-PinFin baseplate. The chip current realized is 800 A per switch. Additionally, improvements regarding vibration robustness have been made.

The scenario depicted (Table 2) indicates that the use of a slightly different combination of materials / construction techniques of DCB substrate and baseplate may be sufficient for an air-cooled semiconductor module. A high-end solution is not the best in these cases as unnecessary expenditure results. The gain in performance can not be utilized (over-design).

First solutions for hybrid drives are now available with the modules introduced here as part of the HybridPACK™ product family. Further developments will follow.

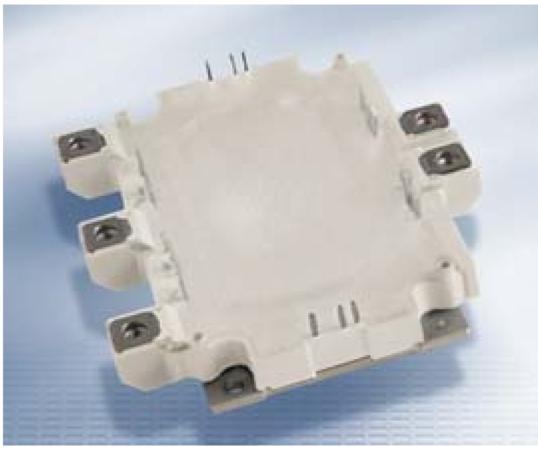


Figure 5: HybridPACK™1 module (SixPACK 600 V / 400 A)

Figure 6: HybridPACK™2 module (SixPACK 600 V / 800 A)

www.infineon.com

Optimising Modern Solar Installations

The inverter uses the current transducers

In addition to the incentives and pressures brought by political initiatives such as the Kyoto protocol, the increasing costs of many forms of energy and the search for 'cleaner' sources of power are boosting interest in alternative energy such as solar.

By Stéphane Rollier, LEM

Many new designs are emerging to make use of these sources of energy at the most profitable and efficient level possible. These designs are supported by today's electronic technologies, including current transducers.

When electricity generated by solar panels is fed back into the grid (a "grid connected" system), the connection can be made in two ways:

The solar array is linked to an inverter, which is connected to the grid via a transformer (Figure 1).

The inverter is directly connected to the grid, avoiding the transformer (transformerless system) (Figure 2).

Another solution is not to feed the electricity to the grid, but to charge batteries to power autonomous installations. This is the "off-grid".

For use in applications such as remote buildings eg: mining settlements, remote settlements in Australia or Canada or in villages in third world countries as well as for road signs, underground lighting, etc.

Today, solar inverters handling power from 500W to 10kW are available on the market, and installations with a capacity up to 500kW are possible, allowing, for example, the continuous lighting of an underground parking floor for a large stadium. System lifetimes of up to 20 years are possible. Both types of system (transformer or transformerless) can supply a single-phase output (for lower-power systems) or three-phase output (for high power), depending on the targeted grid and power installation.

Two or three different kinds of inverters are currently in common use, depending on the design goals for the system, which include size, weight, robustness, electrical separation from the grid, price, efficiency and losses. It is important to measure current in all types of solar inverter – to help to improve efficiency and to protect the system.

The transformerless design is the most efficient type, as there are no transformer losses. Sometimes, in this configuration, a step-up converter (DC/DC converter) is used between the photovoltaic (PV) arrays and the inverter (DC/AC), to adapt the voltage from the arrays to the inverter input voltage.

Often, a Maximum Power Point Tracking (MPPT) module is used just after the PV arrays in order to ensure that they work at their maximum power operating levels. A special software algorithm is used with dedicated electronics to control the operating points of the panels (cells), using current and voltage transducers for that function. Generally speaking, one current transducer can then be used to measure the single-phase output (current supplied to the grid) and one to measure the input DC current (from 10 to 25A). In the case of a three-phase output, two transducers are then used to measure the AC current of the three-phase output. The DC/AC inverter connected to the grid is a full bridge inverter converting the DC signal into a sine wave.

The inverter output current (15 to 50ARMS) flowing to the grid is measured by a transducer for feedback to the controller for pulse width modulation (PWM) sine wave control. Controllers are mainly based on microprocessors or DSPs supplied with +5V and working with voltage references shared with other active components of the electronic control system. LEM's HMS current transducers operate from a +5V power supply. Their internal reference voltage (2.5 V) is provided on a separate pin, allowing them to be used easily with DSPs or microcontrollers. But, they can also accept an external reference (between 2 and 2.8 V) from these same DSPs, from which they then derive their own reference. This symbiosis between all the electronic elements of the control system makes the overall application more efficient (reference drift cancellation in the error calculation). The HMS current transducers are very well suited for all the current measurements required in solar inverters.

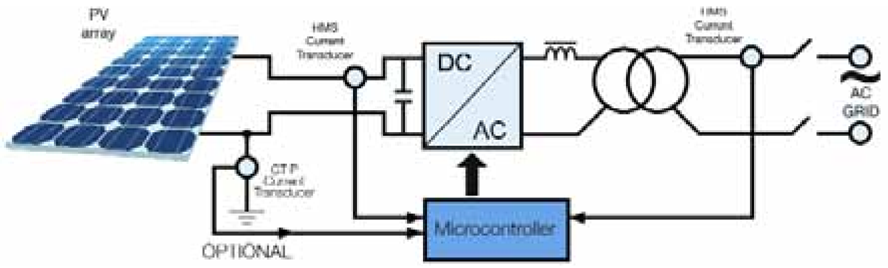


Figure 1:
The solar array is linked to an inverter, which is connected to the grid via a transformer.

The current transducer can be used for peak current detection, for a comparison of real values versus the setup points. The inverter also uses the current transducers in the system that controls the output frequency. Indeed, the inverter shuts down in a short time (less than 2s) whenever the frequency moves outside a pre-selected range.

Offset and temperature drifts have to be the best possible, because on the grid (AC side), low DC values are necessary with a level that must not be exceeded. Another requirement for the grid connection is that DC current must not be supplied into the grid. The DC current generated by the transducer offset or IGBT commutation would cause difficulties in the network. This current could generate a saturation in the transformer, which would generate more losses and more harmonics in the network. With a transformerless configuration, this is less of an issue.

The accepted level differs from country to country, but common requirements are 0.5 percent or 1 percent of the nominal output

8 mm creepage and clearance distances are achieved in the HMS design. Cumulated with a CTI of 600 for their plastic case, this allows HMS to provide high isolation performance (test isolation voltage : 4.3 kVRMS/50 Hz/1 min).

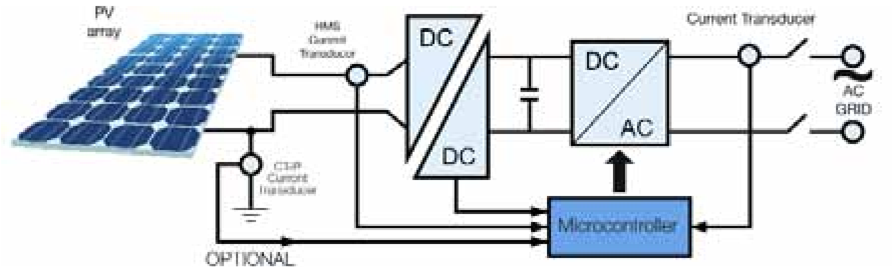


Figure 2: The inverter is directly connected to the grid, avoiding the transformer.

current or, in some countries, it is a defined limit (20mA in the UK, 1A in Germany and Benelux, 100mA in Japan, or 50mA in China and the USA). If the DC current is above the limit, the system must be disconnected from the grid. Today it is still not clear if it is a requirement to measure the DC current or just to detect the threshold.

In future solar designs, this current could be compensated. The DC component would be calculated by measuring the mean value of the AC current; which represents the DC component. Therefore, 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 should be avoided or kept 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 being developed.

HMS current transducers measuring only 16 (L) x 13.5 (W) x 12 (H) mm and integrating the primary conductor are ideal when the space for current measurement on the printed circuit board is tight. The models are directly surface-mounted onto a printed circuit board, reducing manufacturing costs, and avoiding mixing different soldering processes. Despite these small dimensions,

Four standard models are available to cover nominal AC, DC, pulsed and mixed isolated current measurement of 5, 10, 15 or 20ARMS, up to 50kHz, with a measuring span of up to ± 3 x IPN. The same mechanical design is used for all four models so that they can be used to measure current across a complete range of end products. Gain and offset are fixed and set so that, at Ipn, the output voltage is equal to Ref in or Ref out ± 0.625 V.

A unique LEM ASIC designed for use with open-loop Hall-effect technology has been used to provide performance improvements. These include better offset and gain drifts and linearity, in addition to an extended operating temperature range (-40 to +85°C) compared to traditional discrete technology.

The transducers are CE marked and conform to the EN 50178 standard. They can be used in industrial applications such as power inverters (solar, wind, etc) as well as in home appliances, variable speed drives, UPS, SMPS, and air-conditioners to make them more efficient.

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PWM Control Methods Increases Efficiency, Reliability and Extend Battery Lifetime

Brushless DC motors the choice for battery-operated applications

PWM duty cycle control techniques enable greater efficiency and versatility of the brushless DC motor to provide flexible control and novel cyclic operation, as well as better protection schemes for the motor and control circuits.

By Vijay Bolloju, Systems Development Manger,
Motion Applications Center, International Rectifier

There is an increasing demand for battery-operated motor applications in the market today. Traditionally, brushed DC motors have dominated this market. Until now, linear control of series and shunt wound DC motors offered simple, low cost solutions. However, due to the inherent inefficiencies of these solutions, the lifetime in which the battery is able to power the product between charging cycles can be significantly shortened. As a result, some products require additional battery capacity (weight, size, and cost) to be designed-in or suffer in the eyes of the user due to frequent trips back to the charging station.

PWM duty cycle control techniques enable greater efficiency and versatility of the brushless DC motor to provide flexible control and novel cyclic operation, as well as better protection schemes for the motor and control circuits. The high efficiency, higher power densities and reliability make brushless DC (BLDC) motors an ideal choice for battery-operated motor applications because the combination of power electronics and innovative control techniques provide a high performance, efficient, compact and low cost solution.

Typical high-volume battery-operated applications include hand-held power tools, electric garden equipment, and electric vehicles such as golf carts, and scooters.

