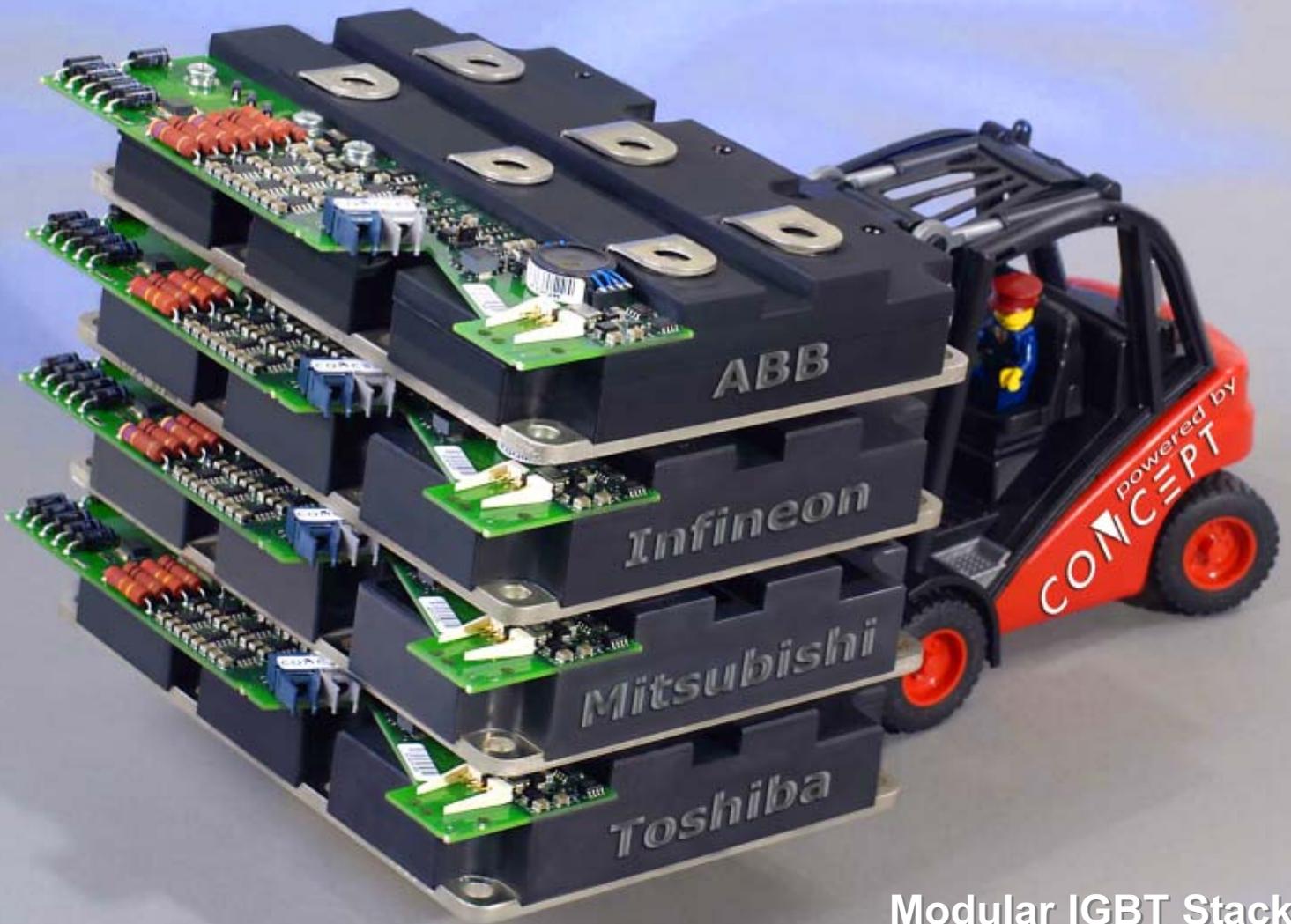


Bodo's *Power Systems*

Systems Design Motion and Conversion

October 2006

Plug&Play IGBT Driver ONE FOR ALL



Modular IGBT Stacks
Automotive Lighting
Effective Load Resistance
Li-Ion Battery Charging

Inverter motor designs: half the energy, cost and time.

50W — 3kW

Smart Power Module

IGBT driving and circuit protection

Motion SPM™

energy savings

Meet energy usage regulations with SPM

Satisfy government energy requirements for home appliances with Fairchild's Smart Power Modules (SPM) for variable speed motor drives. One highly integrated package, with up to 16 discrete components, provides space savings, ease-of-use and greater reliability.

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Smart Power Modules: where energy is critical, SPM is there.



Fairchild Smart Power Modules are the optimal solution for variable speed motor drives in home appliance designs.

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Events**FLUX Users Conference,**

October 19 – 20, Padova Italy,
cedrat@cedrat.com

PowerSystems World,

October 24 – 26, Long Beach CA,
www.powersystems.com

H2Expo, October 25-26,

Hamburg, www.h2expo

Thermo Informatics World 2006,

October 23-27, San Diego CA
November 6-10, Prague,
www.tiw06.com

ELECTRONICA 2006,

Nov. 14 – 17, Munich,
www.electronica.de

SPS/IPC/DRIVES 2006, Nov. 28 – 30,
Nuremberg, www.mesago.de

Engineers and Bavarian Culture

It is October - you may have missed the October fest, it starts in September. Sorry, I did not include the October fest in my event calendar; especially since power electronics is very much involved in the amusements and the lighting. Remember Mr. Edison – he started with the Paris Exposition in 1880 and the Crystal Palace in England in 1882. Both of these lighting displays made a big impression, especially on investors in the new technology. And power technology continues with a vital influence in all of our daily lives.

Electronica in Munich is the next big event for Engineers and others – an extension of the October fest. Exhibitors from all over the world show up to have their big party together with 80,000 visitors. You have to wear the right shoes to survive during these days.

I will be around every day at Electronica - with the magazine and extra bonus copies to distribute. Right after Electronica the big show is SPS /IPC/ DRIVES in Nuremberg. It will attract mostly Engineers, and again I will be there with my magazine. Nuremberg is still Bavaria but the people call themselves Franken. SPS /IPC/ DRIVES has an industrial focus and reflects the strength of industrial electronic competence in Europe. Tool machine design has a long and stable history and has been upgraded by more and more efficient electronics over the decades. As a result, we see continuous growth at the SPS /IPC/ DRIVES show. I remember older days in Sindelfingen near Stuttgart, about 20 years ago. And that Electronica had moved from the Munich city location after getting the old airfield Munich-Riem rebuilt as a fair ground. Do you remember those days at the Theresienwiese in the heart of Munich ?

My contacts in Industry have been collected over a period of more than a quarter of a century. Most of you know me from when we worked on projects – such as IGBTs for motor control; my early job at GE solid state in the mid 80s. From all this I have developed a database, now numbering over 25,000 contacts. You are one of my contacts – a most special one to me ! From two decades as a member of the PCIM Europe advisory board, I have made friends that are now included in my circulation. The magazine circulation has been successful audited



by a steering committee of international companies.

My offer to new and old contacts to reregister and help clean up my databank has generated winners of a week's stay at my harbour view condo. Winners have been notified and if they agree, you will learn what they do and what influence they have in our industry.

To reach University students and engineers, I have included European Institutes of Power Electronics and Electrical Drives in my circulation. As a result the first article from the "Universität der Bundeswehr in München" is in the October issue. This article has a strong practical focus on motor drive applications in the area of switch reluctance drives. From now on these will continue as a feature subject in the publication content page.

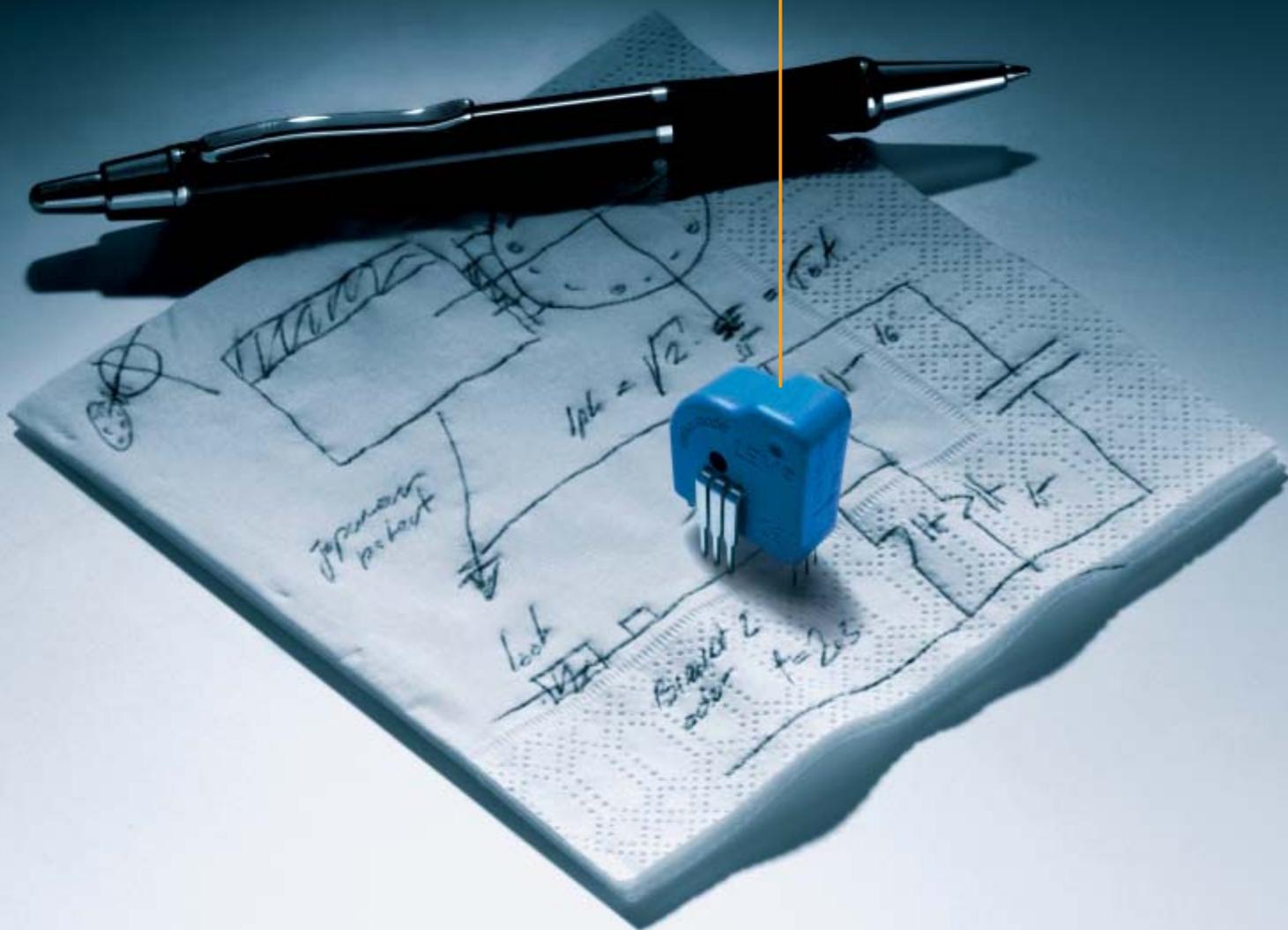
Good delivery of first class contributed articles at the beginning of the month and industry support has enabled a monthly schedule for next year's issues. All details for 2007 are up on my web, and a continuous update of events and news will be included. It is there for your use – have a look.

Well - I hope you all had a relaxing summer vacation and that we are ready to get the shows going. I look forward to see you in Munich or Nuremberg

Best Regards

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Whatever you invent, imagine or develop, LEM's transducers are at the heart of your power electronics applications from the very start. LEM's products, R&D, and people provide knowledge intensive solutions to keep up with your changing industry, allowing your visions to come to life.

www.lem.com

At the heart of power electronics.



Roberto Magnifico VP European Sales

Intersil has promoted Roberto Magnifico to the position of vice president of Sales, Europe, located at Intersil's sales office in Lausanne, Switzerland.

Magnifico joined Intersil in 1997 as a marketing manager and progressed to sales director for Europe in 2002. As sales director he helped drive sales growth and improve Intersil's overall brand in the region. As vice president, Magnifico will play a vital leadership role in Intersil's efforts to re-enter the automotive market and further penetrate key OEM electronics customers throughout Europe.

"I expect that Roberto's continued leadership in the region will allow Intersil to expand its presence in Europe, go after strategic



growth markets and engage with new customers," said Peter Oaklander, Intersil's senior vice president of Worldwide Sales.

"Roberto's strong sales background, as well as his long tenure with Intersil and in the semiconductor industry, makes him ideally suited for these expanded responsibilities." Magnifico has been in the semiconductor industry since 1984. Prior to Intersil, he worked for Phillips Semiconductor for nine years. He began his career in 1984 at ST Microelectronics as a product engineer in the Power Audio Amplifier ICs product group. Magnifico holds a BSEE from L. Settembrini, Milano Tech Institute.

www.intersil.com

Epcos and Taiyo Yuden

Epcos and Japanese company Taiyo Yuden, both among the world's top ten manufacturers of passive electronic components, will cooperate in the field of ceramic capacitors in future. The two partners have signed a cooperation agreement to this effect.

The agreement stipulates that in a first step Epcos will procure unfinished ceramic capacitors from Taiyo Yuden, process them

further and sell them under the Epcos brand. With these products, Epcos is complementing its range of ceramic capacitors offered mainly to customers based in Europe.

Epcos had streamlined its product range of ceramic capacitors and withdrew from unprofitable mass businesses in 2005. In a second step, Epcos and Taiyo Yuden plan to exchange know-how in specific areas of

technology on the basis of licensing agreements. By benefiting from each other's strengths in this way, both Taiyo Yuden and Epcos gain competitive advantages.

www.epcos.com

www.ty-top.com

FLUX Users Conference

CEDRAT is pleased to announce the 14th FLUX Users October 19th and 20th 2006 Conference in Padova, Italy, close to Venice.

During two days, customers and CEDRAT staff will share experiences with FLUX, CEDRAT flagship software solution for electromagnetics and thermal analysis, and pro-

vide valuable information about the new products and developments that keep FLUX, and the other software solutions of CEDRAT's catalogue, on the edge of the technology.