Conventional solutions for these applications use brushed DC motors (Figure 1). The speed control is achieved by reducing the voltage applied across the motor. Typical methods used are rheostat control or linear electronic control. While both methods provide a simple solution to the speed control of the DC motor, they suffer from several disadvantages that include:

- Low efficiency at low speeds and hence low charge cycle time for the battery
- In linear electronic control circuit, the losses in the switch do not depend on the switch characteristics. The switch must be large enough to dissipate the heat generated. This method is costly for high-power motor control applications.
- Speed can be controlled only below base speed
- Speed control is possible in one direction only. Reversal of speed requires extra relays to switch polarity of the voltage across the motor.
- Battery voltage variations can not be compensated
- Limited to brushed DC motor control only

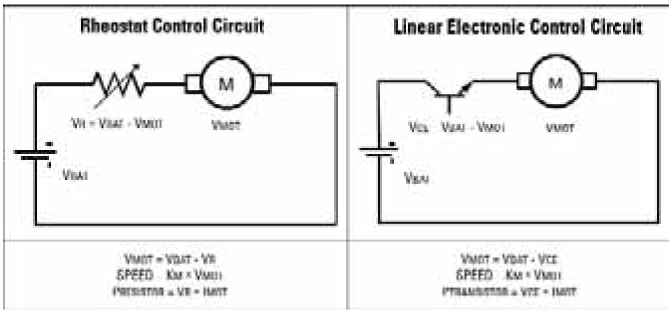

Figure 1: Typical control circuits for low power DC motors

PWM Switching Control Methods

PWM switching control methods improve speed control and reduce the power losses in the system, which increase the mean time between charge cycles of the battery. The reduced losses also help reduce the weight of the system as smaller thermal management components are needed. These two factors are critical for portable equipment.

PWM control methods also enable novel control methods and leverage the latest silicon advancements to reduce losses in the system. With appropriate circuit and control methods, speeds above base speed can be achieved. Moreover, rugged power switches and feature-rich gate drive ICs improve the ruggedness and reliability of the system.

The losses in switching control circuits depend on the switch parameters. MOSFETs with low RDSON and switching losses dissipate less power and hence smaller devices can be used. Therefore, using MOSFETs with the appropriate characteristics reduces the overall system losses, size and cost.

High Voltage IC gate drivers (HVICs) can be used to interface high power MOSFETs to the logic level control circuits to simplify the system design (Figure 2). International Rectifier's HVICs offer several protection features that improve system reliability. Features such as over-current shutdown and under-voltage lockout (UVLO) make the systems more robust. The power supply for the high-side MOSFET gate drive circuit is derived using bootstrapping of the VCC. The bootstrapping technique eliminates the need for multiple isolated power supplies and hence reduces the system cost and the size.

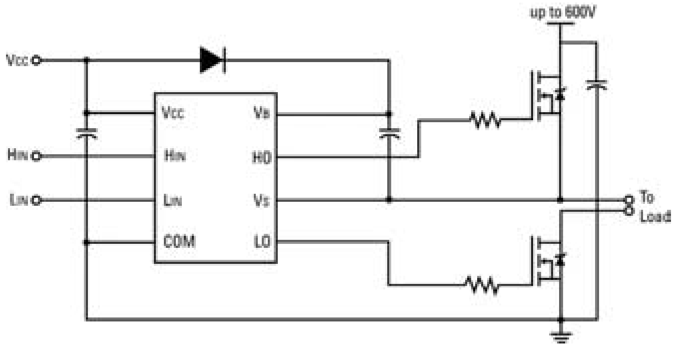

Figure 2: Typical HVIC Driver Application

A single switch chopper (Figure 3) can seamlessly control the speed through duty cycle modulation. The losses in the FWD across the motor can reduce the overall efficiency of the system. The efficiency can be improved by replacing the FWD with a MOSFET (Q2).

The MOSFET (Q2) can be switched ON during the freewheeling period to reduce the losses. The RDSON of the MOSFET is lower than the VF of the diode and hence it will reduce the over all losses in the system. This chopper configuration allows only unidirectional speed control and does not permit recovering the regeneration energy from the motor.

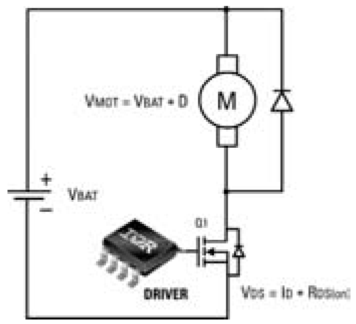

*Figure 3a: Typical Single Quadrant DC Motor Control Circuits using IRS2117 Single Switch Chopper (VMOTOR = VBAT * (TON / TOFF) , Speed = KM * VMOTOR, PRESISTOR = VR)*

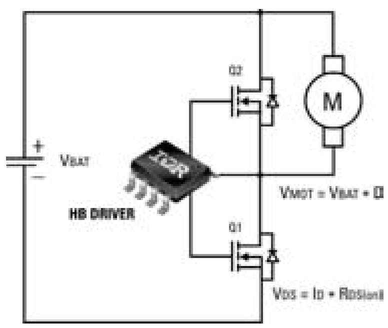

*Figure 3b: Typical Single Quadrant DC Motor Control Circuits using IRS2117, Chopper with Synchronous Switching MOSFET. (VMOTOR = VBAT * (TON / TOFF) , Speed = KM * VMOTOR, PRESISTOR = VR* IMOTOR)*

A full bridge circuit provides greater functionality. This circuit allows four quadrant operation of the DC motor (Figure 4) and enables the battery to capture the regenerative energy from the motor. The motor can be run in both forward and reverse directions and is suitable for electric vehicles, power tools, wheel chairs and any application requiring forward and reverse operation. The half-bridge HVIC drive simplifies the design and size of the system as shown in Figure 5,

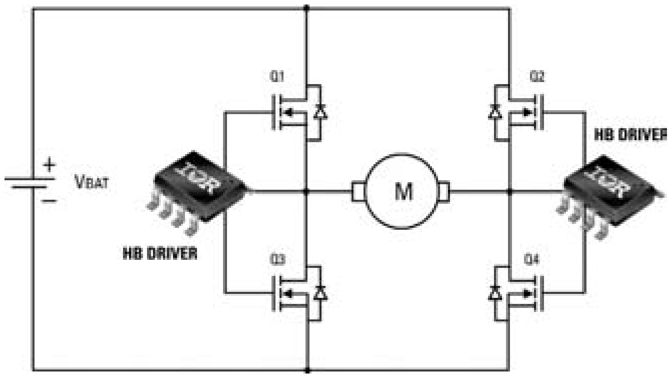

Figure 4: Typical Four Quadrant DC Motor Drive Circuit using IRS2003

The three-phase brushless motor improves the efficiency and reduces the size and weight as well as improving system reliability. BLDC motors do not have a mechanical commutator and brushes. Instead, BLDC motors depend on electronic commutating circuits. The absence of the commutator and the brushes reduce the size of the motor and improve the reliability of the system.

Typical BLDC motors have three-phase windings and hence require a three-phase inverter circuit to control the speed. Figure 5 shows the typical three-phase inverter used for controlling the BLDC motor speed. The HVIC gate drivers simplify the system design by eliminating three isolated power supplies and provide over-current protection and protect the power devices during supply under-voltage conditions.

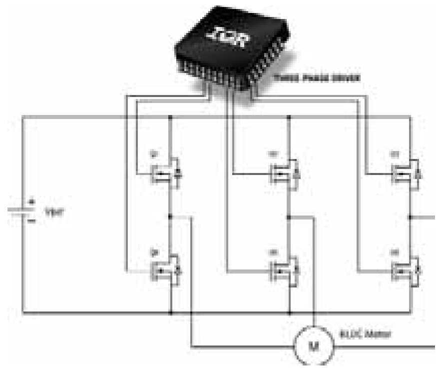

Figure 5: Typical Three Phase Inverter Circuit for BLDC Motors using IR2136

Summary

The PWM switching circuits and synchronous rectification improve the efficiency and increases the speed of the battery-operated motor drive system.

BLDC motor drives further improve efficiency and reliability while reducing the system size and weight. Moreover, the HVIC gate drivers simplify the system design, improve robustness and reduce the overall system size and cost.
For more information go to
http://www.irf.com/product-info/hvic/g5hvic.html

www.irf.com

Predicting LDMOS DC, Small and Large Signal Behavior

A new Verilog model for design

Thanks to their cost effectiveness and high performance, LDMOS devices are widely used in radio-frequency applications, ranging from digital communication infrastructure (cellular base stations) to low-cost portable radios (private mobile radios), commonly known as Walkie-Talkies.

By Amedeo Michelin Salomon and Giuseppe Privitera, STMicroelectronics

To reduce the design cycle time and cost for wireless applications it is useful to have models that can help RF Engineers predict and simulate the behavior of RF Power Transistors.

The model introduced here describes with good approximation dc, small-signal S-parameter and large-signal behavior. This model has been implemented in the Agilent Advanced Design System, in Verilog Language.

In this article we will briefly describe how to extract the model parameters for the PD54003L-E device. As an internally unmatched device, the PD54003L-E can be used in various portable applications over HF, VHF and UHF frequency bands. At the end of the article we will validate this new model using ST's DB-54003L-175 demo-board, especially designed for 2-way portable radio applications using PD54003L-E over the 135-175 MHz frequency band.

Model description and parameter extraction

The model introduced in this article is a behavioral model with the equations written in VERILOG language.

Name	Description
VT0	Threshold voltage [V]
ETA	Drain induce barrier lowering (DIBL) [V^{-1}]
KP0	Transconduttance [$A*V^{-2}$]
THETA	Mobility degradation [$V^{-VGTHETA}$]
VGTHETA	Mobility degradation exponent [-]
THETA2..9	From 2nd to 9th degradation polynomial factor [V^{-2}]
XN	Slope subthreshold current [V^{-1}]
DEL	Body effect linearization coefficient [-]
DELVG	Body effect linearization coefficient independent of Vgs [V^{-1}]
L0	Critical length [m]
L	Channel length [m]
EPS	Output conductance factor if L0>L [m]
KE	Output conductance factor if L0<L [Vm]
DT_KP	Mobility thermal coefficient [-]
DT_VT	Thermal coefficient of threshold voltage [$°C^{-1}$]

Table 1. Parameters required for the extraction of the current generator equations

By observing the equivalent model schematic of Figure 1, the following elements can be noticed:

- Parasitic elements associated with the device
- Nonlinear current generator
- JFET resistance
- Substrate-body diode

Parasitic elements

To model the parasitic elements of the device, a resistance and an inductance are placed in series at each terminal. The model can change the resistance and inductance values according to the simulation temperature.

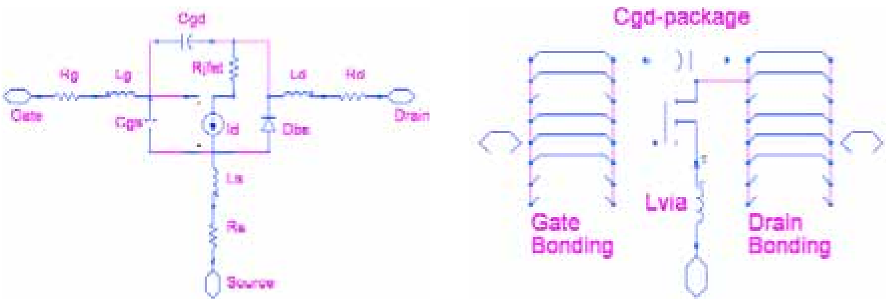

Figure 1. Model schematic

Nonlinear current generator

The nonlinear current generator controlled by Vgs and Vds is the most important factor used to calculate the static and dynamic current of the device. Moreover, the static current is required to define the working region of the MOS.

Table 1 reports all the parameters required to extract the equations of the current generator. To get the generator current equation, a set of equations must be defined. An important parameter to consider is the threshold voltage of the device shown in Formula 1.

Moreover, a new threshold voltage formula is necessary to describe the weak and strong inversion region in a single equation (Formula 2).

To describe both regions, a new gate voltage can be defined, as in Formula 3. Another important parameter to define is the gain factor with zero bias. Referring to Formulas 4, 5 and 6, the gain factor degrades according to the Vgs voltage (mobility degradation).
Formulas 7 and 8, which define the drain saturation voltage, complete the set of equations needed to define the generator current (Formula 9 and 10).
The automatic ADS optimizer was used to extract the parameters for the current generator using input characteristics and transconductance parameter.
L is the physical channel length of the MOS, while L0 influences the output conductance which depends on KE and EPS. DEL and DELVG affect the VD_{SAT} and are extracted from the output characteristics in the saturation region. All the equations have been implemented in VERILOG language.

JFET resistance

The quasi-saturation region is modeled by a nonlinear JFET resistor. The mathematical empirical equation is defined in Formula 11(using the right hand function approach) (Formula 12), where pres depends on the current and on the drop voltage across Rj.
The function g(pres) was created to bind the Rj to the current Id. This is accomplished by introducing a new parameter linked to the dissipated power on Rj (Formula 13), where pres is linked to the dissipated power on Rj through RPWR.
Rj is extracted from the dc output characteristics in the linear region with high bias current.

Substrate-body diode

The body-substrate diode is employed to describe the breakdown, the drain current leakage and the capacitance between the drain and source.
The diode current is implemented in Formula 14, 15, 16, 17 and 18. The charge equation is given by Formula 19.
The remaining model parameters are the capacitances Cgs and Cgd of the MOSFET. The gate-source capacitance is modeled with a constant capacitance, because it is related to a highly doped MOSFET (Formula 20).
Moreover, the gate-drain capacitance can be considered as a classic MOSFET model capacitance, where the equations of the charged capacitance can be divided into four regions.
To extract the capacitance variables, a classic configuration has been used to measure the Ciss, Coss and Crss.

Package simulation

To include all the parasitic elements of the package in the model, several electromagnetic simulations were performed.
The simulated package (PowerFLAT), including the internal structure of the device, takes into consideration the leads, the paddle, wire bonding and the pad on the silicon.
To minimize the simulation time and increase accuracy, the structure was split into two parts (drain and gate). In this way, the reciprocal coupling between the input and output parts are not considered. To take into account such effect, an extra capacitor (Cgd-package) has been used. To complete the package model an extra inductor (Lvia) associated with the source has been added. This inductor represents the effect created by the “via holes”.
Moreover, using the measured S-parameters of the packaged device, it was possible to extract the Cgd-package and the Lvia.
Observing Figure 1, it is possible to see the circuit representing the union between the package model and the device model.

DC and RF small signal validation

Figures 2 compare the measured with the simulated RF small signal S-parameters.The simulations predict with good approximation the S21 and S22 which are the most difficult to predict.

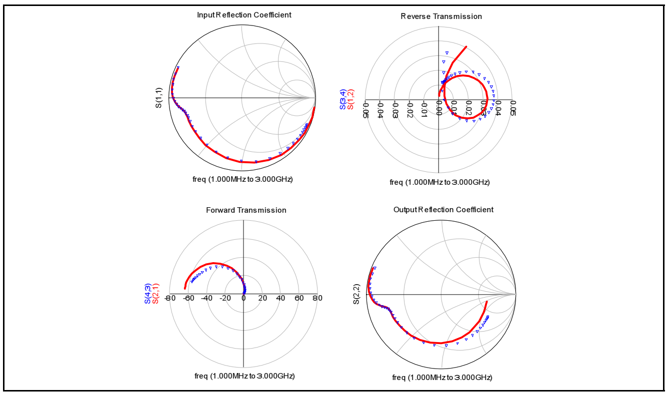

Figure 2. Measured S-parameters vs. simulated parameters (Vds = 7.2V; Idq = 100 mA)

Figure 3. DB-54003L-175 demo-board

Large signal validation

Using the ADS with Harmonic Balance engine simulator, the model has been simulated in conjunction with the dc network and the input and output matching network of ST's demo-board DB-54003L-175 (Figure 3). The DB-54003L-175 demo-board was developed to demonstrate the best broadband performance of PD54003L-E. Figure 4 compares the simulations and measurements of the demo-board at 155 MHz.

Conclusions

The described model is suitable for use in all simulation types, ranging from dc to large-signal analyses. Furthermore, the model shows a good robustness in terms of convergence. Such robustness is given by the good approximation of the device model in the quadratic and saturation regions.

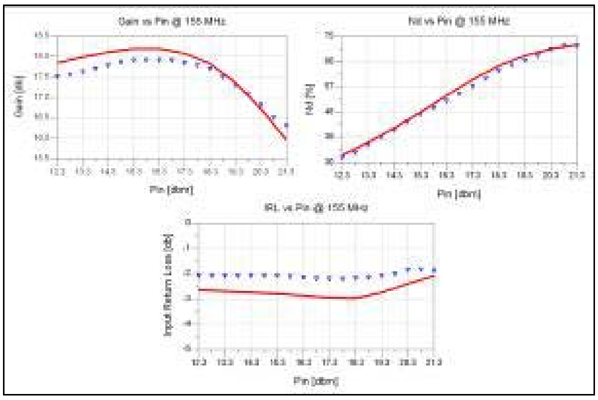

Figure 4. Measured RF demoboard performance vs simulated performance

Formula 1	$V_{TH} = V_{T0} - ETA \cdot V_{DS} + DV\_VT \cdot (T - T_{NOM})$
Formula 2	$VR = V_{TH} + 2 \cdot XN \cdot U_{TH}$; $U_{TH} = \frac{K \cdot T}{q}$
Formula 3	$V_{gg} = \begin{cases} V_{TH} + 2 \cdot XN \cdot U_{TH} \cdot e^{\frac{V_{gs} - VR}{2 \cdot XN \cdot U_{TH}}} & V_{gs} \le VR \\ V_{gs} & V_{gs} > VR \end{cases}$
Formula 4	$KP = KP0 \cdot \left(\frac{T(^\circ K)}{T_{NOM}(^\circ K)} \right)^{DT\_KP}$
Formula 5	$F(V_{gst}) = \begin{cases} 1 & V_{gst} \le 0 \\ 1 + THETA \cdot V_{gst}^{VGTHETA} + \sum_{I=2}^{9} THETA_I \cdot V_{gst}^{I} & V_{gst} > 0 \end{cases}$
Formula 6	$KP_{EFF} = \frac{KP}{F(V_{gst})}$
Formula 7	$A = L0^2 - L^2$; $B = \frac{L}{EPS} \cdot L0^2$; $C = KE \cdot L^3$; $\delta = DEL + DELVG \cdot Vgg$; $D_1 = (B - A) \cdot (Vgg - V_{TH}) - C \cdot (1 + \delta)$; $D_2 = D_1^2 - 4 \cdot C \cdot (Vgg - V_{TH}) \cdot (1 + \delta) \cdot (0.5 \cdot A - B)$
Formula 8	$VDSAT = \frac{\sqrt{D_2} + D_1}{(1 + \delta) \cdot (2 \cdot B - A)}$
Formula 9	$I_{DS} = \begin{cases} KP_{EFF} \cdot Vds \cdot (Vgg - V_{TH} - 0.5 \cdot Vds \cdot (1 + DEL)) & V_{DS} < VDSAT \\ IDSS \cdot (1 + A \cdot \frac{Vds - VDSAT}{B \cdot VDSAT + C}) & V_{DS} \ge VDSAT \end{cases}$
Formula 10	$IDSS = KP_{EFF} \cdot VDSAT \cdot (Vgg - V_{TH} - 0.5 \cdot VDSAT \cdot (1 + DEL))$
Formula 11	$Rj = f(Vds, Vgs) \cdot g(\mathrm{pres}) \cdot h(T)$
Formula 12	$Rj(Vds) = RI0 + SR \cdot [FSI \cdot Log_{10}(1 + 10^{\frac{Vds - VDI}{FSI}}) - FSF \cdot Log_{10}(1 + 10^{\frac{Vds - VDF}{FSF}})]$
Formula 13	$g(\mathrm{pres}) = 1 + (\mathrm{PCR1} + \mathrm{PCR2} \cdot \mathrm{pres}) \cdot \mathrm{pres}$
Formula 14	$Id = \begin{cases} IsT \cdot (\exp(\frac{Vd}{N \cdot Vt}) - 1) & Vd \ge 0V \\ Ir1 + Ir2 + Ir3 & Vd < 0V \end{cases}$
Formula 15	$Ir1 = IsT \cdot [\exp(\frac{Vd}{N \cdot Vt}) - 1]$
Formula 16	$Ir2 = \frac{Vd}{RLEAKT}$
Formula 17	$Ir3 = \mathrm{sgn}(Vd) \cdot Ibv \cdot \exp(-\frac{Vd + BVT + BVVGT \cdot Vgs}{NBV \cdot Vt})$
Formula 18	$Ibv = \begin{cases} I_{BV} & I_{BV} > 0A \\ I_S \cdot \frac{BV}{V_T} & I_{BV} \le 0A \end{cases}$
Formula 19	$\begin{cases} f1 = \frac{CjT \cdot VjT}{1 - MJ};\ Qd = TT \cdot Id + f1 \cdot (1 + (\frac{1 - Vd}{VjT})^{(1-MJ)}) + Cj\_parT \cdot Vd & V_D \le FCP \\ f1 = \frac{CjT}{(1 - FCP)^{(1-MJ)}};\ f2 = 1 - FCP \cdot (1 + MJ);\ Qd = TT \cdot Id + f1 \cdot (f2 \cdot Vd + 0.5 \cdot \frac{MJ \cdot Vd^2}{VjT}) + Cj\_parT \cdot Vd & V_D > FCP \end{cases}$
Formula 20	$Qgs = CgsT \cdot Vgs$

Thanks to this new Verilog model, customers will now be able to predict and simulate the behavior of STMicroelectronics RF DMOS and LDMOS products, reducing design cycle time and time to market.

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The First 100% Solder-Free IGBT Module

Purpose-Designed for Automotive Applications

For train drive converters in electric and hybrid vehicles SEMIKRON developed a 100% solder-free IGBT module for 22 kW – 150kW. SKiM® has a five times higher temperature cycling capability compared to modules with a base plate and soldered terminals.

While some power semiconductor manufacturers are still improving soldered contacts in modules to meet the high temperature requirements of the automotive industry, solder-free pressure contact technology and sintered chips is the optimal solution to increase the temperature cycling capability to 10.000 cycles at Δ100K. One separate coolant loop can be omitted due to these high temperature capabilities of $T_{junction}$ = 175°C and $T_{ambient}$ = 135°C.