As this conference will be the host of one of the European references for heat treatment

and induction heating (University of Padova), we will also seize this moment to provide you technical trainings both days before this conference.

cedrat@cedrat.com

UPS Market Records

The World UPS market grew by 11.5% in the first half of 2006 according to the latest market statistics from IMS Research. Strong growth was observed in all three major regions when compared to same period in 2005.

Surprisingly, EMEA recorded the highest growth for the first half of the year, with the Americas and Asia following close behind.

All three regions boasted double-digit growth figures. These encouraging results are revealed in IMS Research's latest analysis of the UPS market, which provides up-to-date measurements of market performance.

Ash Sharma, Senior Market Analyst with IMS Research's Power & Energy Group, commented "The global UPS market recorded massive growth in the first half of 2006

despite a slight dip at the start of the year. Historical results indicate that the second half of the year could provide growth at an even faster rate, achieving a record market size."

www.imsresearch.com

www.bodospower.com

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The 2SD315AI is a 2-channel driver for IGBTs up to 1700V (optionally up to 3300V). Its gate current capability of $\pm 15A$ is optimized for IGBTs from 200A to 1200A.

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- Dead-time generation
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- Schmitt-trigger inputs
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- Duty cycle 0...100%
- Delay time typ. 325ns

CT-Concept Technology Ltd. is the technology leader in the domain of intelligent driver components for MOS-gated power semiconductor devices and can look back on more than 15 years of experience.

Key product families include plug-and-play drivers and universal driver cores for medium- and high-voltage IGBTs, application-specific driver boards and integrated driver circuits (ASICs).

By providing leading-edge solutions and expert professional services, CONCEPT is an essential partner to companies that design systems for power conversion and motion. From custom-specific integrated circuit expertise to the design of megawatt-converters, CONCEPT provides solutions to the toughest challenges confronting engineers who are pushing power to the limits.

The 2SD315AI has been established on the market as an industrial standard for the last four years. The driver has been tried and tested within hundreds of thousands of industrial and traction applications. The calculated MTBF to MIL Hdbk 217F is 10 million hours at 40°C. According to field data, the actual reliability is even higher. The operating temperature is -40°C...+85°C.



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More information: www.IGBT-Driver.com/go/2SD315AI

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In recent years we have developed a series of customized products which are unbeatable in terms of today's technological feasibility.

Our success is based on years of experience, our outstanding know-how as well as the will and motivation of our employees to attain optimum levels of performance and quality. For genuine innovations, CONCEPT has won numerous technology competitions and awards, e.g. the "Swiss Technology Award" for exceptional achievements in the sector of research and technology, and the special prize from ABB Switzerland for the best project in power electronics. This underscores the company's leadership in the sector of power electronics.

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Switzerland

Tel +41-32-341 41 01
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**Let experts drive your
power devices**

EPE 2007 Call for Papers

The European Power Electronics and Adjustable Speed Drives community will gather in Aalborg, Denmark, in September 2007 to exchange views on research progresses and technological developments in the various topics described hereunder. Deadline for abstracts is 1st of November 2006. The EPE 2007 conference is sponsored by the EPE Association and will be held in the Aalborg Congress & Culture Centre from 2 to 5 September 2007. It is hosted by Aalborg University's Institute of

Energy Technology. Denmark is the distributed power generation nation. More than 20% of the electricity is covered by wind and small combined heat and power plants are covering even more. A perfect place for new power electronic solutions.

EPE is the place for specialists in power electronics, systems and components, to present papers and attend sessions on state-of-the-art technology in this challenging and evolutionary sector. The conference

aims to be a meeting forum for researchers, developers and specialists from the industry. Papers are encouraged on all topics described hereunder for interdisciplinary discussions of new ideas, research, development, applications and the latest advances in the field of power electronics and adjustable speed drives.

www.epe2007.com

Hydrogen and Fuel Cell Technologies

Developments in the energy markets are hitting the headlines again and again. The fossil fuels gas and oil are increasingly being called into question, due to incalculable price developments, limited resources and damaging impact on the environment. It is essential to act now to prepare for an alternative, sustainable energy supply, including the use of hydrogen produced from renewable resources, and efficient fuel cells. Leading companies and research institutes worldwide are working on forward-looking concepts and marketable products. The international

experts meet for an exchange of views on the current status of developments, at the H2Expo, 6th International Conference on Hydrogen and Fuel Cell Technologies, at the CCH (Congress Center Hamburg) on 25 and 26 October. Scientists from Germany and abroad will present their research results, and manufacturers will report on their projects and experience, and their latest products.

The heart of this major innovation forum comprises a symposium and four concurrent workshops. There will be plenty of exciting

discussion, on the basis of high-quality presentations by some 70 speakers from 15 nations. Particularly important issues this year will be transport, infrastructure and renewable energies. The Conference Chairman is Dr. Subhash Singhal from the Pacific Northwest National Laboratory (USA) and Prof. Dr. Wolfgang Winkler from the University of Applied Sciences HAW (Hamburg).

www.h2expo.de

Thermo Informatics World

Thermo Electron Corporation, world leader in analytical instrumentation and informatics, has scheduled its annual software user group meeting and laboratory informatics conference. Thermo Informatics World (TIW) 2006 North America, will take place October 23-27, 2006, at the San Diego Sheraton in San Diego, California. TIW Europe will be held November 6-10, 2006, at the Hotel InterContinental in Prague, Czech Republic. The conference theme – The Path Forward – focuses on how the right informatics

strategies and solutions can alleviate pressures on industries by helping them to work more efficiently.

In both North America and Europe, TIW provides conference attendees – Laboratory Scientists, Lab Managers, Information Technology/Systems Managers and Operations Executives from all industries – the opportunity to meet and discuss issues and trends concerning laboratory informatics, evolving technologies, and changing

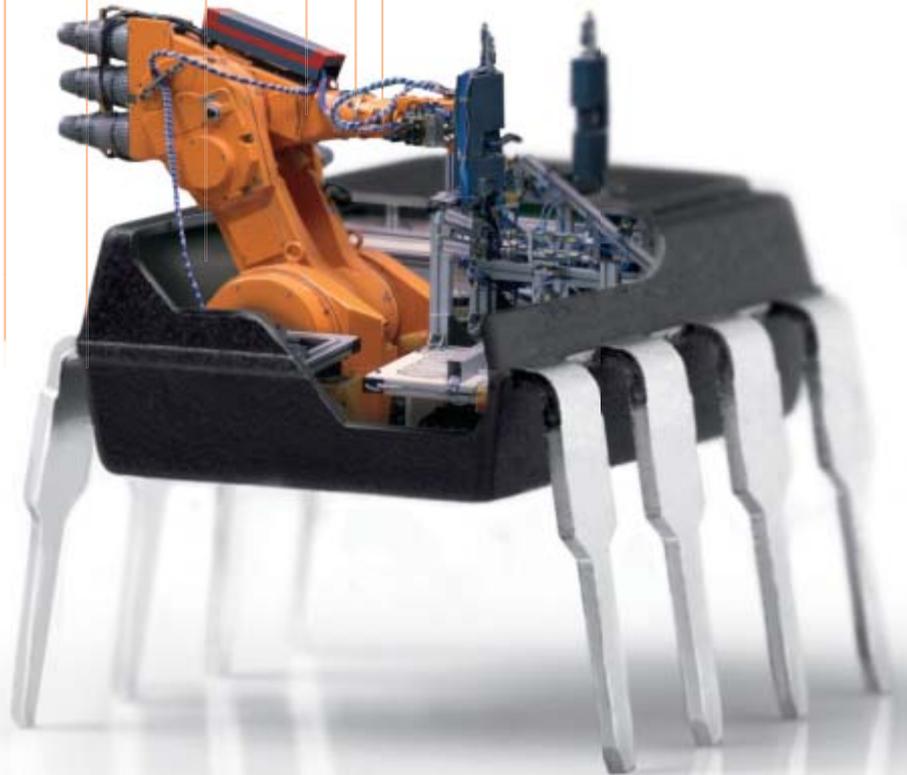
market requirements. The program for 2006 features compelling customer presentations, product development discussions, user networking and learning – exploring how to take advantage of continually evolving technologies to drive improvement within laboratories and businesses.

www.tiw06.com

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standing temperature- and moisture-resistant properties. At the same time, the integration of a photodiode and signal-processing IC on a chip – another Sharp technology – makes high switching speeds possible.

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SHARP

| Microelectronics

POWER MOS 8 Generation

Microsemi Corporation has launched the first 15 devices in their newest generation of POWER MOS 8 products.

These new MOS 8 MOSFET and FREDFET devices are designed for high power, high performance switch mode applications including power factor correction, server and telecom power systems, solar inverters, arc welding, plasma cutting, battery chargers, medical, semiconductor capital equipment and induction heating.

Key Performance Features:

- Improved oscillation immunity and reduced EMI
- Low $R_{DS(on)}$
- Low gate charge
- Low switching losses
- Avalanche energy rated
- Lower thermal resistance
- FREDFETs available with fast recovery body diodes

Microsemi engineers employed advanced design techniques to optimize capacitances and gate resistance. The result is a family of devices with improved oscillation immunity, lower peak slew rates, reduced EMI and high dv/dt ruggedness capability. These features combine to simplify filtering and paralleling of multiple devices in high power applications.

In addition, advanced manufacturing processes for the new MOS 8 products have lowered their thermal resistance and enabled higher current ratings for each die size and package type compared to earlier devices. Low capacitance and gate charge specifications enable high switching frequency capability and low switching losses.

All MOS 8 devices are 100% tested for avalanche energy capability and are offered only in RoHS compliant packages.

"Our new POWER MOS 8 family utilizes advanced technologies and manufacturing processes to deliver what our customers have asked for in our new generation of MOSFETs and FREDFETs," said Russell Crecraft, Vice President and General Manager of Microsemi's Power Products Group in Bend, Oregon. "Our MOS 8 family will offer the industry's broadest range of high voltage, high power, high performance MOSFETs, FREDFETs and PT IGBTs," he said.

MOS 8 FREDFETs have all of the features and advantages of MOS 8 MOSFETs, with the added benefit of a faster body diode recovery speed of <250ns. These devices provide superior ruggedness and reliability in applications where the body diode carries forward current, such as popular zero voltage switching (ZVS) bridge topologies.

First to be released in the POWER MOS 8 family are ten MOSFET and five FREDFET devices with power ratings from 19 to 75 amps and voltage specifications from 500 to 1200 volts. Additional power/voltage combinations will be introduced throughout the balance of 2006 and into early 2007.

The first Ultrafast Recovery FREDFETs, rated at 500 and 600 volts, will feature a 150ns recovery time and are scheduled for release in the fourth quarter of 2006. MOS 8 IGBTs with 600 & 900V ratings will follow in early 2007.



quarters in Irvine, California, is a leading designer, manufacturer and marketer of high performance analog and mixed signal integrated circuits and high reliability semiconductors. The company's semiconductors manage and control or regulate power, protect against transient voltage spikes and transmit, receive and amplify signals.

The first POWER MOS 8 devices:

Volts	Rds(on)	Id (Amps)	Part Number	Device Type	Package Style
500	0.14	42	APT42F50B	FREDFET	TO-247, D3
	0.10	56	APT56M50L	MOSFET	TO-264, T-MAX®
	0.10	38	APT38M50J	MOSFET	SOT-227
	0.075	51	APT51M50J	MOSFET	SOT-227
	0.075	75	APT75M50B2	MOSFET	TO-264, T-MAX®
600	0.21	34	APT34F60B	FREDFET	TO-247, D3
	0.21	34	APT34M60B	MOSFET	TO-247, D3
	0.16	43	APT43M60L	MOSFET	TO-264, T-MAX®
	0.16	30	APT30M60J	MOSFET	SOT-227
1000	0.46	29	APT29F100L	FREDFET	TO-264, T-MAX®
	0.46	19	APT19F100J	FREDFET	SOT-227
	0.40	31	APT31M100L	MOSFET	TO-264, T-MAX®
	0.40	21	APT21M100J	MOSFET	SOT-227
1200	0.80	22	APT22F12B2	FREDFET	TO-264, T-MAX®
	0.68	24	APT24M120L	MOSFET	TO-264, T-MAX®

MOS 8 technology utilizes a simplified manufacturing process that significantly lowers costs compared to previous Microsemi power MOSFET products. All the announced POWER MOS 8 devices are available for immediate sampling. Technical information is available on the Microsemi web site, <http://www.microsemi.com>. Samples can be ordered through this site, or from Microsemi sales representatives and authorized distributors.

Microsemi Corporation, with corporate head-

Microsemi's products include individual components as well as integrated circuit solutions that enhance customer designs by improving performance, reliability and battery optimization, reducing size or protecting circuits. The principal markets the company serves include implantable medical, defense/aerospace and satellite, notebook computers, monitors and LCD TVs, automotive and mobile connectivity applications.

www.microsemi.com

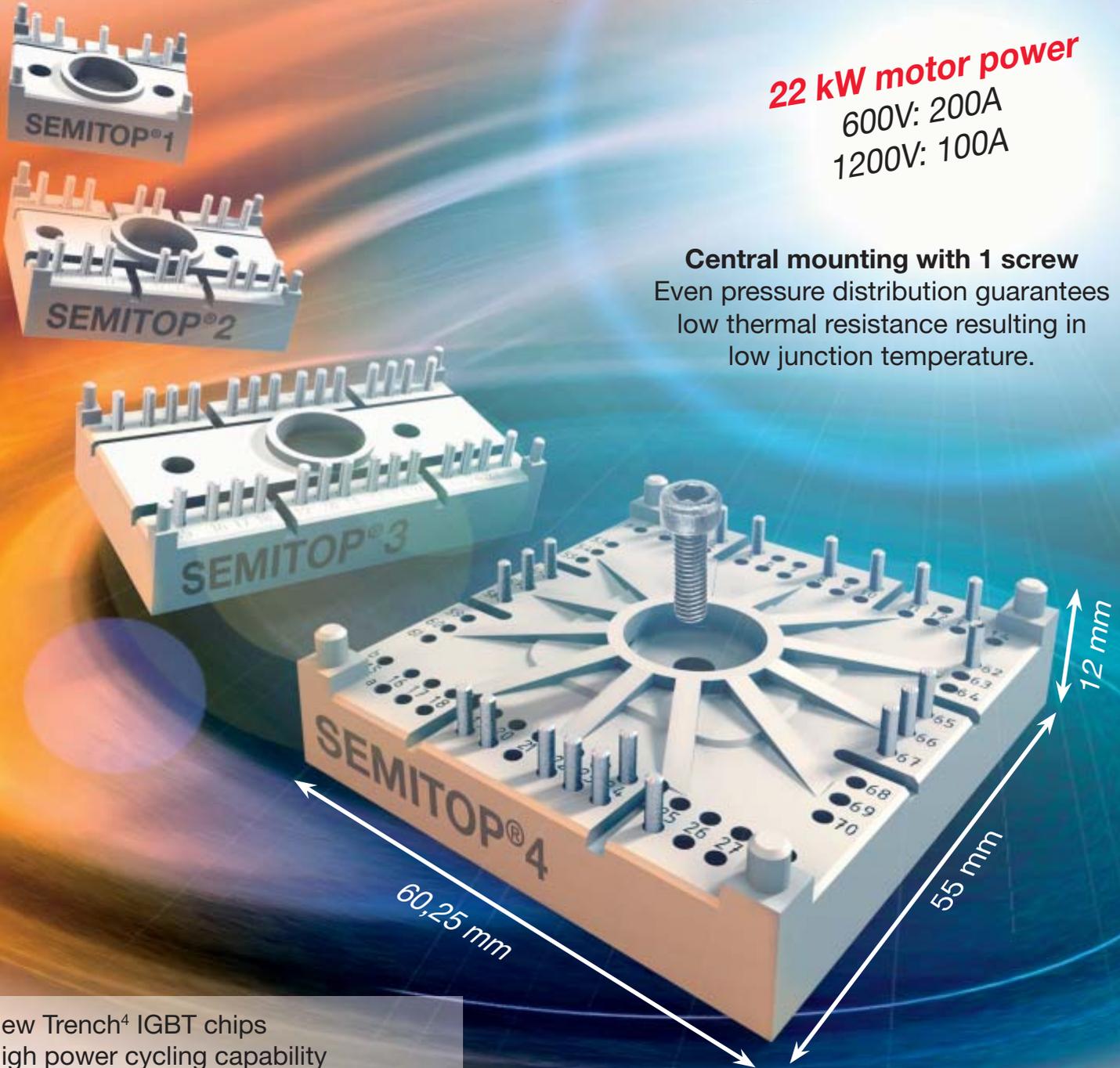
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Transducers in Power Electronics

Innovation through Integration

By Hans Dieter Huber, Vice President Industry, LEM

Power electronic systems have been used in the electrical industry almost from its inception. Traditionally these systems were utilized to control the process or environment. Classic examples are variable speed drives and the domestic light dimmer switch. Today the focus is evolving towards the energy savings or adapting energy from renewable sources like wind or solar. In the future the need to reduce CO2 emissions and energy efficiency availability of back up systems will dramatically increase the use of power electronics. We have already mentioned variable speed drives which now focus on efficiency as well as control to the point where electronic braking is used to generate electricity to feed back into the primary supply. A great deal of progress is also being made in the area of lighting control, domestic appliances, computers, telecoms and domestic applications. Power electronics increase efficiency by delivering the correct type of power at the most efficient voltage, current and frequency.

Modern systems are becoming more complex and require a precise coordination between the power semiconductors, system controller, mechanics and the feedback sensors. Transducers have a pivotal role in providing the necessary information from the load to fulfill that function. We can compare the use of transducers to adding eyes to the system. They can supply the brain of the system, in real time, with information regarding the condition of the controller. Of course, the cost of transducers must be in relation to the added functionality as well as being balanced within the total cost of the Bill of Material compared to the savings they can generate for the system.



In a lot of systems, the additional cost of the transducers appears to be too high for the target system cost. However if one looks at the savings achieved, this argument is sometimes flawed as the transducers can increase the information available as well as reduce the cost of other system components. Two examples for this are air conditioning and motor drives. In an air conditioning system, the micro controller can be reduced in complexity and therefore cost by having an accurate current measurement instead of repeating a mathematic model. Similarly, in motor drives, the motor frame size can be reduced by using a current transducer feedback to manage overload conditions and improve the overall performance.

With the move to greater integration and lower component count, the use of transducers can help overcome some of the issues with isolation, thermal management and vibration effects. Transducers can also solve some of the EMC issues due to the close proximity of other parts. Typically, the electronics are integrated into a single active element. Dependant on the topology, this typically becomes one complete unit with an external electronic assembly for signal processing and compensation. The trend today is moving towards size and cost reduction.

Within the power electronics system there is a need to integrate other components like heat sinks, magnetics and coils. In this area MEMS (Micro-Electro-Mechanical-Systems) is developing as a key technology. Some good examples are already available in the sensing field and this is an invitation to look at assemblies differently in the future. Finally the only limitation in size will be from the external constraints of creepage, clearance and isolation levels.

In summary, the drive for greater integration, cost savings and size reduction will drive new technologies into the power electronics market making the integration of larger sub systems much easier and cost effective. Working within these driving forces, smaller and lower cost transducers can help improve the total innovation and integration of the system helping the market offer more cost effective solutions to the consumer.

www.lem.com

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New DualPACKs

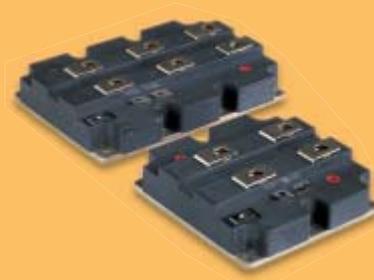


with Soldering Pins
1200V : 225A - 450A



with Spring Contacts
1200V : 225A - 450A

New High Power IGBT



1-Pack

1200V : 1200A - 3600A
1700V : 1200A - 3600A

2-Pack

1200V : 800A & 1200A
1700V : 600A & 1200A



6-Pack IGBT

600V : 15A - 150A
1200V : 10A - 150A
1700V : 100A & 150A

PIM IGBT

600V : 30A - 100A
1200V : 10A - 75A



High Power 6-Pack

1200V : 225A - 450A
1700V : 225A - 450A

*Special version available
for rough environments*

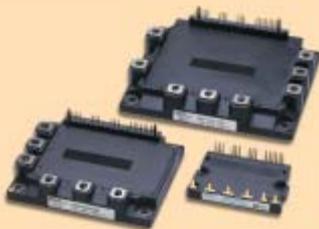


2-Pack IGBT

600V : 50A - 600A
1200V : 50A - 450A
1700V : 150A - 400A

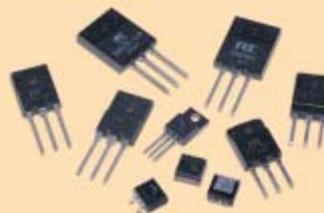
1-Pack IGBT

600V : 600A
1200V : 200A - 800A



IPM-IGBT

600V : 15A - 300A
1200V : 15A - 150A



Discrete IGBT

600V : 5A - 75A
1200V : 3A - 25A



Rectifier Modules

800V : 30A - 250A
1600V : 30A - 125A

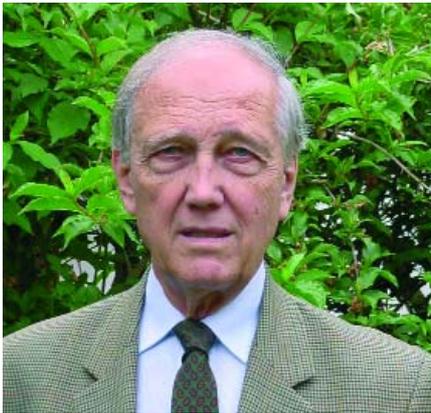
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THE LENNOX REPORT

ELECTRONIC COMPONENTS INDUSTRY



SEMICONDUCTORS

According to the WSTS global semiconductor sales in June grew 9.4% over prior year and declined 0.7 sequentially to \$ 16 639 B. Asia Pacific led with a 12.8% increase over prior year followed by the Americas 11.4% and Japan's 6.5%. Europe added only 1.4% but declined 1.9% sequentially and year-to-date still negative at 1.6%.

In Euros Europe was up 1.2% over prior year but -3.9% equentially, +2.8% year-to-date. s The ZVEI reports June semiconductor sales in Germany (in Euros) down 2% compared to prior year with the second quarter 2006 9% below the first one due mainly to low microprocessor sales. Six months sales were 2% below prior year though discretely, opto and sensors managed to add 17%. The June B/B ratio improved slightly to 0.99

Philips has signed an agreement, as widely expected, to sell an 80.1% stake in its semiconductor business to a consortium of Kohlberg Kravis Roberts & C° (KKR), Silver Lake Partners and Alpinvest Partners for about € 6.4 B. The business had 2005 sales of € 4.6 B (€ 2.44 B in the first half of 2006) and employs 36 000 worldwide.

The transaction is to be effective in the fourth quarter of this year and is subject to closing conditions and regulatory approvals.

Infineon had quarter ended June 20, 2006 revenue of € 1.9 B, +23% over prior year and narrowed its net loss to € 23 M from € 240 M last year.

STMicroelectronics increased second quarter revenue 15.4% over prior year to \$ 2.5 B and net income rose to \$ 168 M from \$ 26 last year. Sales grew mainly thanks to telecom, +38%, while automotive and consumer decreased. The firm expects a two-digit revenue growth this year, above market growth put at 9%. ST claims the N° 1 position for IPAC, protection, ASD, Thyristors-Triacs, and N° 3 for rectifiers, all part of its Tours, France, discrete division. The plant presently exports 40% to China, 31% Europe, 15% Asia/Pacific and 8% the Americas.

Texas Instruments spent \$ 2 B in R&D last year, plans to increase this year and just opened a second R&D center in India. TI recently announced plans for a 45 nm

technology, is already working on the next node with IMEC one of the partners. The firm is also active in plug-in power supplies via an alliance founded three years ago with Artesyn and Astec called POLA. TI had second quarter revenue of \$ 3.7 B, up 24% over last year with net profit almost quadrupled to \$ 2.39 B partly due to asset sales.

Samsung and Siltronic have announced a first joint venture of its kind by constructing a 300 mm fab in Singapore, a \$ 1 B project equally owned, slated for production in mid-2008 and designed for a capacity of 300 000 wafers per month. Siltronic, part of Wacker Chemie, is a global leader in ultra-pure silicon wafers and its parent will enter into a long-term contract with the joint venture called Siltronic Samsung Wafer Pte Ltd. to ensure supply of hyper pure polycrystalline silicon.

OPTOELECTRONICS

Solar energy will not become cost competitive until 2025, so University of

Southampton's Dr. Bagnall. It currently relies on expensive bulk multi-crystalline or single semiconductors but second generation solar cells could use cheap silicon thin-films deposited on glass and eventually benefit from nanotechnologies, photonics optical materials, plasmonics and semiconductor polymer. Meanwhile California's Nanosolar plans to produce about 200 M cells per year or 430 MW, is now in pilot production using a thin-film printing process on reel-to-reel equipment without vacuum processing. Aleo Solar, a German maker of solar energy products, had 2005 sales of € 107 M and is building a plant in Spain and possibly in Italy.

PASSIVE COMPONENTS

Epcos' sales climbed 15% to € 330 M in the quarter ended June 30, with automotive suppliers like Bosch, Hella and Siemens VDO accounting now for 25% of sales compared to only 9% in 2000 while consumer electronics has lost in importance. The firm has joined the MOBILIS project to develop BAW-SMR resonators on a single silicon chip.

Kemet had quarter ended June 30, 2006 revenue of \$ 169.6 M, up 27% sequentially and +49% over prior year (+27% excluding tantalum business acquisition which contributed \$ 24.5 M in the quarter). Net income of \$ 12 M increased 51.9% sequentially. SMD capacitors were 87% of sales, leaded parts 13% while 34% of sales were in the Americas, 41% Asia Pacific and 25% in Europe. Tantalum parts now contribute 66% to sales, MLCC 34% with alu-electrolytic a niche product. Distribution in Europe accounts for about 50% of revenue. The firm is rated neck-to-neck in tantalum sales with AVX which reported a 14.6% sales increase in the same quarter over prior year to \$ 319.8 M with net income up 255% to 36.2 M \$

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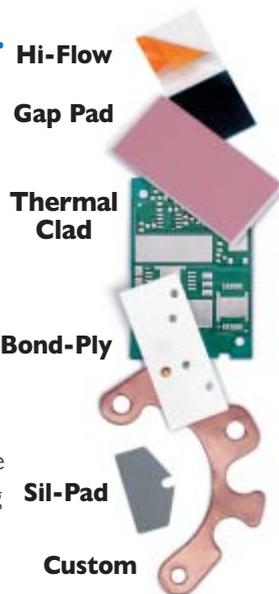
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Digital Power Forum

Pulse of the Industry

“We can see the handwriting on the wall,” according to one of the companies attending the third annual Digital Power Forum (DPF '06), held in Richardson, Texas, in September. This year's Forum confirmed that digital power management and control is already established and could become a larger portion of the power supply market sooner than expected.

By Linnea Brush, Senior Research Analyst, Darnell Group

Over 300 delegates representing original equipment manufacturers, power converter companies and semiconductor makers contributed to the Forum, making it the only event to focus on a rapidly emerging technology that is predicted to capture up to 30% of the overall power supply market in the next few years. This year's DPF expanded to include both a “Power Track” and a “Data Center Track,” highlighting the importance of digital power from loop control to facilities management. Original equipment manufacturers (OEMs) such as Google, AMD, Hewlett-Packard, Intel, Cisco, Sun, Fujitsu and Samsung contributed strongly to the presentations and discussion.

Advanced Chipset and Platform Division with Intel, stated that, “Industry standards on digital power management communication will facilitate end user efficiencies and system customization.” He went on to say that, “PMBus will be the best power and thermal management interface. Intel expects to help drive PMBus to support all the needs of the Enterprise Data Center.” Intel's migration from their own Pconfig and Power Supply Management Interface (PSMI) to PMBus is a major shift that will increase the importance of the PMBus standard going forward.