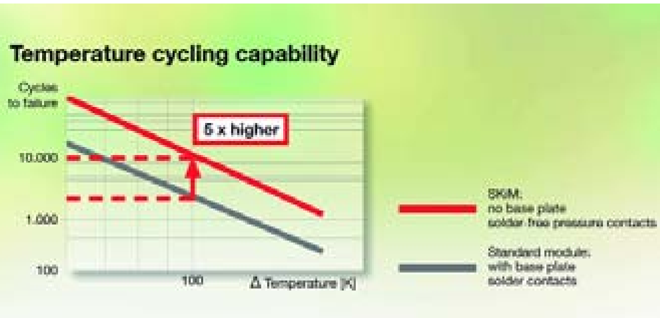

Figure 1: Comparison between SKiM and a soldered standard module with base plate.

The solder-free pressure contact system and an internal laminated bus bar results in a homogeneous current distribution. Every IGBT and diode chip has its own connection to the main terminal. The result is a low module resistance of $R_{CC'+EE'} \leq 0{,}3\ m\Omega$ compared to soldered modules with approximately 1,1 mΩ. The connection to the driver board is also solder-free with springs for high temperature cycling and fast solder-free mounting.

Figure 2: The first ever 100% solder-free IGBT module specially designed for electric and hybrid vehicles.

The chips are sintered not soldered thereby achieving the high power cycling capability. The sinter joint is a thin silver layer that has a superior thermal resistance than a soldered joint and due to the high melting point of silver no joining fatigue leading to an increased service life.

The fact that the substrate is pressed on to the heat sink at many different points means that there is no bimetal effect. The substrate lies flat on the heat sink. At just 20 µm thick, the thermal paste layer is far thinner than in conventional modules with a base plate, where it is normally around 100 µm thick. This means that, despite the comparatively low thermal spreading, the same thermal properties are achieved.

The packaging and connection technology of the SKiM module fully exploits the silicon capabilities resulting in a cost-efficient solution. More than 15 years of experience in pressure contact technology is integrated into the SKiM IGBT module.

SKiM modules come in six-pack topology consisting of three independent half-bridges in one case. Each of the three half-bridges is equipped with its own NTC temperature sensor. In keeping with current standards, the DC and AC main terminals are 17 mm high and are positioned on opposite sides of the module. The upper of the case contains the drive terminals. The fast design-in is guaranteed by the standard terminal height of 17 mm and a configuration similar to other six pack modules. Two case sizes are available: SKiM 63 (120 x 160 mm²) SKiM 93 (150 x 160 mm²)

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The Forward Converter

Basic construction and function

As an aid for understanding, the individual switching states in the steady state system are examined.

By Dr. Thomas Brander, Würth Elektronik

The figure 1 shows the basic construction of a forward converter. Whereas the energy is temporarily stored with the flyback converter before it is transferred to the secondary side, in the forward converter, energy is transferred directly between the primary and secondary sides.

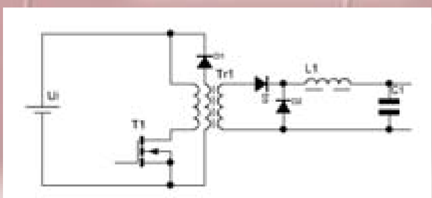


Figure 1:
Circuit diagram of a forward converter

As an aid for understanding, the individual switching states in the steady state system are examined. With the switch T1 closed, there is the same polarity at both dots of the transformer circuit diagram so that the diode D2 is conducting. In accordance with the function of the transformer the current transformed from the secondary side flows on the primary side and the linearly increasing magnetizing current.

The transformed input voltage is applied to the secondary winding. This serves to charge the choke. A linearly increasing current flows through the choke and the load.

If the switch T1 is now opened, the current cannot continue to flow on the primary side. The polarity in the magnetic components reverses so that D2 is blocked on the secondary side. The choke L1 now transfers the stored energy to the load (or the output capacitor) via D3. The current through the choke again decreases linearly.

The core of the transformer has been magnetized by the magnetization current. The remanence of the core material would cause the core to saturate within a few switching cycles. So it has to be demagnetized after each switching period. Various techniques have been used for this purpose.

The simplest option is presented in Figure 1. During the shutdown phase the magnetizing current is fed back via diode D1 through the auxiliary winding. The number of turns used for the auxiliary winding is usually the same as that used for the primary winding. This means that the same time is required for demagnetization as for magnetisation. The converter can therefore be driven at a maximum duty cycle of 50%.

Further possibilities for demagnetization are presented by the forward converter with two switches (two-switch forward) (Figure 2) and the forward converter with active clamping (active-clamp forward) (Figure 3). In the case of the two-switch forward, the core is demagnetized via both diodes so that no auxiliary winding is required. For the active-clamp forward, the capacitor on the transformer generates a higher negative voltage, so that the demagnetization is achieved in a shorter time. This means that duty cycles higher than 50% are possible.

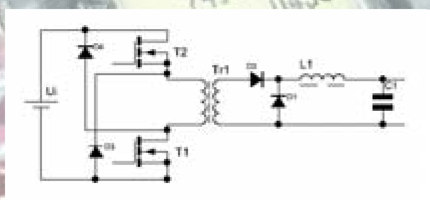


Figure 2: Circuit diagram of a 2-switch forward converter

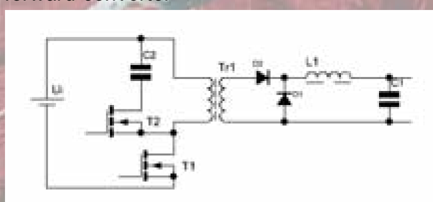


Figure 3: Circuit diagram of a forward converter with active clamping

Transformer design and defining inductance

As previously mentioned, the forward converter behaves like step-down converter with pre-switched voltage transformation. The following relationship is therefore given between the turns ratio and the duty cycle:

$$\frac{N_1}{N_2} \cdot \frac{U_o}{U_i} = v_T$$

The number of primary turns can be defined for a particular core with the main transformer formula:

$$\int U dt = n \cdot A_{Fe} \cdot B$$

The effective currents through the transformer are given by:

$$I_{eff,sek} = I_o \cdot \sqrt{v_T}$$

$$I_{eff,prim} = I_o \cdot \frac{N_2}{N_1} \cdot \sqrt{v_T}$$

This allows the wire thickness for the windings and the copper losses to be determined. Another auxiliary winding may have to be fitted de-pending of the demagnetization circuit. As it is only the magnetizing current that flows through it here, a relatively fine wire is sufficient.

The same approach is taken towards dimensioning the output choke as with the step-down converter. The same relationship exists between the ripple, frequency and inductance:

$$L = \frac{U_o \cdot (1 - v_{T\min})}{I_{pp\max} \cdot f}$$

The effective current through the choke is equal to the output current. The peak value is equivalent to the output current plus half the ripple current:

$$I_{eff,L} = I_o$$

Ieff,L=effective current through the choke

$$I_{max} = I_o + \frac{I_{pp}}{2}$$

A standard inductance can now be selected with these data.
Forward converter with the LTC1681 with synchronous rectifier

Figure 4a shows a two-switch forward converter with the following properties:

Input voltage: Ui= 36 V–72 V
Output voltage: Uo= 5 V
Output current: Io= 7 A
Switching frequency: f = 150 kHz
Maximum duty cycle: íTmax= 50%

The converter is not isolated. Therefore the transformer only needs functional isolation, i.e. it must not fail with the voltages applied.LTC1681 drives the two primary MOSFETS while LTC1693 drives the synchronous MOSFETs. The primary MOSFETS Q1 and Q2 are switched on at the same time. At the same time, the MOS-FETQ3 is also closed, whereas Q4 has to be open. In the off-phase, Q1–Q3 are simultaneously “switched off” and Q4 is closed. Due to the switch topology (two-switch forward), the duty cycle is limited to 50%.

A WE-FLEX series standard transformer could be selected for the trans-former. The turns ratio is given from Equation 1:

$$\frac{N_1}{N_2} < \frac{U_{i\min}}{U_o} \cdot 0,5 = \frac{36V}{5V} \cdot 0,5 = 3,6$$

A turns ratio of 3.1 can be generated with the WE-FLEX. The maximum duty cycle is given by:

$$_{T\max} = 3 \cdot \frac{5V}{36V} = 0,42$$

On the primary side, the transformer is then driven by the Volt-µs product.

$$\int Udt = \frac{U_i \cdot v_T}{f} = \frac{36V \cdot 0,42}{150kHz} = 100\mu Vs$$

The maximum Volt-µs product of a transformer is directly proportional to the number of primary turns, so that the Volt-µs product of a winding specified in the FLEX transformer table can be multiplied by the windings connected in parallel. Conversely, to select the transformer, the Volt-µs product calculated above can be divided by the number of windings connected in series to define a minimum value for the trans-former.

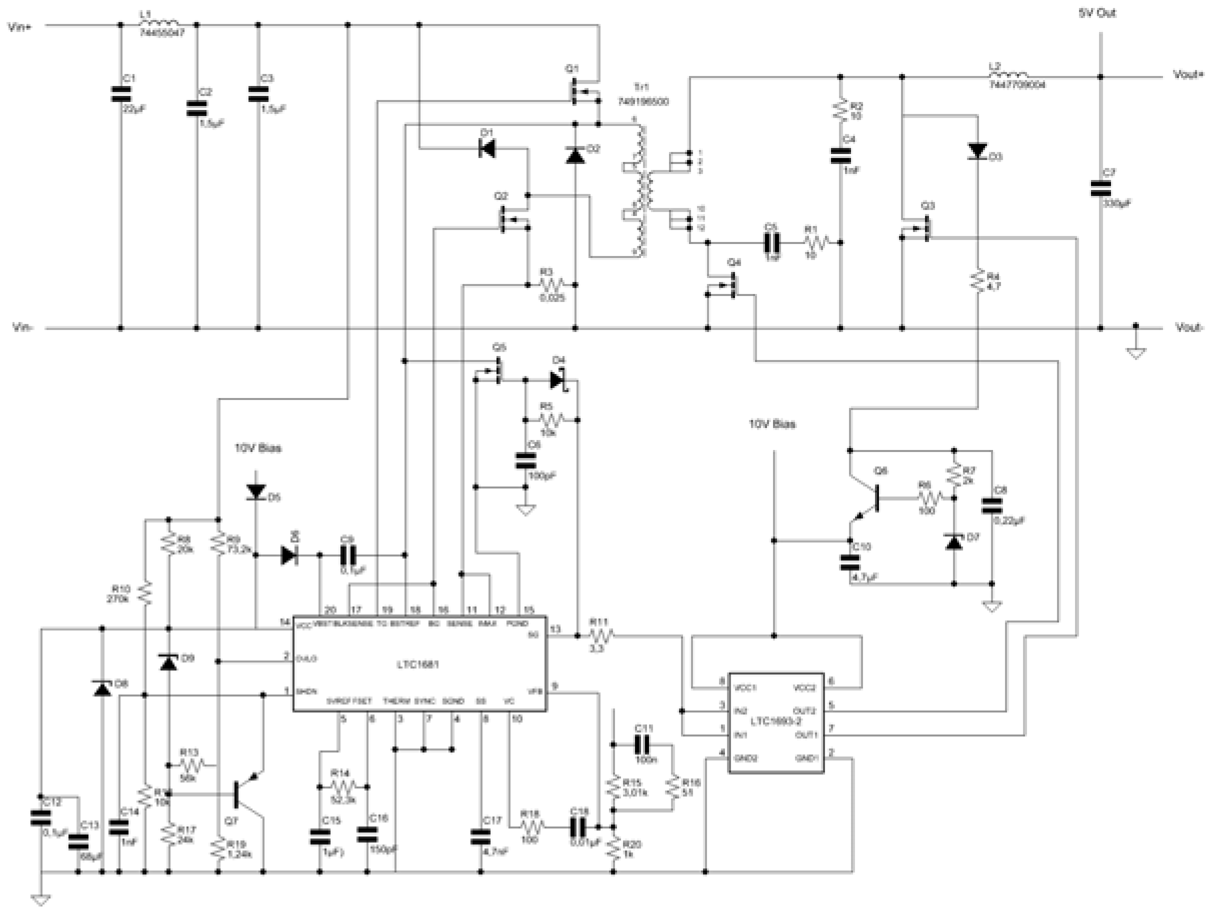


Figure 4a: Forward converter with LTC1681

$$Volt-\mu\sec_{base} > \frac{100\mu Vs}{3} = 33{,}3\mu Vs$$

The effective currents are obtained from Equations 3 and 4:

$$I_{effsek} = I_o \cdot \sqrt{v_T} = 7A \cdot \sqrt{0{,}42} = 4{,}54A$$

$$Ie_{ffprim} = I_o \cdot \frac{N_2}{N_1} \cdot \sqrt{v_T} = 7A \cdot \frac{1}{3} \cdot \sqrt{0{,}42} = 1{,}51A$$

As the three windings on the primary side are connected in series, the other three windings can be connected in parallel on the secondary side. For the minimum rated current of a winding it follows that INbase=1.51 A.

This leads to the following requirements for the transformer:

Transformer without air gap
V-µsecbase>33.3 µVs
INbase>1.51 A
This leads to part number WE-FLEX transformer 749 196 500.

Now the output choke L2 has to be selected. The ripple should be a maximum of 100% of the output current at maximum input voltage. Equation 5 gives:

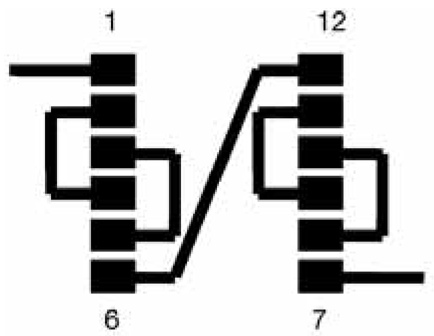


Figure 4b: Layout recommendation for transformer 1 902 959 110.00 in Figure 4a

$$L_2 = \frac{5V \cdot (1-0{,}21)}{7A \cdot 150kHz} = 3{,}8\mu H$$

The maximum current is 10.5 A. For example, 744 770 900 4 from the shielded power inductor series WE-PD is suitable or, in case of problems with the package height, 744 355 048 0 from the WE-HCA high current power inductor series.

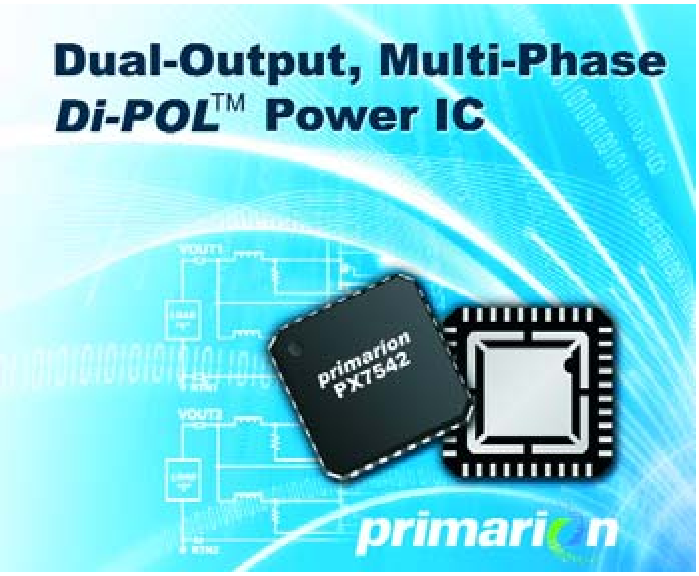
As the ripple is also reflected on the primary side, this also has to be considered when selecting the input choke. The choke has to be suitable for an effective current of 1.5 A. An inductance of 4.7 µH is also selected. The unshielded SMD power inductor 744 550 47 from the WE-PD4 series is suitable for this purpose.

www.we-online.com

Dual-Output, Multi-Phase Digital DC/DC Controller

Primarion, a mixed-signal semiconductor company that designs, manufactures and markets digital power integrated circuits (ICs), announced the addition of the dual-output, four-phase PX7542, with 100 picoseconds pulse width modulation (PWM) resolution, to the Primarion Di-POL™ product family of fully programmable digital power conversion and power management ICs.

The highly configurable PX7542 is a power conversion and power management IC for synchronous DC/DC converters in the telecom, datacom, computing and storage markets, compliant with PMBus™ 1.1 specifications. The IC simplifies design and increases density of system level power management architecture with its minimum footprint, by controlling two independent outputs with two phases per output, or one to four phases in a single output mode. The control function handles both DCR and RDSon current sense topologies and a programmable output range of 0.5V to 8V.



“Datacom, telecom, computing and storage market OEMs look for increased flexibility, efficiency, cost savings and density in managing their power systems,” said Deepak Savadatti, vice president of marketing for Primarion. “The numerous features of the PX7542, combined with the easy to use GUI, address these key attributes while improving overall system reliability. With the introduction of the PX7542, Primarion has become a one-stop-shop for OEMs, offering cost-effective digital solutions with controllers featuring single output from one to four phases and dual outputs from one to two phases per output.”

Configurations for the PX7542 are easily loaded, edited and saved to von-volatile memory (NVM) over the device’s I2C serial interface using Primarion’s graphical user interface (GUI). With configurations stored on the IC, the controller can perform real-time adjustments to the designer’s previously configured settings and thereby optimize performance accuracy, without the delay of accessing outside memory storage.

Other technologies would typically require an external microcontroller for this type of enhanced performance. By integrating the digital control functions with the PMBus interface and easy to use GUI, the PX7542’s power management capabilities provide one complete solution, eliminating the need for additional components.

“Primarion has obviously studied the market carefully to determine customer requirements before introducing the PX7542,” said Morry Marshall, partner, Advanced Technologies, Semiconductor Partners LLC. “Their GUI helps designers configure, optimize and monitor the power system with no programming required. It combines flexibility with ease of design.”

The PX7542 is driven by a single +5V supply and operates over a frequency range of 150KHz to 1MHz. Precise current sharing between phases allows the flexibility to regulate multi-phase operation for higher output loads. The PX7542 maintains accuracy through internal calibrations, which assess and improve system-level current sense error sources upon startup. The programmable current sense temperature compensation allows designers to tailor responses for accuracy over temperature.

Primarion’s innovative power system solutions are optimized for flexibility, efficiency and ease-of-use. The PX7542 expands Primarion’s digital power management and conversion solutions portfolio and brings overall system cost saving and improved performance to customers.

Summary of Features:

Supports two independent outputs with single or two phase control for each output
Supports a single output with one to four phases; Capable of current sharing and frequency sync with other controllers in the family:
Compliant with PMBus 1.1 specification (library of 60 core PMBus commands)
Real-time monitoring and reporting of voltage, current and temperature
Sequencing, margining and tracking of the output voltage over the serial interface
Wide output range: 0.5V to 8V
Supports both DCR and RDSon current sense topologies with digital temperature compensations
Compatible with both tri-state and non-tri-state FET drivers
Extensive fault protection and reporting with user-configurable fault behavior
Digital control loop and active voltage positioning (AVP)
Configurable PWM generator
Start-up into pre-biased load
Internal voltage and temperature referencing
Internal oscillator (no external reference required)

Availability

Already sampling with customers, Primarion’s PX7542 power system controllers are available for general sampling this quarter. The PX7542 is available in a RoHS-compliant, 6mm-x-6mm 40-lead QFN package.

www.primarion.com

EPE Conference Goes Strongly Renewable

ECPE 2nd SiC User Forum

EPE, Aalborg, Denmark Congress & Culture Centre from 2 to 6 September 2007
ECPE, Copenhagen, Denmark 6 to 7 September 2007

Six tutorials, the EPE Wind day, six parallel lecture sessions covering all areas related to Power Electronics, three dialogue sessions allowing face-to-face discussion with the authors, six specialized workshops and panel discussions on state-of-the-art topics, including a match-making workshop in preparation of the coming calls of FP7, industrial exhibition and technical tours.

The European Power Electronics and Adjustable Speed Drives community will exchange views on research progresses and technological developments. The EPE 2007 conference is sponsored by the EPE Association and will be held in the Aalborg. It is hosted by Aalborg University's Institute of Energy Technology.
The conference has received more than 950 synopsis and about 650 papers are selected and received for publication in the field of power electronics and its application. The organizers expect more than 900 participants from all over the world enjoying Aalborg and the spirit of EPE'2007 as one of the leading power electronics conferences in the world.
Denmark is one of the frontiers in renewable energy supplies and distributed generation. Today about 20 % of all electrical energy is produced by wind turbines and further 30 % is covered by small combined heat and power plants, which is a record in this scale. Further due to strong national energy savings programs the use of electricity has almost been 25 years even though production and population have increased. Europe has set up new targets for renewable energy and Denmark has the goal to remain one of the leading countries in the world. These issues will of course be addressed at the EPE 2007 conference.

Content and Program

The conference is organized with 6 tutorials on Sunday with the following topics:

1. Modeling and Control of Permanent Magnet Synchronous Motors
2. Propulsion systems for hybrid and fuel cell electric vehicles
3. Superjunction devices & technologies - Benefits and Limitations of a revolutionary step in power electronics
4. Power Electronics and Control for Renewable Energy Systems
5. Grid Requirements, Monitoring, Synchronization and Control of Wind Turbines under Grid Faults
6. Wind-farm integration and testing with the use of a real-time simulator

During the three days of main conference 160 papers will be presented in lecture sessions – done in the morning through six parallel tracks. In the afternoons posters will be presented.
One of the highlights will be on Monday September 3 where many high level technical papers will be presented in wind turbine and wind power system technology with contributions from several leading manufacturers. The 100 papers received in this field highlight the present technological importance. Also other fields like adjustable speed drives, switched mode power supplies, automotive, custom power systems, new power devices will be thoroughly represented through highly interesting papers.
Two key-note presentations in multi-level converters for utility applications and Silicon Carbide Components, respectively, are held Tuesday and Wednesday mornings. Each day, the late afternoons hold several workshops in power electronics, power systems, education etc.