In a similarly unexpected move, Analog Devices Inc. introduced a new digital current

immunity and improved transient performance and improves the accuracy of the current-share bus.

“The transition to submicron geometries has resulted in the cost-effectiveness of digital solutions,” stated Anton Bakker, Senior Staff Engineer with Analog Devices, during one of the technical sessions. “Our new digital current sharing implementation offers several important advantages compared with traditional analog approaches. Our emphasis in this development has been on ease of use and the ability to share between power supply vendors and silicon vendors,” Bakker concluded.



Figure 1: Delegates to Digital Power Forum '06 at the Opening Plenary Session.

The Forum was a vehicle for announcements that are expected to have a significant impact on the adoption and growth of digital power and control. During the opening Plenary Session, Intel Corp. announced its membership in the PMBus™ Organization. Thomas Macdonald, Vice President,

sharing scheme, announcing that it would make the technique freely available without license. The digital current sharing scheme is claimed to provide advantages over conventional analog techniques, including improved noise immunity and easier layout. It uses fewer components, provides fault

Other announcements included iWatt Inc.'s acquisition of privately held Simple Silicon, Inc. (SSI). SSI designs analog front ends (AFEs) for products such as LCD TVs, digital cameras and DVD players, and analog building blocks such as power management, ADCs, DACs, PLLs. The combination of iWatt's high-performance digital control technology and SSI's precision analog expertise is intended to enable further integration of analog and power functions in next-generation ASICs, as well as standard products for the computing, telecom and consumer markets.

“Over the past six years, SSI has established themselves as a premier supplier of breakthrough analog IP,” said Curtis Davis, President and CEO of iWatt. “The key to their success has been the development of high-performance AFEs that they leverage into ASIC and ASSP silicon solutions by working closely with leading customers in the consumer and communication markets.”

Zilker Labs, Inc. announced that it had signed an agreement with technology distributor Avnet Electronics Marketing Asia, an operating group of Avnet, Inc. Avnet will support Zilker Labs' business throughout the Asia-Pacific region, including major markets such as Korea, Taiwan, China and Hong Kong. Zilker Labs also has an Asian subsidiary, Zilker Labs Asia, Ltd., based in Hong Kong, that supports customers throughout Asia.

"Digital power is emerging as an important product category for the global electronics market," said Stephen Wong, president of Asia Pacific, Avnet Electronics Marketing. "Zilker Labs well complements our product line card. Combined with our extensive product offerings, our local teams will be able to provide total solutions to customers and generate demand for Zilker Labs' products in the region."

Along with the sessions, DPF '06 included a Roundtable discussion and a "Breakfast with Darnell" presentation. The Roundtable featured speakers from Delta Electronics, Zilker Labs, Texas Instruments, Analog Devices, Coldwatt and Primarion, and was moderated by the financial analyst firm, C.E. Unterberg, Towbin. The topic was, "When Will the Switchover to Digital Take Place?" All of the panelists agreed that the switchover was already occurring, with some companies saying that 25-30% market penetration would signal successful commercial adoption. This is expected "very soon." The trend is toward a "really tight coupling between the OEMs and the suppliers."

According to the Roundtable speakers, analog and digital solutions will continue to co-exist, with development tools being critical to the success of digital implementation. Functionality, not process, will be important. A representative from Hewlett-Packard said that risk reduction, ease of use and lower cost were necessary. He also said that cost parity with analog was not enough; digital had to be better than analog in order to get widely used. This led to a discussion of, "where can digital do things that analog can't?" Designers should not be just duplicating analog functions in the control loop.

"Breakfast with Darnell" has become a popular feature of the Digital Power Forum. It is a small, first-come, first-served session with a brief presentation by a Darnell Group analyst. The presentation is designed to stimulate discussion on a focused, controversial issue. This year's topic was "Digital Power: Who's in the Lead?" and was based on the results of a survey included in Darnell Group's Emerging Markets in Digital Power Electronics report.

The survey was designed to measure perception of who are the current leading power supply and semiconductor companies. Based on the responses, Delta Electronics emerged as "best in class" on four out of eight features/functions/attributes: Price, Pure Digital Solution, Quality, and Support. This was an unexpected result and might be due to Delta's aggressive business model, or possibly the fact that they do not "officially" side with any industry group, such as PMBus or the Z-Alliance.

Although Delta is perceived as the leader now, the competitive landscape is likely to change over the next few years. Newer companies like Powervation and CHiL Semiconductor are coming on the scene, with more expected as digital makes commercial strides.

Delegates to DPF '06 found the quality of attendees to be exceptional, and many indicated that "access to their customers" (including a strong presence from system makers) was key to their satisfaction with the conference. Many commented on the networking opportunities in the exhibit hall, where about a dozen companies displayed new products and demos. The consensus was that next year's Digital Power Forum (in San Francisco, California) would be even better.

For more information on Emerging Markets in Digital Power Electronics: Component, Converter and System-Level Opportunities, Second Edition visit:

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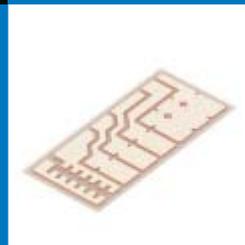


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One for All - Plug & Play Drivers for High-Power IGBTs

High-performance gate driver for IGBT modules from 1200V to 3300V.

Growing power-system complexity calls for the utilization of ready-to-use building blocks. This approach is particularly suited to IGBT gate drivers, where fully customized Plug & Play components are an attractive option for successful design.

By Georg Näf and Sascha Pawel, CT-Concept Technologie AG

CONCEPT offers outstanding driver solutions based on 20 years experience to meet the specific needs of power system designers. Our award-winning SCALE technology provides a versatile and highly scalable platform to set up power conversion systems quickly and easily. SCALE is based on CONCEPT's tried and tested integrated chip set. When used in SCALE cores, a broad range of IGBT modules can be served by each driver core in its respective voltage and current range. SCALE Plug & Play drivers, on the other hand, are highly specialized designs, dedicated to individual IGBT modules. All necessary monitoring and protection functions as well as module-specific control of turn-on and turn-off switching speeds are already built into the Plug & Play driver. This allows system designers to avoid time-consuming design iterations at the performance-critical interface between power switch and digital intelligence.

Overview

CONCEPT offers Plug & Play drivers for a large number of widely used IGBT modules. Its newest member, the 1SD536F2, continues the ongoing extension of our Plug & Play family.

The 1SD536F2 is a new development based on the successful 1SD418F2 with its 6-year history of industry design-ins. It is available for insulation voltages between 1200V and 3300V. Built around the same reliable bidirectional signal transmission system and high-voltage insulation, the 1SD536F2 doubles the output driver current from 18A to 36A. The

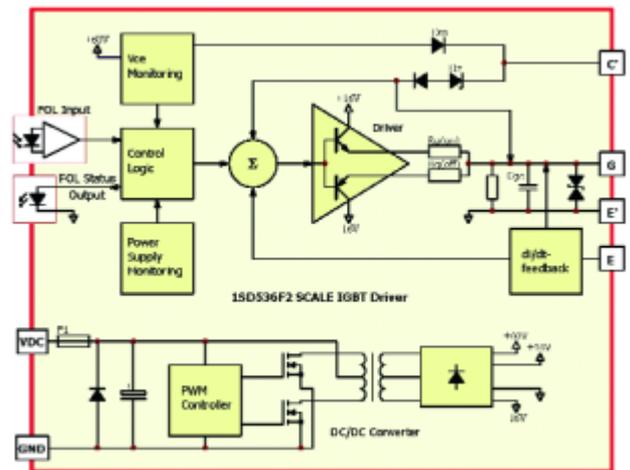


Figure 2: Block diagram of the 1SD536F2

total drive power is raised from 4W to 5W. Both features facilitate fast switching of existing and future high-power modules.

Figure 2 gives an overview of the internal structure of the 1SD536F2. The input of the user-generated control signals as well as the error and status feedback are transmitted via fiber optic links (FOL) that are highly insensitive to EMI. Three different types of fiber optic interfaces are available to choose from. After having run through the input interface, the signals enter the central control logic. Here, all internal monitoring stages report to status control. In normal operation, the signals are then passed on to an analog summing point. This circuit block connects the signals to the driver's feedback loops for active clamping and di/dt-control. After final amplification in the output stages, the signals are driven to the gate of the power device.

In addition to common "intelligent" monitoring and protection features such as under-voltage lock-out, desaturation detection and

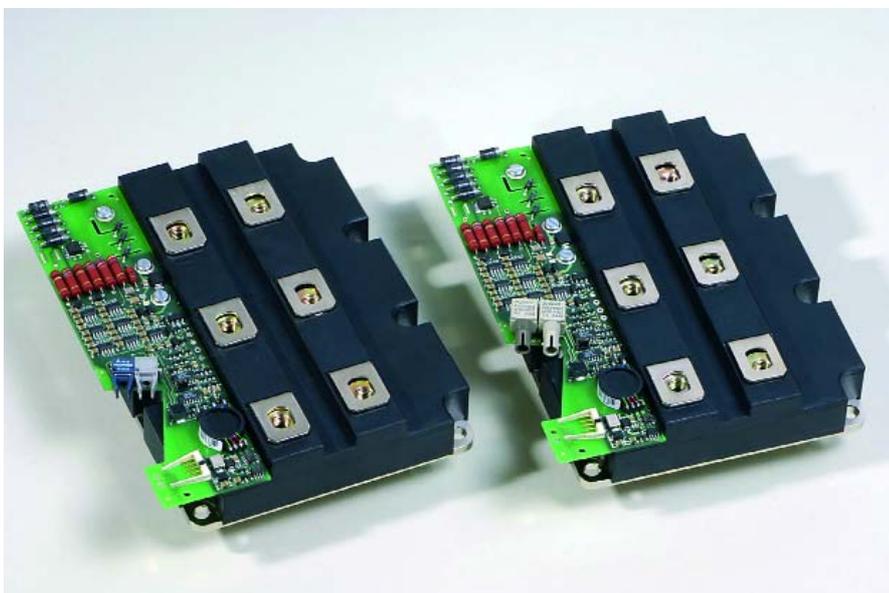


Figure 1: 1SD536F2 mounted onto high-power modules

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conventional active clamping, the driver provides an advanced active clamping scheme. As can be seen from Fig. 2, the active clamping feedback not only influences the IGBT gate directly but also uses a second path inside the driver. The benefits of this second loop are reduced thermal stress in the driver output stage and the clamping diodes during clamping as well as reduction of the total phase lag inside the feedback loop. This significantly enhances the stability of the active clamping configuration with reduced oscillation of the terminal voltages and therefore lower losses. An optional capacitive feed-forward path (not shown) speeds up the dynamic response of the active clamping in applications with steep and rapidly varying voltage transients.

Like all SCALE Plug & Play drivers, the one-channel 1SD536F2 is a compact component that provides high system-design flexibility because each IGBT can be controlled completely individually. All our Plug & Play drivers are ready-to-use products. Putting them to work literally is as simple as 1 (placing the driver onto the module), 2 (tightening three screws) and 3 (turning on), because the drivers are mechanically fitted and electrically optimized for a specific IGBT module. Secondary-side power is transferred via an internal DC/DC converter integrated into the driver. This converter provides the bipolar output voltage of $\pm 15\text{V}$ as well as an auxiliary voltage level of 60V for detecting high-voltage desaturation.

The 1SD536F2 is particularly suited for multi-level topologies up to 3300V insulation voltage. A dedicated operating mode allows the error detection and monitoring stages to be incorporated into a hierarchical control regime. In this way, the external system controller can determine the optimum response

to any reported error depending on the current operating status of the system. If a desaturation error is detected in an IGBT of a 3-level inverter, for instance, the affected driver must not turn off the power switch because a single IGBT cannot block the whole DC link voltage. The correct timing of the turn-off sequence has to be given by the system controller.

Adaptation to IGBT Modules

The 1SD536F2 Plug & Play driver can be optimized for all usual IGBTs in IHM-type modules. This module type is widely used by leading manufacturers of high-power components such as ABB, Infineon/Eupec and Mitsubishi. CONCEPT Plug & Play drivers are completely matched to the respective IGBT module. To achieve this goal, an elaborate test and optimization procedure is performed on every new module/driver pair.

When starting to adapt a Plug & Play driver to a new module type, the principal criterion is maximum switching performance in real-world application environments. Reducing turn-on and turn-off losses is naturally of equal importance because it directly enhances the performance of the power system and at the same time cuts costs because it promotes cooling. That is why switching performance is the number one concern of all power system designers. CONCEPT endeavours to deliver the highest attainable module utilization while always keeping a keen eye on the very complex aspects of usability. Finding the optimal balance is often a delicate task that requires both technical understanding and extensive experience.

In the following, a complete adaptation cycle will be outlined in the same order that the actual measurements are taken.



Figure 3: Dynamic high voltage characterization site

The first concrete step in the adaptation process is to test a basic configuration of the drivers to be optimized. Automated optical inspection is applied during PCB assembly, followed by an in-house optical inspection at CONCEPT. The electrical status is verified by in-circuit testing and functional tests using an automated test system.

Figure 3 shows a typical test set-up comprising the high-voltage DC link, the IGBT module, the driver and measurement equipment. A large DC link capacitor bank is used at 1700V and 3300V respectively. This ensures realistic worst-case testing in a half-bridge environment. The measurement equipment is made up exclusively of state-of-the-art instruments of high bandwidth. A high acquisition bandwidth must be maintained through the whole chain of probe heads, current transducers and oscilloscopes in order to guarantee test results capable of detecting possible high-frequency effects such as unwanted voltage and current oscillations. To ensure reliable operation of the IGBT module, these effects must be avoided by the driver design.