Frede Blaabjerg , General Chair,
fbl@iet.aau.dk

www.epe2007.com

In the same week Thursday and Friday the European Center of Power Electronics will organize the 2nd ECPE SiC User Forum in Copenhagen, Denmark 6 to 7 September 2007

Potential of SiC in Power Electronic Applications

After the first Silicon Carbide (SiC) User Forum organised by ECPE in 2006, technology has developed further - in particular new power electronic systems with SiC components and new SiC devices have been reported. Time has thus come to continue the exchange between experts involved in converter and device development: The second SiC User Forum will focus on typical power electronic systems the use of SiC is highly promising for - i. e., electric drives, converters in transportation and power supplies; additionally an insight in recent material and device technology — which is the base for future system development — will be given. Renowned experts from all over the world have been invited to give an overview in keynotes, to in depth explain their research and development work in technical presentations and to share their knowledge in discussion forums as an indispensable part of the event.

The SiC User Forum is this way intended as a platform to share experience and ideas, to discuss and find out which power electronic systems are predestinated for usage of SiC and how to appropriately design-in those novel, almost ideal but also challenging components. It aims at finding and pointing out approaches to exploit the high potential of SiC and to support its beneficial introduction in power electronic systems.

www.ecpe.org


EPE 2007
AALBORG
12th European Conference on Power Electronics and Applications
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Comparing Regulated Charge-Pump and Inductor-Based DC/DC Converters

It is the design engineer to make the choice of topology

Charge pumps, also known as inductorless DC/DC converters, are a special class of switching DC/DC converter that uses capacitors as energy storage elements. When compared to inductive switching DC/DC converters, which use inductors as energy storage elements, charge pumps offer unique characteristics that make them attractive for certain end-user applications.

By Qi Deng, Senior Product Marketing Engineer,
Analogue and Interface Products Division, Microchip Technology Inc.

This article compares the architecture and operation of a regulated charge pump with that of the most widely used inductor-based DC/DC converters, such as the buck regulator, the boost regulator and especially the Single-Ended Primary Inductive Converter (SEPIC).

The Regulated Charge Pump

One of the simplest and most commonly used charge-pump architectures is that of doubling. The doubling charge-pump architecture includes four switches, an external energy storage and transfer capacitor commonly known as the flying capacitor, and an external output capacitor commonly known as the reservoir capacitor.

Figure 1 illustrates the doubling charge pump architecture. This architecture's operation consists of two phases; charging (energy storage) and discharging (energy transfer).

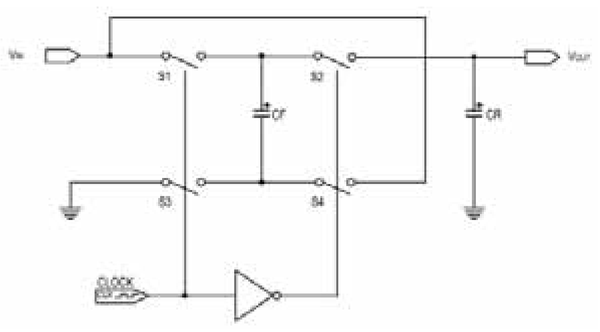


Figure 1: Unregulated, Doubling Charge Pump

During the charging phase, switches S1/S3 are closed (switch on) and S2/S4 are open (switch off). The flying capacitor (C_F) charges to the input voltage (V_{IN}) and stores energy that will be transferred during the next discharging phase. The reservoir capacitor (C_R), having been charged to $2V_{IN}$ with energy transferred from C_F during the previous discharging phase, supplies the load current.

During the discharge phase, switches S1/S3 are open and switches S2/S4 are closed. C_F is now level-shifted by V_{IN} and, since C_F has already been charged to V_{IN} during the previous charging phase, the total voltage across C_R is now $2V_{IN}$ (hence, the name doubling charge pump). C_F then discharges to transfer energy stored during the charging phase to C_R, as well as supply the load current.

The frequency of the charge/discharge cycle is determined by the frequency of the clock. It is a common practice to use a higher-frequency clock to reduce the capacitance, and hence the size, of both the flying and reservoir capacitors.

The output voltage of the simple doubling charge pump in Figure 1 is not regulated, as it changes according to the input voltage and load. This is not desirable for applications that require a source with regulated output voltage. However, the addition of a simple feedback loop easily overcomes this. Figure 2 illustrates a very simple doubling charge pump with a regulated output, typically called a regulated charge pump.

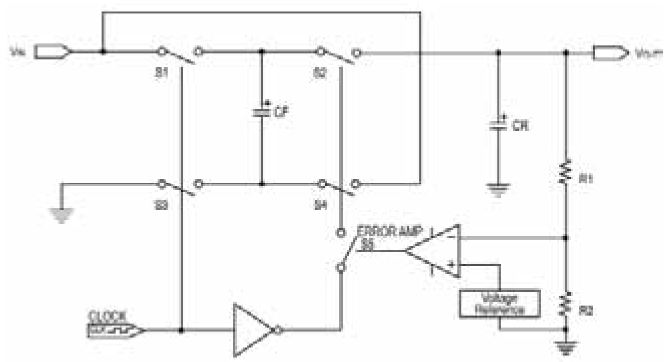


Figure 2: Regulated Charge Pump

In Figure 2, a switch (S5) is added to provide additional control on switches S2/S4. A comparator, the output of which is determined by the differential between a fraction of output voltage (V_{OUT}) through a resistor divider (R1 and R2) and a highly accurate voltage reference, controls the state of S5. The comparator usually has built-in hysteresis to prevent oscillation. The comparator, resistor divider, voltage reference and S5 switch complete the feedback loop. This loop regulates the output voltage of the charge pump by controlling the on and off states of switches S5 and S2/S4 in the discharge phase.

During the discharge phase, if V_{OUT} is below the preset regulated output voltage, the comparator closes S5, which in turn closes S2 and S4. This allows C_F to transfer energy to C_R and the load, in order to bring V_{OUT} up to the preset regulated voltage. When V_{OUT} is brought up to the preset regulated voltage, the comparator opens S5, which in turn opens S2 and S4 to terminate the energy transfer. If V_{OUT} cannot be brought up to the preset regulated voltage during this discharging phase, S5, S2 and S4 stay closed until the end of the phase.

Alternatively, if V_{OUT} rises above the present regulated voltage, the comparator opens S5, which in turn opens S2 and S4. This terminates the energy transfer from C_F to C_R and the load, in order to bring V_{OUT} down to the preset regulated voltage. S5 and S2/S4 stay open if V_{OUT} cannot be brought down to the preset regulated voltage during the discharging phase.

The regulated charge pump can output a regulated voltage that is between ground and $2V_{IN}$, by simply manipulating the values of the resistors (R1 and R2) in the divider. This means that the regulated output voltage can be either higher or lower than the input voltage. However, this is not the case for the most commonly used DC/DC conversion topologies that use inductors as energy storage elements, such as buck (step down) and boost (step-up) regulators.

Buck and Boost Converters

The operation of the majority of today's inductor-based DC/DC converters is periodic, with a period of time (T) controlled by the frequency of the clock. To simplify analysis in this article, only fixed-frequency inductor-based DC/DC converters operating in continuous current mode are considered. Inductor-based DC/DC converter operation includes two phases: switch on (close) and switch off (open). The switch-on duration (t_{ON}) is controlled by the feedback loop and determined by the amount of deviation of V_{OUT} from the preset, regulated output voltage. The switch-off duration is therefore given as $T - t_{ON}$ (see Figure 3).

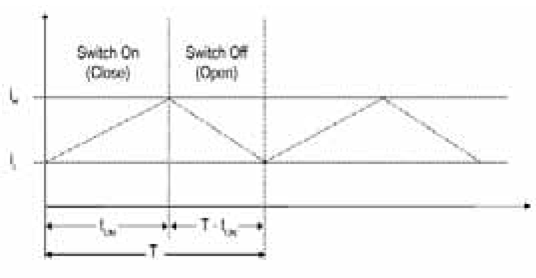


Figure 3: Fixed Frequency, Continuous Mode, Inductor-Based DC/DC Converter Timing

The operation of the buck regulator is generally well understood. Its regulated output voltage is given as:

$$V_{OUT} = V_{IN} (t_{ON}/T)$$

This equation can also be expressed as:

$$V_{OUT} = V_{IN}D$$

where D is the Duty Cycle and is equal to t_{ON}/T

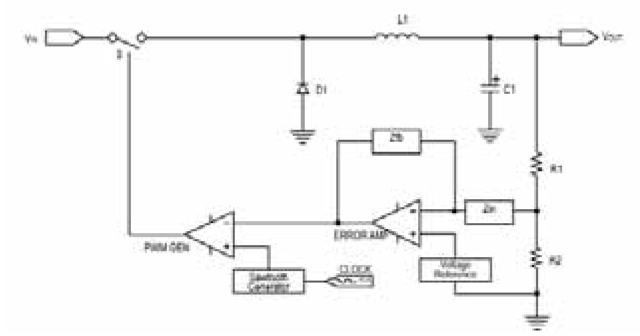


Figure 4: A Buck Converter

From the above equations, it is easy to see that the output voltage of a buck converter is always lower than its input voltage, as the Duty Cycle (D) is always less than 1. Figure 4 illustrates the architecture of a buck regulator.

The operation of the boost regulator is also generally well understood, with its regulated output voltage is given as:

$$V_{OUT} = V_{IN} T/(T-t_{ON})$$

This equation can also be expressed as:

$$V_{OUT} = V_{IN} / (1 – D)$$

where D is the Duty Cycle and is equal to t_{ON}/T

Therefore, the output voltage of a boost converter is always higher than its input voltage, as the 1/(1 – D) is always greater than 1. Figure 5 illustrates a boost regulator architecture.

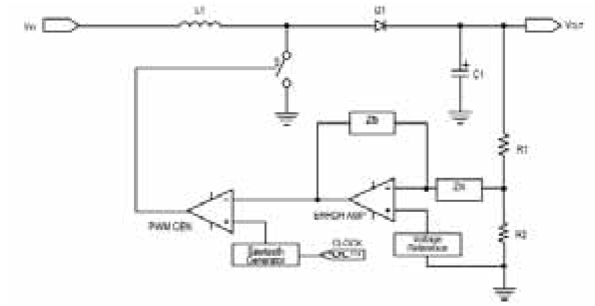


Figure 5: A Boost Converter

Consequently, in applications that require the regulated output voltage to be either higher or lower than the input voltage, neither the buck nor the boost regulator is suitable.