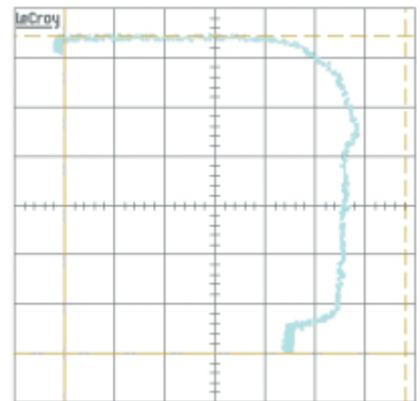


Figure 4: Collector current vs. collector emitter voltage (RBSOA)

The DC link has been built for low stray inductance, thus allowing for aggressive, hard-switching test transients. These measurements define the maximum performance under rapid worst-case conditions typically encountered in highly optimized fast-switching applications such as induction heating or SMPS. At the opposite end of the spectrum, analogous tests are selectively performed with critically high stray inductances to satisfy the demands of large high-power systems such as traction applications. Voltages are taken from the auxiliary terminals of the module and the measurements take the relevant module parasitics into account.

Low-Side Turn Off

Low-side turn off is the first switching measurement. The turn-off gate resistor is adjusted for this series of measurements in order to minimise the switching losses. At the same time, several components of the active clamping circuitry are tuned to assure a safe maximum collector voltage, fully exploiting but not exceeding the voltage rating and SOA of the IGBT module. The RBSOA curve is taken under rapid worst-case conditions,

i.e. the test conditions are characterized by hard switching with a low stray inductance, maximum permissible DC link voltage and twice the rated current (Fig. 4). This worst-case RBSOA curve is then checked against the specifications of the IGBT module manufacturer.

It is not unknown for up-to-date high power modules to exhibit collector current snap-off under hard switching, especially in partial load regimes. This trend can be expected to continue in the future, because the improved carrier engineering inside the power devices (IGBTs, diodes) themselves leads to smaller excess carrier reservoirs. Whereas these decrease turn-off losses, under certain criti-

cal conditions too few carriers are available to sustain collector current flow and the current snaps off. This can be seen in an extremely steep current transient towards the end of the turn-off process. Especially the massive oscillations introduced into the system make this effect so particularly undesirable. Oscillations constitute a potential threat to the overall signal integrity due to EMI.

Apart from snap-off, a driver-integrated di/dt control is optionally available to safely eliminate phases of steep collector current transients from the switching behavior. In the comparative measurement of Figure 5, the effect of di/dt control can be seen. The fast-

varying collector current during turn off without di/dt limiting gives rise to high-frequency oscillations that also affect the gate drive signal, leading to possible violation of the system's EMI margins. No such effect is observed with activated di/dt limiting. The collector current changes smoothly from twice the rated current to zero.

This situation is most critical under high-current stress. Fig. 6 shows a comparative measurement of a power module turning on into a short circuit with and without di/dt limiting respectively. Here, the prime function of di/dt control is not only to combat spurious oscillations but also to limit excess voltage across the main terminals of the power device due to stray inductances and the high rate of change of the collector current during turn off. The favorable effect on the excess voltage of limiting di/dt is clearly seen in Figure 6.

High-Side Turn Off

All parameters determined by the low-side measurements described are subsequently checked for high-side operability. The measurements are taken up to maximum DC link voltage and twice the rated IGBT current.

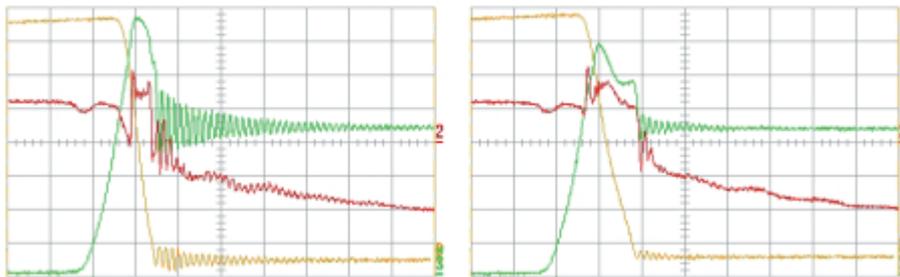


Figure 5: Turn-off waveform without di/dt limiting (left) and with active di/dt limiting (right)
green: V_{CE} , 200V/Div.; red: V_{GE} , 5V/Div.; yellow: I_C , 1000A/Div.; 0.5 μ s/Div

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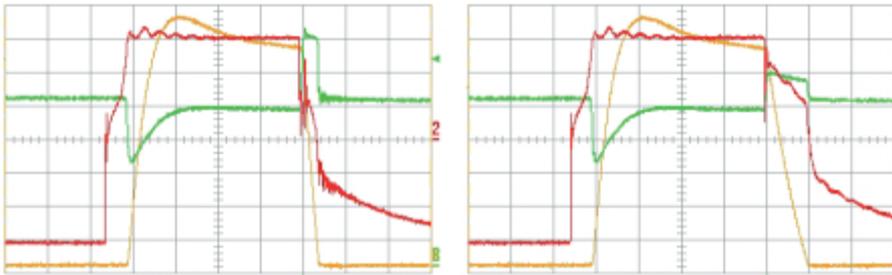


Figure 6: Short circuit turn-off without di/dt limiting (left) and with active di/dt limiting (right)
green: V_{CE} , 200V/Div.; red: V_{GE} , 5V/Div.; yellow: I_C , 2500A/Div.; 2 μ s/Div

High-Side Turn On

The first test for all turn-on characterizations is to check whether the freewheeling diode remains within the safe operating area during reverse recovery. The device under test for the RRSOA measurement is the low-side diode. All critical constellations are sought by varying the current and temperature. The two effects most commonly encountered are reverse recovery current snap-off and excessive values of the maximum instantaneous power dissipation. Both situations can be avoided by careful adjustment of the IGBT turn-on speed. Once again, a low-inductance DC link in the measurement set-up ensures that the driver/module combination can be tested at its full power capacity.

Low-Side Turn On

With the freewheeling diodes in their safe operating area during the whole forward and reverse recovery process, the low-side turn on can be analyzed (Figure 7). All turn-on parameters are fine-tuned during the course of this series of measurements.

Short Circuit Behavior

Short circuit testing is generally performed with a modified high-voltage set-up. This is to ensure the lowest possible residual inductance and resistance of the short circuit path between the IGBT under test and the DC link. Such a configuration results in the most

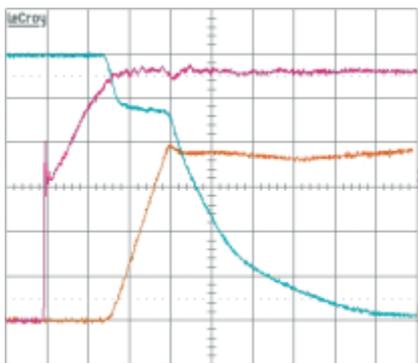


Figure 7: Low-side turn on
green: V_{CE} , 200V/Div.; red: V_{GE} , 5V/Div.; yellow: I_C , 1000A/Div.; 0.5 μ s/Div

critical condition with respect to turn-off overvoltages. In regular two-level mode, the driver needs to detect the occurrence of a short circuit quickly. Subsequently, the IGBT will be turned off with the driver's full strength, thus reducing turn-off switching losses.

Short circuit detection delay is crucial in multi-level topologies because of the additional communication delay when the error is first transmitted back to the primary side and a coordinated turn-off signal is then issued by the system controller. The timing of the 1SD536F2 ensures secure turn-off of the worst-case short circuit in less than 10 μ s. This time-span is matched to the sustainable duration of short circuits in modern IGBT modules. If the module manufacturer does specify a dedicated short circuit SOA (such as Mitsubishi), the CONCEPT Plug & Play driver will naturally maintain that safe operating area (Figure 8).

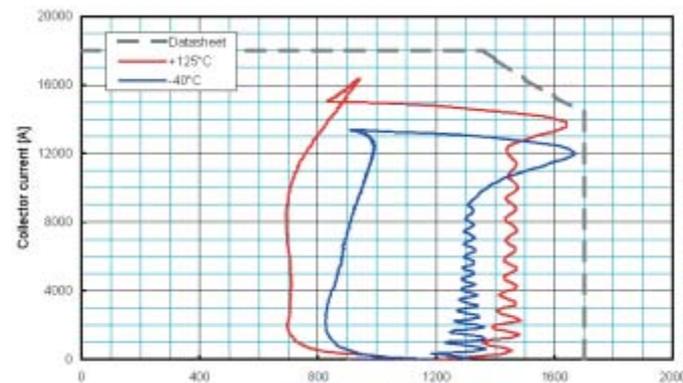


Figure 8: Short circuit SOA measurement at -40°C and 125°C
(courtesy of Mitsubishi Electric)

CONCEPT Plug & Play drivers relieve the system designer of numerous complicated and highly specialized development steps. Series of measurements at different temperatures are particularly laborious and time-consuming. All combinations of adaptation parameters are measured at CONCEPT up to 125°C in an elaborate work-flow scheme. Having a thoroughly validated and optimized driver for the IGBT module of choice combines system design flexibility with the bene-

Concept 1SD536F2 driver for 1200V IGBTs:	
ABB	5SNA2400E120100
Infineon	FZ2400R12KE3
Infineon	FZ3600R12KE3
Concept 1SD536F2 driver for 1700V IGBTs:	
ABB	5SNA1600E170100
ABB	5SNA1800E170100
ABB	5SNA2400E170100
Infineon	FZ2400R17KF6
Infineon	FZ2400R17KE3
Infineon	FZ3600R17KE3
Mitsubishi	CM1800HC-34N
Mitsubishi	CM2400HC-34N
Concept 1SD536F2 driver for 2500V IGBTs:	
ABB	5SNA1200E250100
Concept 1SD536F2 driver for 3300V IGBTs:	
ABB	5SNA1200E330100
Infineon	FZ1200R33KL2C
Mitsubishi	CM1200HC-66H

Table 1: Currently adopted IGBT modules for the 1SD536F2

fits of using a tried and tested building block. This is particularly true for the vital interface between the digital control and power components. Our series of Plug & Play drivers aims to achieve this combination of reliability, high performance and ease of use.

The 1SD536F2 has already been adapted to a wide variety of IGBT modules from ABB, Infineon/Eupec and Mitsubishi (see Table 1). Mitsubishi recently carried out an in-depth examination of the 1SD536F2 and has sub-

sequently approved the driver for their high-power modules.

Currently, the 1SD536F2 is available for voltages between 1200V and 3300V with module current ratings between 800A and 3600A. If your favourite module is not yet supported, please

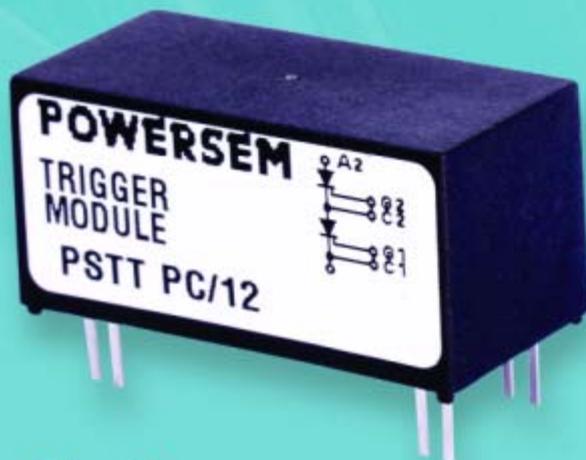
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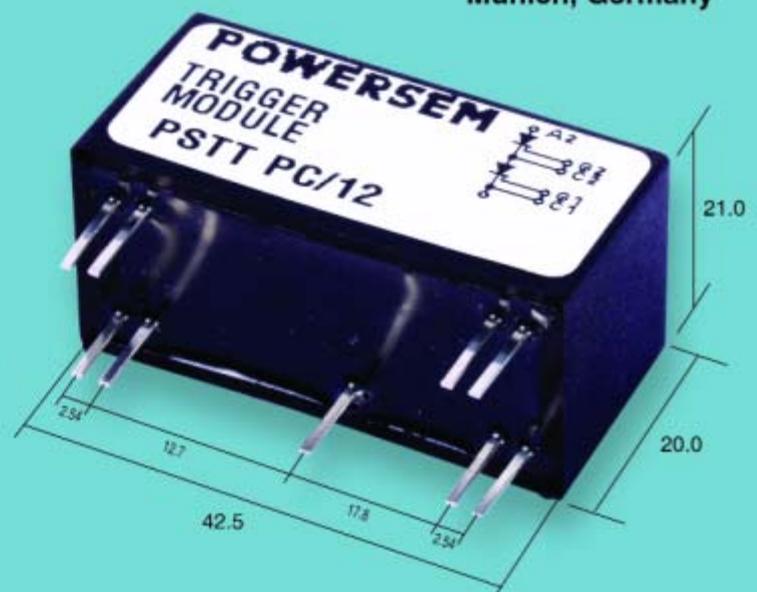
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Modular IGBT Stacks to Increase Power Density

Integrating the New PrimePACK

The integration of the new PrimePACK module into an existing inverter platform is discussed. The mechanical features of the module allow an optimization of the thermal management and to increase the usability of the IGBTs. Measurements of the inverter performance are presented.

*BY M.Schulz, O.Schilling, M. Wölz, G. Borghoff, J. Schiele;
Infineon Technologies AG, Warstein*

Whenever a power module is integrated into a converter platform thermal, electrical and mechanical constraints have to be considered. The PrimePACK housing offers a practical interface between IGBT power switches and the converter surroundings [1]. The first integration of the PrimePACK module in a converter is presented based on the well known ModSTACK inverter series [2]. It is shown, how an optimised cooling concept results in an improved utilization of the available heat sink area and helps to lower the thermal resistance.

The PrimePACK offers the chance to increase the operation temperature to 150°C. First results covering the performance and the increase in converter usability under these harsh conditions are presented.

Converter architecture

The approved design kit ModSTACK for power converter solutions consists of OEM components for thermal management, electrical and mechanical interconnection and interfaces between power unit and control. Different circuit topologies and expansion of system power range are available using ModSTACK components.

By choosing suitable IGBT halfbridge modules the most common topologies can be realised. High voltage electrolytic capacitors are used for the DC link circuit of the power unit to ensure safe operation up to 1070V. The monitoring and control unit is supplied with signals supervising phase current, DC voltage, on-state voltage and heat sink temperature. The control unit is equipped with EiceDRIVER integrated IGBT driver cores [3]. Figure 1 gives an overview about the functional components of the inverter.

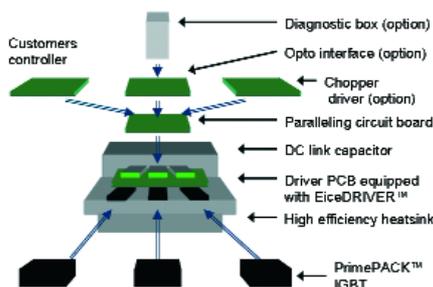


Figure 1: Modular ModSTACK power unit equipped with PrimePACK IGBT halfbridge modules.

The ModSTACK was originally designed for IHM modules and is now adapted to the PrimePACK package as depicted in fig. 2. It is compatible with both PrimePACK2 and PrimePACK3 which will be available in the module line-up.

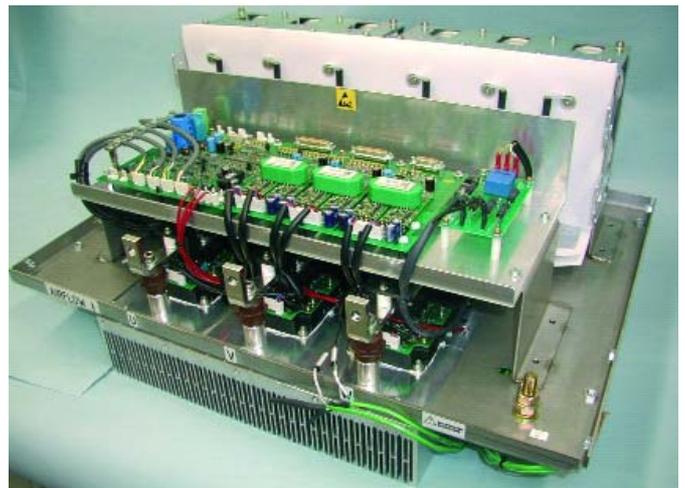


Figure 2: Photo of a ModSTACK power unit equipped with PrimePACK2 according to the scheme in figure 1.

Thermal properties and layout optimization for an air cooled heatsink

The PrimePACK offers a practical solution to improve the thermal management by lowering the thermal resistance R_{thch} between baseplate and heat sink. Due to the rectangular footprint of the PrimePACK a small distance between the screws that tighten the baseplate to the heatsink is achieved even for a large overall contact area between both components. The thickness of thermal grease d_g can thus be kept in a very low regime of $d_g < 50\mu m$. The copper baseplate furthermore ensures effective heat spreading through its high thermal conductivity of $\lambda = 385 W/mK$. In an experimental setup R_{thch} is measured on a water cooled heatsink. This represents a worst case situation because water cooled systems are characterised by less thermal spreading in comparison to their air cooled counterparts.

The heatsink is equipped with a set of thermo-couples that allows measuring both the temperatures at the module baseplate T_c and



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inside the heatsink close to the surface T_{hs} . The thermocouples TC1 and TC2 are positioned underneath the devices that generate power as shown in figure 3.

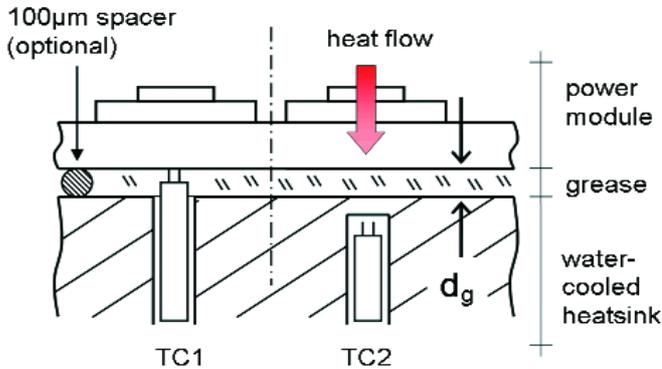


Figure 3: Schematic cross section of measurement setup including position of thermocouples.

If the total electrical power dissipated in the power module P_{el} is known, the following formula can be applied to evaluate R_{thch} :

$$R_{thch} = \frac{T_c - T_{hs}}{P_{el}} = \frac{T_{TC1} - T_{TC2}}{P_{el}}$$

The influence of the amount of thermal grease that is dispensed on the surface of the module baseplate prior to mounting it onto the heatsink is investigated. A thermal grease with $\lambda=1W/mK$ is used. The measurement is done for the PrimePACK2 subsequently for IGBTs and diodes and R_{thch} is calculated by paralleling both values. The result is given in figure 4, where R_{thch} is plotted as a function of the dispensed thickness d_g^* .

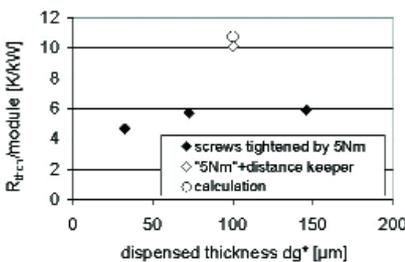


Figure 4: Correlation between R_{thch} and grease thickness d_g^* , which is measured prior to mounting.

The following conclusions are drawn:

If a 100µm spacer is applied to guarantee $d_g=100\mu m$ after mounting, the measured value is $R_{thch}\sim 10K/kW$. This is close to the calculated value.

If mounting is done without spacers, lower R_{thch} values of about 4...6K/kW are reached that only slightly depend on the amount of grease dispensed as excessive grease is squeezed out during the mounting process very effectively due to the aforementioned small distance of mounting screws. Besides, the heat transfer at the metallic contact between baseplate and heatsink plays an

important role and does not depend on grease thickness at all. In general the R_{thch} of a PrimePACK module is rather insensitive towards the method by which heat conduc-

tive grease is dispensed making thermal management more reliable by means of the footprint geometry.

In the range of $d_g^*<50\mu m$, R_{thch} of ~4...5K/kW can be reached.

The thermal resistance between the heatsink and ambient air R_{thha} depends on how IGBT modules are positioned on the heatsink surface. In order to find an optimised geometry R_{thha} is determined by measurements using resistors as well defined heat sources. Square shaped resistor modules are mounted to a PrimePACK baseplate instead of IGBTs to create a reference module.

R_{thha} is calculated by the formula

$$R_{thha} = \frac{T_{hs} - T_a}{P_{el}}$$

The ambient temperature T_a is measured at the entrance of the air flow. To determine the heatsink temperature T_{hs} , small grooves are milled into the surface of the heatsink to place thermocouples close to the module baseplates.

Using the reference modules described allows for the variation of the arrangement in order to find an optimised geometry. It turns out that less thermal stacking and lower R_{thha} values are obtained if the longitudinal axes of the rectangular modules are aligned in parallel to the heatsink fins in comparison to the geometry with perpendicular orientation of modules and fins. Figure 5 shows a comparison for different footprints. The lowest values are obtained for the PrimePACK3 because it offers the largest contact area.

Inverter performance

Measurements were done on the

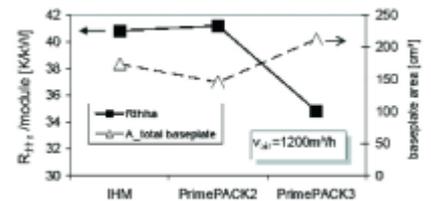


Figure 5: Measured R_{thha} -values for different reference modules on an air cooled heatsink with surface=400x400mm² and height=88mm.

ModSTACK inverter equipped with FF600R17IE3 PrimePACK2 modules under laboratory conditions. In Detail, these were $U_{CC}=900V$, $f_{sw}=2,5kHz$, $f_0=50Hz$, $\cos(\Phi)=0$, $T_a=24^\circ C$. The maximum RMS current is calculated as a function of the junction temperature T_{vj} . For $T_{vj,max}=125^\circ C$, $I_{rms}=380A$ respectively for $T_{vj,max}=150^\circ C$, 440A were obtained. At 440A_{rms}, the IGBT operates up to its nominal current of $I_C=600A$. The operation point is successfully mastered which is proven by the turn off waveform in figure 6, that is recorded at the operating inverter

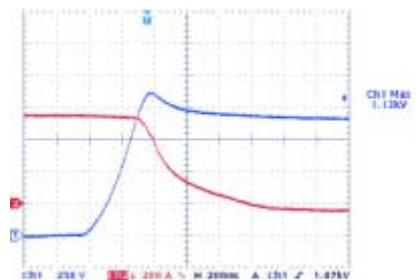


Figure 6: IGBT turn-off at $U_{CE}=900V$, $I_C=600A$, $T_{vj}=145^\circ C$, $I_{rms}=440A$, $R_G=1,6\Omega$ $f_s=2,5kHz$.

The usability of PrimePACK and IHM dual IGBT modules is compared based on measured R_{th} values and application conditions that allow driving a 690V_{rms} motor. The implemented safety margin for over-current capability is 20% for 10s. Since the PrimePACK is designed for operation of up to $T_{vj}=150^\circ C$, the calculation is also done for this extended temperature. The result is given in figure 7.

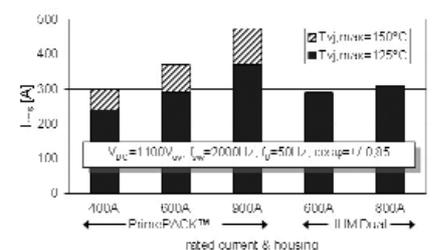


Figure 7: usable rms current in a ModSTACK inverter for different 1700V IGBT modules and rated currents.

Apparently the PrimePACK module offers the chance to reach a higher power density even if the maximum junction temperature is kept at 125°C. Assuming that T_{vj} can be raised up to 150°C, I_{rms} can further be increased by roughly 25%. The future work will focus on qualifying products in the new package for this extended.

Conclusion

The first integration of PrimePACK IGBT module into an existing converter proved to work safely. The optimisation of important issues like thermal management are well supported by the new power module. The potential for higher inverter power density is shown and proven by experimental runs of a laboratory inverter. The most striking benefit will come into play when first products are qualified for operation up to $T_{vj}=150^{\circ}\text{C}$.

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Automotive Lighting Solutions

The inrush current creates a thermal stress on the driver

Despite the development of new lighting technologies such as the Xenon lamp (HID) or LED lights, the incandescent bulb will remain the most commonly used light source for the next generations of cars.

Jerome Pillet, Senior Engineer Intelligent Power Devices, Power Semiconductors Product Unit, Automotive Business Group, NEC Electronics (Europe) GmbH

Consisting of a tungsten filament inside an evacuated glass bulb, these lamps, as used in today's automotive market, are available in a wide variety of types, but strictly specified to international standards according to their mechanical, electrical and luminous characteristics for exterior lighting applications. The following table shows the most commonly used lamps in the European automotive market, as classified per ECE R37.

simply by varying the duty cycle of the PWM signal to the lamp driver.

For all these reasons, silicon drivers, rather than relays, are today the preferred solution for lighting applications. Naturally, silicon drivers also offer advantages in system integration and the mounting process.

Used Lamps in the European Automotive Market

Category	Rated Power (W) @ 12 V	Objective Values		Application in the Car
		Maximum Power	Luminous Flux (lm)	
H1	55	68 W @ 13.2 V	1550 ± 15%	Low and high beam, fog lights
H4	55	68 W @ 13.2 V	1000 ± 15%	
H7	55	58 W @ 13.2 V	1550 ± 10%	
H9	65	73 W @ 13.2 V	2100 ± 10%	
P21 W	21	26.5 W @ 13.5 V	460 ± 15%	Flashers, back drive, brakes, fog
P27 W	27	32.1 W @ 13.5 V	475 ± 15%	
R10 W	10	11 W @ 13.5 V	125 ± 20%	Plates, position
R5 W	5	5.5 W @ 13.5 V	50 ± 20%	Side flashers, side lights

Bulb properties

In filament lamps, the luminous energy is produced by a tungsten filament heated within a few ms from ambient temperature up to about 2,800°C. Electrically speaking, the filament impedance increases strongly at lamp switch-on, which corresponds to an inrush current phase. The peak current can be much more than 10 times the nominal current. The graph below shows the inrush current of an H9 bulb at 240°C, driven by a car battery at 15V with the NEC driver μ PD166007. The peak current reaches 80A for a nominal current of 6.2A.

Figure 1: Lamps used in European car applications

Light control in modern cars

In the past, lamps were directly controlled by mechanical switches at the steering wheel or on the dashboard. Nowadays, light control is via a dedicated electronic module. Usually called Body Control Unit or Module (BCU / BCM), this device receives information through the CAN network from various command modules, e.g. the top head column, dashboard panels, light sensors etc. The BCU switches the lamps on or off, but also contains diagnostic features. Indeed, for obvious safety reasons, both legislators and car makers nowadays require increasingly more diagnostic functions for light systems. Thus defective lamps for key functions such as brake lights or position lights must be reported to the driver via the dashboard

In most cases, the output of the BCU must be able to drive either LEDs or bulbs, or Xenon light or incandescent bulbs, depending on the lamp function. The selection is usually made by software configuration, so the lamp driver must normally have extended performance to support various types of loads.

An advantage of the BCU microcontroller is that bulbs can be driven in Pulse Width Modulation (PWM) mode to regulate the RMS voltage, allowing light intensity adjustment, or simply avoiding light intensity variation over battery voltage. This feature is especially useful when driving LED lights, since a single LED matrix can be used for position or brake lights,

The driver should not limit the inrush current, otherwise the lamp might not switch on or could switch on with a significant delay, which is clearly unacceptable from a safety point of view.