The Single-Ended Primary Inductive Converter (SEPIC)

One of the increasingly popular inductor-based DC/DC converters that is capable of outputting a regulated voltage, either higher or lower than the input voltage, is the SEPIC topology.

As illustrated in Figure 6, the SEPIC topology is unique in that, unlike the buck and boost converters, it functions with two external inductors (L1 and L2) and two external capacitors (C_P and C_{OUT}). The operation of the SEPIC topology also includes two phases, however, its operation is not as widely discussed because it is fairly complicated and has only recently gained popularity.

Again, to simplify analysis in this article, only a fixed-frequency SEPIC regulator operating in continuous current mode for both L1 and L2 will be considered.

To understand the operation of the SEPIC regulator, begin with the equilibrium state, during which the switch is off. There is no DC current following through C_P. The voltage across C_P (from left to right) is V_{IN}, with its left side connected to V_{IN} through L1, and right side connected to ground through L2.

During the switch-on phase, the right side of L1 is switched to ground and V_{IN} is the voltage across it. The left side of C_P is level-shifted to ground and, as the voltage across C_P from left to right is V_{IN}, as explained above, the voltage at the right side of C_P is $–V_{IN}$. With its bottom side grounded, L2 is in parallel to C_P, and the voltage on its top side is also $–V_{IN}$. The diode (D1) is now reverse biased and there is no current flowing through it.

In this phase, L1 is charged by V_{IN} and L2 is charged by C_P. As D1 is reverse-biased, neither inductor performs the charging of C_{OUT} or supplies the load, as the load current is only supplied by C_{OUT}. As such, both inductor currents climb up in a linear fashion, starting from the beginning of the switch-on phase with initial values of i_{L1} and i_{L2}, and continuing through the end of the switch-on phase with terminal values of i_{H1} and i_{H2}, respectively (see Figure 6).

The relationship between the voltage across an inductor and the current flowing through it is given by:

$$V = L\,(di/dt)$$

As derived from this equation, the voltage-current relationship of inductors L1 and L2 during the switch-on phase is given as:

$$i_{H1} – i_{L1} = (V_{IN} – 0)\, t_{ON}/L1 = V_{IN}t_{ON}/L1$$

$$i_{H2} – i_{L2} = (0 – (-V_{IN}))\, t_{ON}/L2 = V_{IN}t_{ON}/L2$$

During the switch-off phase, since the current through L1 cannot change instantaneously, the same current flows out of the right side of L1, forcing it to swing from ground to above V_{IN}. This effectively level-shifts the left side of C_P above V_{IN} as well, which causes a current to flow out from its right side, putting D1 into forward bias. This means that the voltage at the right of C_P, which is also the top of L2, is now equal to V_{OUT}, ignoring the small diode drop. Additionally, it establishes that the voltage across C_P from left to right is V_{IN}, so the voltage at the node between C_P and L1 is now $V_{IN} + V_{OUT}$.

The inductor currents from both L1 and L2 now charge C_{OUT} as well as supply current to the load. Both inductor currents drop down in a linear fashion, starting from the beginning of the switch-off phase with the initial values of i_{H1} and i_{H2}, and continuing through the end of the switch-off phase with terminal values of i_{L1} and i_{L2}, respectively (see Figure 6).

The voltage-current relation of inductors L1 and L2 during the switch-off phase are given as:

$$i_{L1} – i_{H1} = (V_{IN} – (V_{IN} + V_{OUT}))\,(T - t_{ON})/L1 = -V_{OUT}(T - t_{ON})/L1$$

$$i_{L2} – i_{H2} = (0 – V_{OUT})\,(T - t_{ON})/L2 = -V_{OUT}(T - t_{ON})/L2$$

From either of the four previous equations VOUT can be derived as:

$$V_{OUT} = V_{IN}\, t_{ON}/(T - t_{ON})$$

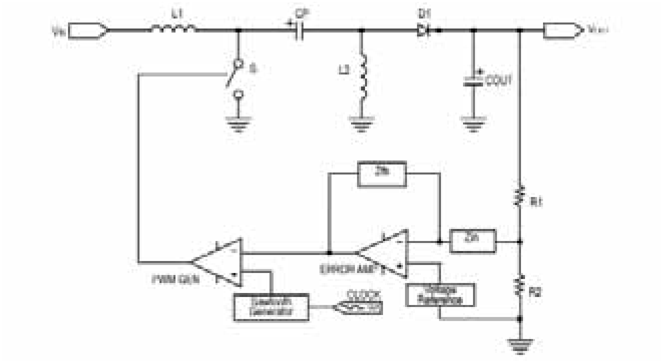


Figure 6: SEPIC Regulator

Which can also be expressed as:

$$V_{OUT} = V_{IN}\, D/(1 – D)$$

where D is the Duty Cycle, and is D is equal to t_{ON}/T

From these equations it can be seen that the output voltage of a SEPIC regulator can be either higher or lower than its input voltage, as D/(1 – D) can be either greater or less than 1.

The Comparisons

Both the regulated charge pump and the SEPIC can output a regulated voltage that is either higher or lower than the input voltage. In some end-user applications that require design simplicity and cost effectiveness, the regulated charge pump is more desirable than the SEPIC regulator.

	Regulated Charge Pump	Buck Converter	Boost Converter	SEPIC Regulator
Complexity	Low	Medium	Medium	High
Footprint	Small	Medium	Medium	Large
Cost	Low	Medium	Medium	High
Efficiency	Medium	High	High	Medium to High
Output Current	Low	High	Medium	Medium to High

Table 1: Comparisons

A regulated-charge-pump-based solution is simpler than the SEPIC–based solution, because it does not require inductors to operate. Hence, in comparison to the SEPIC regulator, the regulated-charge-pump approach is simpler in design, smaller in footprint and lower in cost.

The SEPIC regulator, however, is the more desirable choice if high efficiency is required for all load voltage and current conditions. Additionally, as an inductor-based DC/DC topology, a SEPIC regulator is capable of outputting higher current than a regulated charge pump.

Conclusions

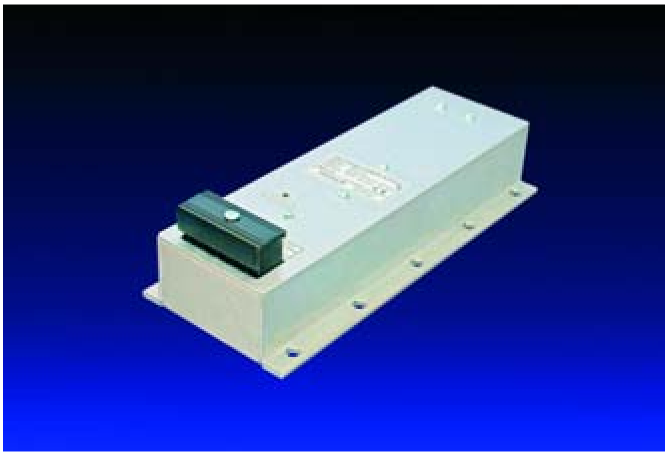
Comparisons between regulated charge pumps and inductor-based DC/DC converters, such as buck, boost and especially SEPIC regulators, are shown in Table 1 and can be summarised as follows:
The regulated-charge-pump-based solutions are, in general, simpler in design, smaller in footprint, and lower in cost.
The SEPIC regulator, in many cases, has higher efficiency, and can output higher current.
It is the design engineer’s responsibility to make the choice of topology, based upon the system requirements and tradeoffs.

www.microchip.com

Encapsulated DC/DC for Railway

The RWD 200 is a recent addition to Absopulse Electronics' RWY series of rugged, field-proven, DC/DC converters. Designed for operation in railway and other harsh environments, the RWD 200 provides a complete 200W power solution in a compact enclosure and weighs 1.3 kilograms. A built-in redundancy diode allows for 1+1 redundant operation when two modules are connected in parallel.

This push-pull converter employs advanced FET technology to deliver a single output of 12Vdc/16A or 24Vdc/8A. Input ranges include 24V (14.4 – 37Vdc), 36V (22 – 55Vdc), 48V (28 – 74Vdc), 72V (42 – 110Vdc) or 110Vdc (57 – 168Vdc), which are typically required in railway applications. The units are capable of continuous operation in these ranges. Other input and output options are available on request.



www.absopulse.com

4MHz 500mA Buck Regulators Featuring Hyper Light Load

Micrel launched the MIC23050/1, two ultra-fast transient performance and high efficiency 4 MHz, 500mA synchronous buck (step-down) regulators assembled in a tiny 2mm x 2mm MLF package. These devices utilize a novel and patented switching scheme that offer best-in-class light load efficiency and industry-leading transient performance. The devices use the smallest inductors in their class and provide very low output ripple at all loads. The unique combination of features makes these devices the perfect choice for today's portable applications where high efficiency, fast dynamic response, low output noise and a small solution size are critical. Target applications include cellular phones, portable media players, GPS systems, WiMax modules, digital still and video cameras and USB peripherals. The MIC23050 is available in volume.

www.micrel.com

Stackable DC/DC Controller for High-Density Blade Servers

Texas Instruments introduced a single-channel version of its TPS40K stackable controller family that transforms power supplies in data centers and telecommunications equipment into fully scalable, interleaved power systems with higher performance and design flexibility.

TI's TPS40180 synchronous, DC/DC controller allows a system designer to connect or "stack" together multiple power modules, resulting in a high-density power supply that supports 10 A to 200 A of output current. Based on the TPS40140 dual-phase controller announced in 2006, the single-channel version provides greater design flexibility when additional circuitry or daughter cards are added to the board — especially when the dual-phase capabilities of the TPS40140 are not needed.

The TPS40180 features automatic phase-balancing, which allows a power supply to minimize the ripple current in both the output and input capacitors, and results in an overall smaller solution size. Designers can also implement topologies where multiple output rails can be synchronized to achieve greater levels of power density and flexibility, while minimizing electromagnetic interference (EMI) system noise. The load share feature enables modular power supply design where modules can be paralleled together, so that each module will deliver power equally to the load.

power.ti.com

Austin MegaLynx Point-of-Load DC/DC Converter

Tyco Electronics' Power Systems announced general availability of its Austin MegaLynx point-of-load (POL) DC/DC converters in SMT packages. Designed to meet the power needs of the latest generation of FPGAs and ASICs, the Austin MegaLynx converter series extends the output current range of the Austin SuperLynx converters up to 30Amps in an efficient SMT package.
The Austin MegaLynx converter series includes four versions. The ATS020 and ATS030 supports an input voltage range of 6-14 Vdc, with a programmable output voltage range of 0.8V - 3.63Vdc and 0.8V – 2.75V respectively. The ATH version supports an input voltage range of 4.5-5.5Vdc, with a 0.8-3.63Vdc output voltage range.
The ATM version supports input 2.7 to 5.5Vdc input with 0.8 to 2.0Vdc output range. The Austin MegaLynx converter can reach efficiencies of greater than 92.5 percent at nominal input voltage conditions and rated output current. In addition, standard features include programmable output voltages, remote on/off, remote sense, monotonic start up, EZ-SEQUENCETM, over current and over temperature protection.