The inrush current creates a thermal stress on the driver, which must therefore be designed to handle repeated inrush currents of this

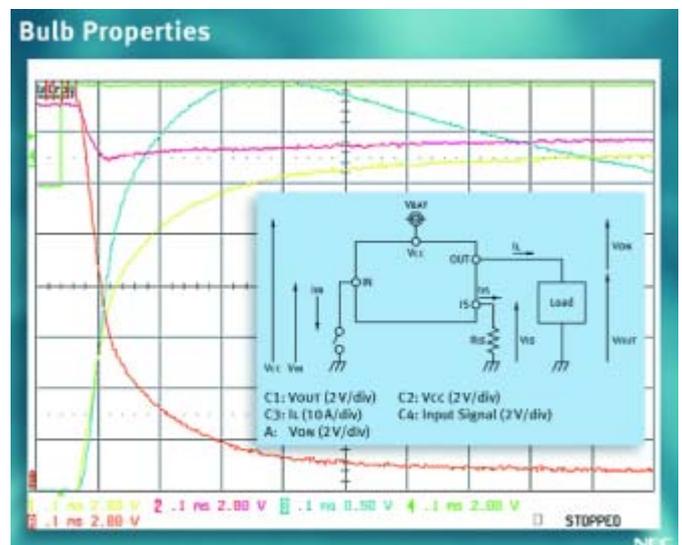


Figure 2: Bulb Properties

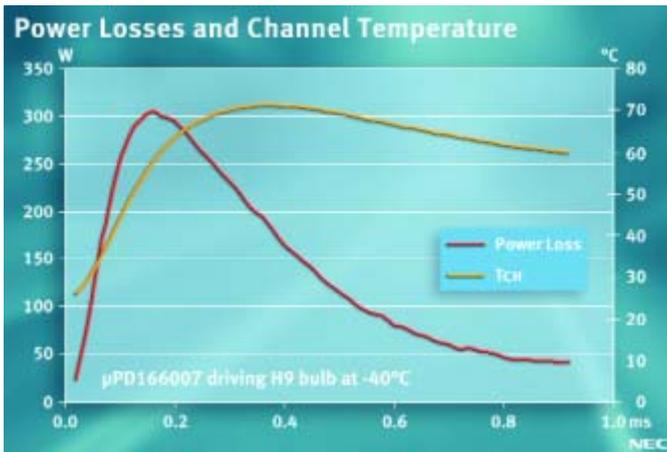


Figure 3: Power losses and channel temperature of the µPD166007 driving an H9 bulb at -40°C

magnitude without any loss of reliability and performance over the expected lifetime. As an example, the graph below shows the power dissipation and junction temperature increase of the µPD166007 when switching on the H9 bulb. The channel temperature rises by about 50°C within 300µs!!!

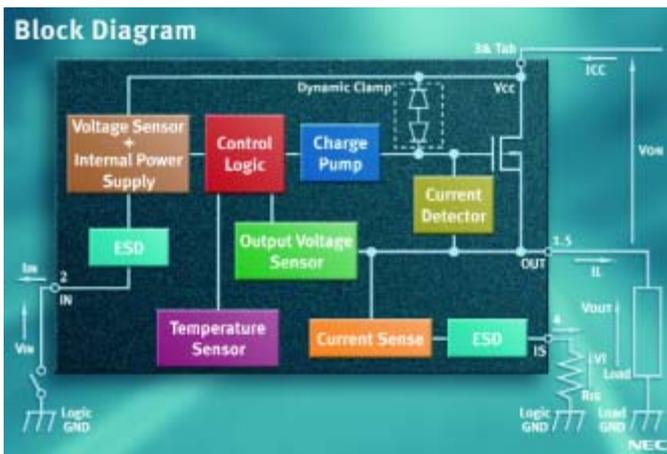


Figure 4: This driver consists of two main parts: (1) a power switch; (2) a control part.

Drivers for lights

A silicon driver for automotive applications is an integrated device, usually directly driven from a microcontroller port. The figure below shows a block diagram of the NEC Intelligent Power Device (IPD) µPD166007,

The power part is made of an N-Channel Power MOSFET, into which a current sensor and a temperature sensor have been integrated. The size of the power part, and consequently the Rdson, will depend on the target load.

The control part realizes the gate drive along with protection features and diagnostics.

- Gate drive. The Power MOSFET is usually connected in high side position (i.e. to the car battery driving a load connected to ground). The drive circuitry includes a charge pump to supply the appropriate gate voltage.
- Protection features. The protection functions are mainly overcurrent and overtemperature detection.

Overcurrent protection.

The overcurrent protection has a short reaction time and continuously monitors the output current. It reacts if the output of the device is shorted to ground in a very low impedance path. The overcurrent protection must be designed to allow the inrush current of the lamp flow. When an overcurrent is detected, the device reacts to prevent power switch destruction, either by limiting the current or switching the device off. Usually, diagnostic information will be output at one dedicated pin of the device.

Overtemperature protection.

Excessive output current due to a temporary or permanent overload at the driver output may cause the channel temperature to rise above the maximum value. In this case, the overtemperature protection prevents the destruction of the device by switching off. Typically, the overtemperature protection will react to a “short circuit” occurring in a light module at the cable termination.

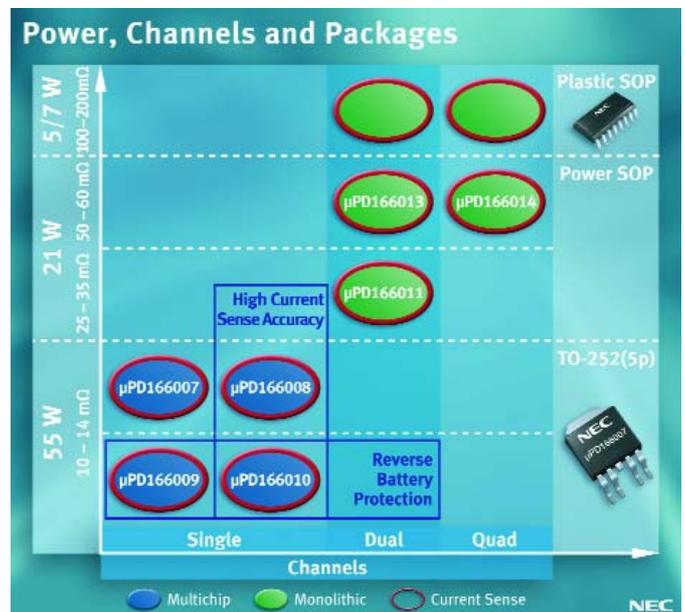


Figure 5: Power, Channels and Packages

Silicon drivers and short circuit

A load can be connected to the BCU by a cable several meters in length. A short between any point of this cable and ground would create a “short-circuit” ranging from a few mOhm to several 100mOhm impedance. Ideally, such a “short-circuit” will trigger one of the protection mechanisms, but it could also create an excessive power dissipation situation below the levels at which protection mechanisms are activated. This situation would drastically reduce the driver lifetime and could lead to early failure of the driver.

In practice, a feature that can read back the load current is central to ensuring the reliability of a system. Silicon drivers can provide the microcontroller with a proportional image of the current into the load. This information is usually handled by the microcontroller’s A/D converter. Such a setup also enables an open load situation to be detected. In fact, this feature is set to become a mandatory requirement of car makers. Naturally, NEC drivers will support this feature.

NEC Electronics is developing a comprehensive family of Intelligent Power Drivers (IPD) targeting the control of automotive lights.

Effective Load Resistance

A New Method to Evaluate DC/DC converters Efficiency

This article offers an alternative to efficiency measurements as an evaluation tool of power supplies. The proposed method works well with little dependency on the output voltage and temperature.

By Alan Elbanhawy, Fairchild Semiconductor, San Jose CA, USA

Power supplies have always been evaluated and compared based on the how efficient the conversion process is. Equations 1 and 2 are two of the most used formulae to calculate the power conversion efficiency η . The use of efficiency as a yardstick to evaluate DC-DC converters represents a very simple and in most cases effective way of comparison. Efficiency figure combined with the details of the converter parameters also allows the thermal engineer to calculate the thermal load of the converter and whether heatsink and/or cooling airflow is required. The efficiency tool works very well when we have established standard input and output voltages that are more or less fixed in value.

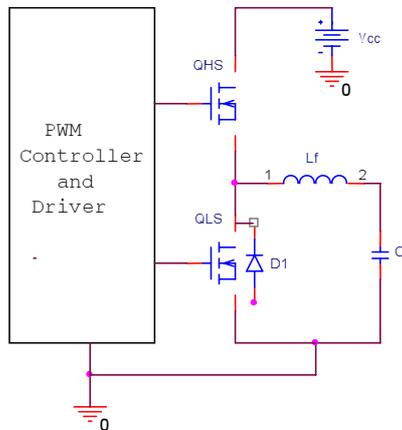


Figure 1. Synchronous Buck Converter

We will show that the efficiency alone is not the right tool to compare converters operating at different output conditions even with a fixed input voltage and switching frequency. We will explain why that is and propose an alternative methods that measures the performance "almost" independent of the output voltage that gives a much more accurate and unambiguous idea about the converter's performance so we introduce the concept of the Effective Loss Resistance, Rol

Efficiency Calculations

The power conversion efficiency (ζ) may be calculated using the equation:

$$\eta = \frac{\sum_{i=1}^n V_{outi} I_{outi}}{\sum_{j=1}^m V_{inj} I_{inj}} \times 100 \% \quad \dots (1)$$

This equation can also be written as follows:

$$\eta = \frac{\sum_{i=1}^n V_{outi} I_{outi}}{\left(\sum_{i=1}^n V_{outi} I_{outi} + \sum_{j=1}^m P_{Lossj} \right)} \times 100 \% \quad \dots (2)$$

Figure 1 depicts a simplified block diagram of a synchronous buck converter used in the evaluation of this paper. It is worthwhile mentioning that this work may be adapted to almost all DC-DC converters

Figure 2 shows the efficiency of a given converter at different output voltages. Although the power loss is mainly dependant on the load current at a fixed switching frequency and input voltage and is very lightly dependant on the output voltage within the range from 2V to

1V i.e. we have "almost" constant power loss in all of the out voltage conditions while the efficiency ? varies dramatically. So even though the power loss is "almost" a constant, the very fact that we have a smaller output voltage will result in non realistic smaller efficiency figure.

Synchronous Buck Converter Losses

Loss mechanisms in DC-DC converters can be divided into two major groups as follows: Conduction or Ohmic losses, which is the loss due to $I_{load}^2 \times R_{DS(ON)} \times \Delta$ where $R_{DS(ON)}$ is the on-resistance of the MOSFET, I_{load} is the load current and Δ is the duty cycle. Please note that this loss mechanism is mainly dependant on I_{load}^2 because of the quadratic relationship and to a lesser degree on the output voltage since Δ is a function of the output voltage that is topology dependant.

Dynamic or switching losses = $I_{load} \times V_{in} \times \frac{1}{2} \times f_s \times (tr+tf)$ where V_{in} is the input voltage and tr & tf are the rise and fall times and f_s is the converter's switching frequency. Again you can see that the dynamic losses are not dependant on the output voltage.

This means that the losses are dependant on the output voltage in a secondary way. This leads immediately to the conclusion that we have more or less fixed losses regardless of the output voltage.

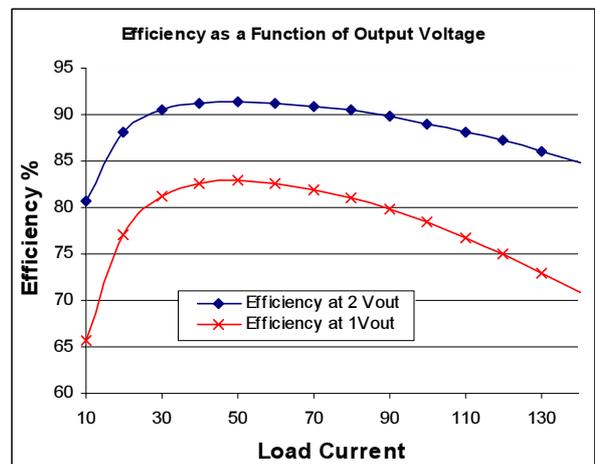
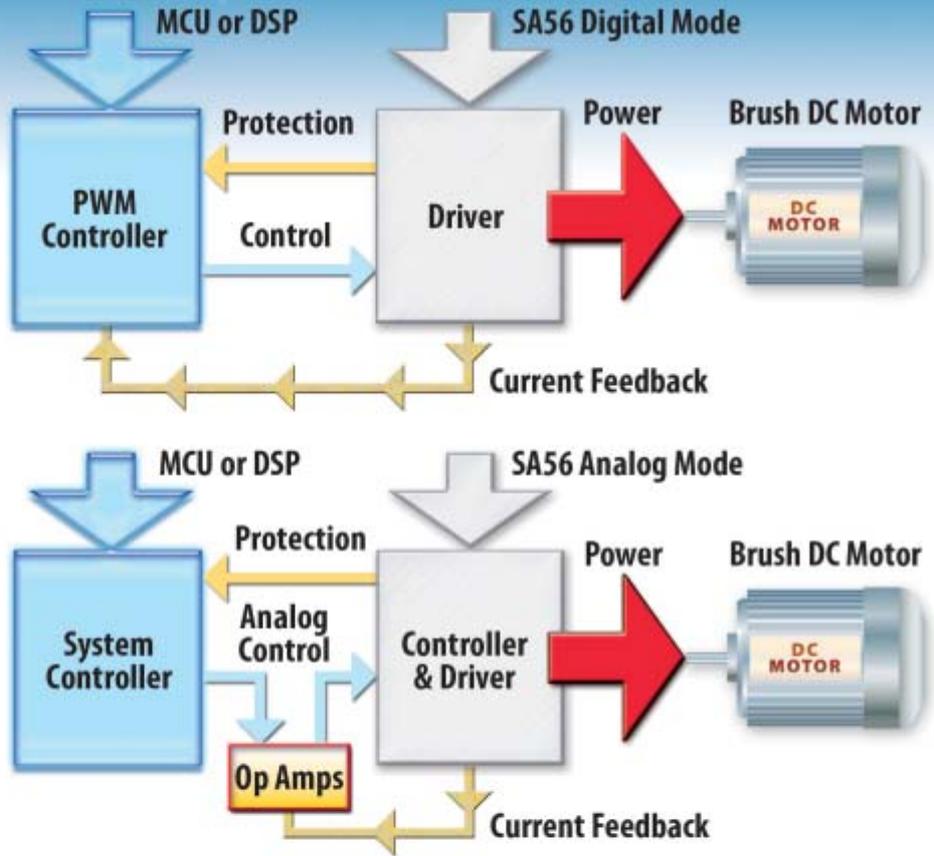


Figure 2. Synchronous buck converter's efficiency as a function of the output voltage

SA56 Digital Mode



SA56 Analog Mode



Industry's first 5A monolithic PWM amplifier works with digital or analog control to drive bi-directional DC motors up to 1/3HP on 55V supplies.