Current share (-P) and base plate (-H) with additional ground pins for improved thermal performance are available as options.
"The Austin MegaLynx converter fulfills the need for high on-board current with low output ripple, as required by the latest ICs," said Sabi Varma, vice president, marketing and development engineering at Tyco Electronics Power Systems business. "Austin MegaLynx offers higher current capabilities than our SuperLynx II in the existing package."

www.tycoelectronics.com

Low-Cost Motor Control Digital Signal Controllers

Microchip announces free source code for sensorless Field Oriented Control (FOC) of Permanent Magnet Synchronous Motors (PMSMs), suitable for any of their Motor Control dsPIC Digital Signal Controllers (DSCs), including the dsPIC33FJ12MC family.

With electric motors consuming a significant percentage of the energy generated worldwide, and increasingly stringent energy regulations being introduced, the demand for advanced, efficient control of variable-speed motors is increasing. Microchip's motor control dsPIC families offer dedicated hardware, alongside a range of free software algorithms, allowing many applications to take advantage of these advanced control methods.
Specific motor control features of the new dsPIC33FJ12MC family include a Motor Control PWM module with two independent clock sources (enabling, for example, motor control and power factor correction algorithms in a single device), an optimised Analogue-to-Digital Converter, and an on-chip quadrature encoder interface.
For emulation, debugging and programming, Microchip offers the full-featured MPLAB REAL ICE tool and the low-cost MPLAB ICD 2 tool. The 16-bit 28-pin starter board (part number DM300027) can be used for development of simpler applications with the dsPIC33FJ12MC devices, while the FOC algorithm can be fully evaluated using the dsPICDEM MC1 Motor Control Development Board

www.microchip.com/motor

Ansoft Announces HFSS v11

Ansoft Corporation (NASDAQ: ANST) announces the release of HFSS v11. This release of Ansoft's flagship product features new technology that delivers even greater accuracy, capacity and performance than before. HFSS v11 includes new higher-order hierarchical basis functions combined with an iterative solver that provides accurate fields using smaller meshes and thus more efficient solutions for large multi-wavelength structures. A new fault tolerant, high-quality finite element meshing algorithm allows HFSS to simulate very complex models two to five times faster using half of the memory compared to previous versions.
HFSS is the standard for 3D full-wave electromagnetic field simulation, a critical aspect in designing high-performance electronic devices that are more portable, smaller in size and operate at higher frequencies. These devices include RF/microwave components, on-chip passives, PCB interconnects, antennas and IC packages.
The dynamic link between HFSS and the company's advanced, combined frequency- and time-domain circuit simulator Nexxim, and Ansoft Designer, the company's integrated schematic and design management front-end, creates a powerful electromagnetic-based design flow. This design flow enables users to merge complex, highly nonlinear transistor-level circuits with 3D full-wave accurate component models to solve challenging high-performance

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200V ICs for Low-Voltage Motor Drive

International Rectifier has introduced a series of 200V ICs for low- and mid-voltage motor drive applications including power tools, low-voltage servo drives, electric garden equipment, and electric vehicles such as cranes, golf carts, and scooters.
The IRS200x family of half-bridge, high-side and low-side driver ICs is tailored for low-voltage (24V, 36V, and 48V) and mid-voltage (60V, 80V and 100V) motor drive applications including both three-phase inverter and half-bridge. Under-voltage lockout (UVLO) protection is a standard feature provided across the family while the IRS2003 and IRS2004 also include deadtime protection. In addition, the IRS2004 features a shutdown input pin. These new 200V ICs feature low quiescent current that enables a low-cost bootstrap power supply for the high-side circuitry, eliminating the need for large and expensive auxiliary power supplies that discrete optocoupler- or transformer-based designs typically require, making them well suited for low-voltage applications that require a small footprint.
The IRS200x devices are offered in eight-pin SOIC and DIP packages and feature gate voltage (Vout) up to 20V, typical turn-on current (Io+) of 290 mA, typical turn-off (Io-) current of 600 mA, and accept input logic levels of 3.3V, 5V and 15V. The new 200V devices utilize IR's advanced high-voltage IC process which incorporates
next-generation high-voltage level-shifting and termination technology to deliver superior electrical over-stress protection and higher field reliability.

www.irf.com

Line Filters for Medical Applications

The new, compact 2-line filters of the SIFI-F (B84111FM*) series are now also available in a medical version. Not only do they offer all the advantages of the standard SIFI-F version, they also boast an extremely low maximum leakage current of 2 ìA. With its compact dimensions, the SIFI series from EPCOS is therefore well suited for medical applications such as ultrasound devices, X-ray systems, or other medical diagnostic devices where low leakage current is a critical factor.

Despite their compact design, they offer very good suppression of symmetrical and asymmetrical interference.
Applications for all three of the important approvals, namely UL, cUL and ENEC, have been submitted. The SIFI-F, along with the larger SIFI-G and SIFI-H, is designed for the climate category of up to +100 °C. Filters for all current strengths up to 36 A are available from stock as samples.

www.epcos.com

Handbook for Transformer Design

Introducing Wurth Elektronik's essential textbook for transformer design. The application and design handbook "Abc of transformers" is a practical guide for selecting suitable transformers for the respective application. The 100 page textbook delivers a detailed insight into the functionality of transformers. There is also an overview about the quantities of the transformers and their applications.
Examples of applications and detailed procedure for an assortment of transformers are the cherry on the top.
The book cost 10 Euros and also includes free simulation software developed by Wurth Elektronik. After entering your parameters into the software you will be recommended a suitable component. The book and the CD are a perfect complement for certain and fast transformer design.

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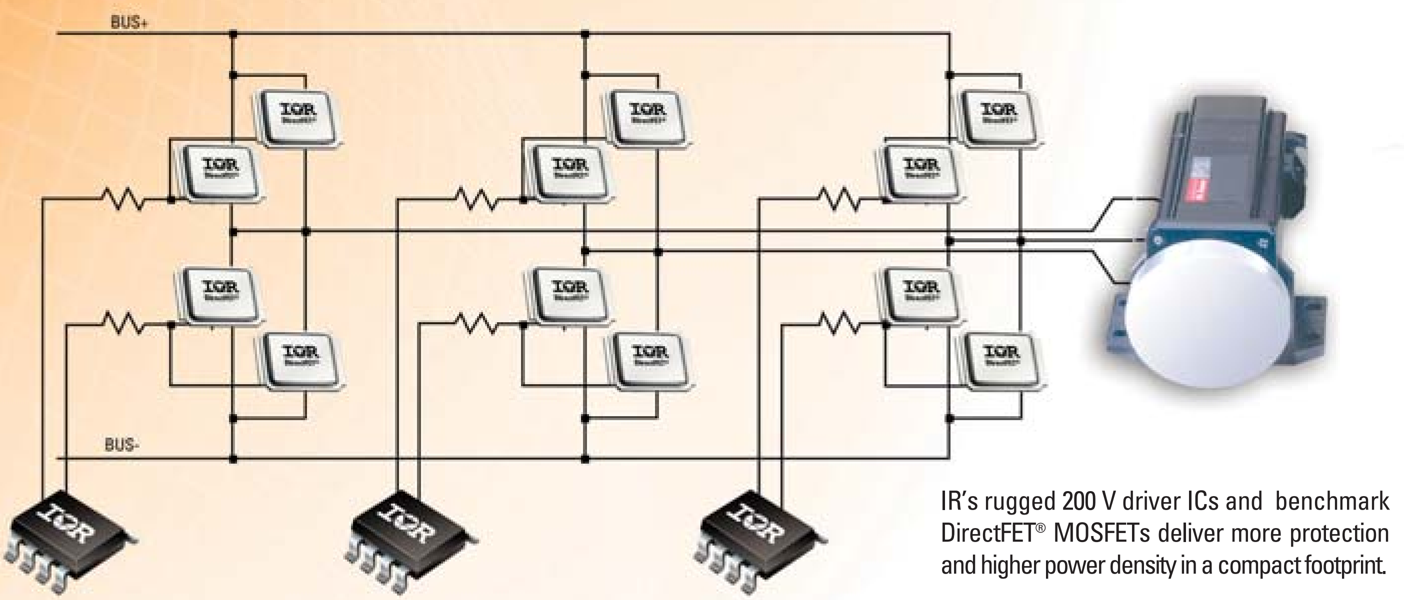

IR's rugged 200 V driver ICs and benchmark DirectFET® MOSFETs deliver more protection and higher power density in a compact footprint.

IRS200x FEATURES

- High-side circuitry powered by bootstrap power supply
- Undervoltage lockout protection
- 3.3 V, 5 V, and 15 V input logic compatible
- Cross conduction prevention logic (for half-bridge drivers)
- Shutdown input available on

IRS2004(S)PBF

- 50 V/ns dV/dt immunity on floating Vs pin

DirectFET FEATURES

- 1.4° C/W junction to case thermal resistance ($R_{th(J-C)}$) enables highly effective top-side cooling
- Less than 1° C/W $R_{th(junction-pcb)}$ in half the footprint of a d-pak
- Over 80% lower die-free package resistance (DFPR) than d-pak
- 0.7 mm profile compared to 2.39 mm for d-pak

200 V Driver ICs

Part	Package	UVLO	Compliance	Typical Current	Input Logic	Additional Features
IRS2001PBF	DIP8	UVLO, VCC	RoHS & PBF	290 mA / 600 mA	HIN, LIN	Independent high & low side drive
IRS2001SPBF	SOIC8 Bulk					
IRS2001STRPBF	SOIC8 Tape & Reel					
IRS2003PBF	DIP8	UVLO, VCC	RoHS & PBF	290 mA / 600 mA	HIN, LIN/N	Deadtime
IRS2003SPBF	SOIC8 Bulk					
IRS2003STRPBF	SOIC8 Tape & Reel					
IRS2004PBF	DIP8	UVLO, VCC	RoHS & PBF	290 mA / 600 mA	IN, SD/N	SD Input & deadtime
IRS2004SPBF	SOIC8 Bulk					
IRS2004STRPBF	SOIC8 Tape & Reel					

DirectFET MOSFETs

Part	Package	Polarity	VBRDSS (V)	$R_{DS(on)}$ 4.5 V Max. (mΩ)	$R_{DS(on)}$ 10 V Max. (mΩ)	I_D @ TC = 25° C (A)	Qg Typ	Qgd Typ	$R_{th(JC)}$	Power Dissipation @ T_C = 25° C (W)
IRF6635	DirectFET	N	30	2.4	1.8	180	47.0	17.0	1.4	89
IRF6613	DirectFET	N	40	4.1	3.4	150	42.0	12.6	1.4	89
IRF6648	DirectFET	N	60		7.0	86	36.0	14.0	1.4	89
IRF6646	DirectFET	N	80		9.5	68	36.0	12.0	1.4	89

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