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SA56	
Operational Control	DSP, MCU or Analog
Output	Full Bridge
Supply Voltage	12V to 60V Single Supply
Output Current	5A Continuous, 10A PEAK
Power Delivery	Up to 250W
Switching Frequency	100KHz
Production Volume Pricing	USD \$8.90

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Why is this important? Because as can be seen in the efficiency equation (2) above, the smaller the output voltage the smaller the output power for the same output current. This results a lower efficiency for smaller output voltage as can clearly be seen in Figure 2. One can see that there is a limiting condition as the output voltage goes to zero while maintaining the same output current at which point the efficiency is theoretically zero:

$$\eta = \lim_{OutputPower \rightarrow 0} \left(\frac{OutputPower}{OutputPower + C \text{ losses}} \right) = 0$$

That is to say that the efficiency of a given converter is proportional to the output voltage for the same load current. This fact makes the comparison very difficult under different conditions of output voltage. "Fig 2," depicts this very case where you can see that the efficiency at an output voltage of 2 volts is about 8% larger than that at 1V output at the same load current though the power dissipation is "almost" the same and the thermal load is also "almost" the same.

It can be shown that the efficiency is different for different heat sinking techniques for the same circuit and the same input and output voltages. In this case, there is less power dissipation where we have a heatsink and air flow compared to the same design in still air and no heatsink.

This leads to the following dilemma, as different DC-DC converter manufacturers show their efficiency results that optimally reflects their products; Starting with two converters A & B from two different vendors having the same efficiency figure, the engineer is left to compare them by guessing whether converter A tested at 30 Amps and a heatsink (of unknown performance generally) is better than converter B tested at 25Amp with no heatsink and 400LFM airflow?

The question that can be asked now is, "Is there a different way to evaluate converters independent of the output voltage and heat sinking techniques?"

The Proposed New Approach

In the above discussion, we have demonstrated the need for a different approach that can have a universal appeal both to vendors and buyers of converters and more importantly, to the circuit and thermal design engineer so that quick decisions regarding design issues can be crystal clear across different disciplines.

One can clearly see that the power loss is a better way to demonstrate the performance

of power supplies within a limited span of output voltages, say 1V – 2V where the power loss may be considered constant. Needless to say if we widen the span of voltage say from 1V to 5V all the secondary effects will start becoming prominent and will not yield the same consistent results. Figure 3 shows the losses as a function of the load current for different schemes of heat sinking.

To understand Figure 3 let us see what is happening here. It can be seen that the difference in losses is rather slight up to 60 Amps with less than two watts differential at this point. We can deliver currents up to 120 Amps when we have both heatsink and airflow from the same board because we can remove heat very efficiently from the board due to the use of the air and heatsink. The reader is unlikely to easily figure out that all four curves are taken for the very same VRM with heat sinking as the only difference though this is the case. In "Fig. 3," the testing was stopped when the board temperature reached 105°C – 110 °C.

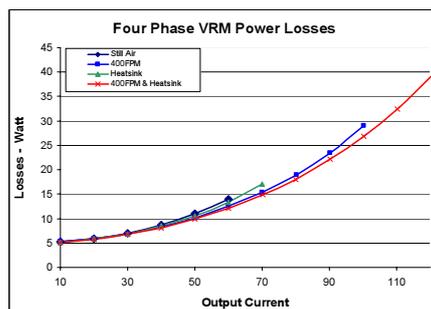


Figure 3. Power Loss vs. Load current

It is worthwhile mentioning that the difference in power dissipation between the fully heat sinked case and the still air case is mostly due to temperature differential since the fully heat sinked case is running at a much lower temperature and since the MOSFET on-resistance may be expressed as follows:

$$RDS(ON)_T = RDS(ON)_a \times (1 + \alpha \times \Delta T)$$

where $RDS(ON)_T$ and $RDS(ON)_a$ are the MOSFET on-resistance at a temperature T and ambient temperature and ΔT is the temperature rise above ambient. The above equation indicates that at higher temperatures, the on-resistance is higher resulting in higher losses that can be observed in Figure 3.

Effective Loss Voltage

One way to explore the converter performance is to introduce the term: "Effective Loss Voltage" which is equal to

$$\frac{Power \text{ dissipation}}{I_{Load}}$$

This represents a DC voltage in series with the converter output which dissipates power when I_{load} passes through it as can be seen in Figure 4. On the y axes we have the "Effective Loss Voltage" and the x axes we have the load current.

Here are the benefits of this representation: We have direct evaluation of the losses as a function of heat sinking

This graph translates the abstract efficiency curve into a actual performance as a function of the load current and power losses.

Effective Loss Resistance

The second way is to propose the measuring of the "Effective Loss Resistance" Rol.

$$Rol = \frac{Total \text{ Converter Power Loss}}{Load Current^2}$$

Figure. 6 shows Rol for similar set of tests measured in Figure 2 with different output voltages and heat sinking scheme. It clearly shows that for a given current, the effective loss resistance, Rol is "almost" the same and "almost" independent of the heat sinking technique. Clearly Rol will differ slightly from one heat sinking technique to the other and the concept of "Rol Band" could be utilized to describe the difference in maximum and minimum Rol as will be shown later.

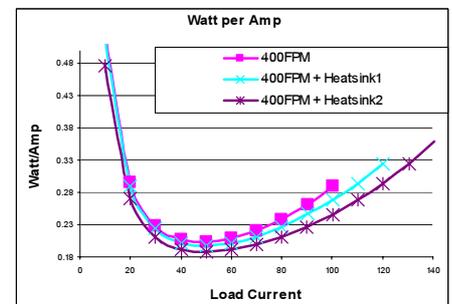


Figure 4. Loss voltage vs. load current

Figure 5 shows the effective loss resistance Rol in all four cases of heat sinking and clearly showing that the converter performance is "almost" independent of the cooling and output voltage leading to the conclusion that the effective loss resistance Rol, is a reliable means to evaluate the converter performance.

As mentioned above, there are some differences in the losses between a 1V and 2V output. A "Rol Band" could apply here too to fully describe the circuit performance. This may be presented as $Rol = Ro \pm \Delta R$. Where this equation applies to say 1/2 load to full load losses. Now we have a very simple parameter with spread that describes the performance of a given converter say a VRM operating between 1V and 2V. One may

derive an equation for RoI that may help in converter comparison using an analytical approach such as a spreadsheet or a mathematical software analysis tool.

An unbiased comparison of different power supplies may now be done either using a set of curves as in Figure 5 or a set of equations in RoI and Iload mentioned above.

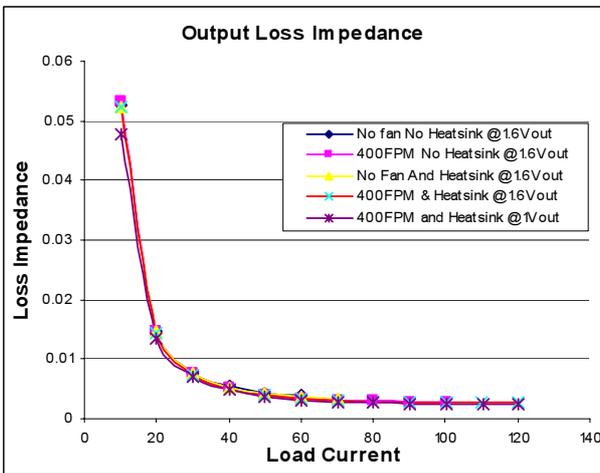


Figure 5. Effective Loss resistance of a converter under different conditions of output voltage and cooling

For completion, Figure 6 shows RoI for different heat sinking conditions. As can be seen, RoI has a mean value and band at each current that represents the spread of the data range. In this particular case the data spread is due mainly to the temperature effects on the converter as explained above.

By knowing RoI and the \pm spread one can immediately evaluate the effect of heat sinking on the total performance and would allow for correct decision making regarding whether the converter requires heat sinking.

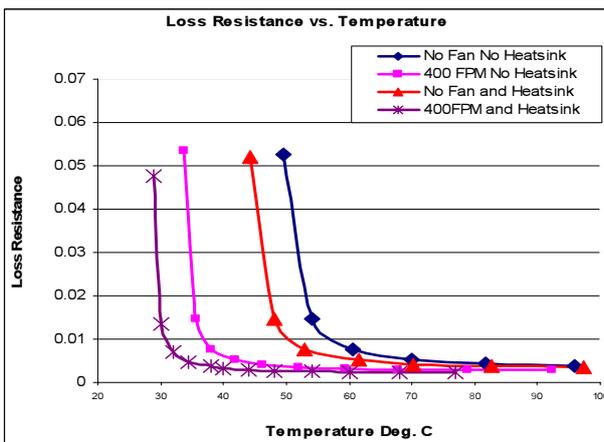


Figure 6. Effective Loss Resistance Vs. Temperature

Conclusion

Some conditions must apply for power efficiency measurements to be used as a comparison tool between different converters. These conditions are the same input and output voltages, same switching frequency, same heat sinking and the same range of load current

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A tool is needed that is independent of the above mentioned conditions. The Effective Loss Resistance, RoI, of a synchronous buck converter is "almost" independent of the output voltage and the heat sinking approach.

Effective Loss Resistance may be published in the data sheet of DC-DC converters allowing the design engineer to hold a very simple and accurate comparison between any number of converters

The mean value of RoI measured at the current range of interest may be used to determine the best converter for the application

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Changing the Output Voltage of a Switching Regulator on the Fly

There are many different ways to change the output voltage

Applications that require the output voltage of a power supply to change dynamically come from a wide variety of areas. Examples are sensor applications that require a different supply voltage under varying circumstances and LED applications where the DC current through an LED needs to be reduced when the ambient temperature rises above a critical point to name but a few possibilities.

By Frederik Dostal, National Semiconductor

This article discusses some methods of changing the output voltage of a power supply on the fly. It includes a “how to guide” as well as information on the frequency domain behavior of the control loop of such a system.

Digital Voltage Scaling

Digital voltage scaling (DVS) is becoming more and more important to reduce energy consumption in portable applications by adapting the supply voltage of DSPs and microcontrollers depending on the upcoming tasks. Power supplies for DVS applications are usually set up with VID pins which come with special power management ICs specifically designed for such applications. These VID pins controlled digitally and are used to change the reference voltage of the controller IC, generating a programmable output voltage.

Most switching regulators are not designed for specific microprocessor (DVS) applications so they do not allow modification of the internal reference. The only way to change the regulated output voltage is to modify the feedback pin circuitry.

In principle there are many different ways to change the output voltage by influencing the feedback pin. Three of the most important ways are mentioned in this article.

One basic way is to add an additional resistor in parallel or in series to the feedback resistors. To do this on the fly, transistors have to be used in the signal path and the signal controlling the output voltage will have to be able to turn the transistor on and off. Figure 1 shows additional resistor and transistors in the feedback path of a power supply to modify the output voltage.

Direct connection of Vcontrol to the feedback divider

A second possibility is to use the voltage control signal and feed it through a second resistive voltage divider into the feedback pin. The output voltage can be set to multiple voltages and can be changed in continuous transitions and not just discretely as in the way described in the previous paragraph. Also, only one or two additional resistors are required, making this a low cost alternative. The downside of this method is that the programming voltage (Vcontrol) is rather restrict-

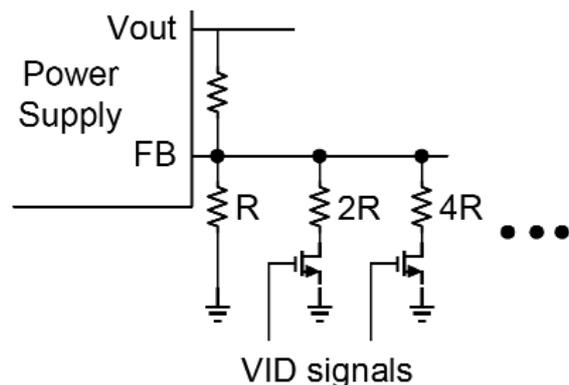


Figure 1. Additional resistors and transistors in the feedback path

ed. The control signal will have to be able to drive the resistive dividers and every bit of this control voltage’s behavior is used by the FB pin to alter Vout in a purely analog manner.

Using an operational amplifier in the feedback path

A very flexible way of influencing the feedback pin while not being so restricted in terms of the control signal is to use an operational amplifier. It can be used to inject some current into the feedback divider which then forces the control loop of the power supply to change the output voltage. This way the output voltage can be varied continuously as a function of the current injected into the feedback node.

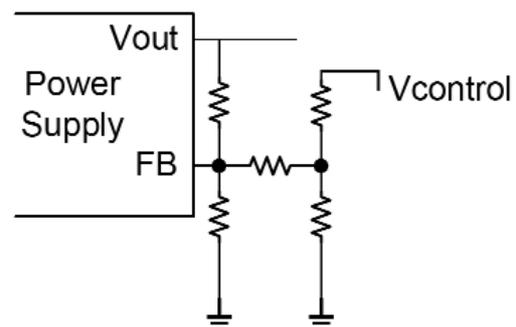


Figure 2. Voltage control with possible second voltage divider

Often, the information controlling the output voltage change on a power supply in sensor applications as well as motor drive applications is an analog signal. Depending on the nature of this control signal, the circuit around the operational amplifier can be defined to set the lowest voltage output independent of what the control signal range is. Also there is great flexibility in the ratio of control signal change to change in the output voltage.

Figure 3 shows an amplifier circuit in the feedback path of a switching power supply. The difference amplifier uses an operational amplifier and four additional resistors R1 through R4. The output of the operational amplifier acts like a voltage source. In order to inject a current into the feedback node this voltage is converted into a current by resistor R5. It equals the internal impedance of the current source which the operational amplifier and R5 constitute. Together with the feedback resistors R6 and R7 any output voltage changes can be set based on almost any given control signal.

The signal voltage V1 is the control signal. The voltage V2 is a reference voltage for the operational amplifier. It should be a fairly constant voltage since variations on it will change the output voltage of the power supply as well. If a fairly precise rail in the system is available it can generally be used. A good solution is a low voltage reference IC such as National Semiconductors LM4040.

Concerns of the operational amplifier

The operational amplifier needs a supply voltage that ensures proper operation at both ends of the output voltage range. Depending on what the specifications of the power supply are the amplifier may or may not be connected directly to Vin or Vout. In some designs, an amplifier with a wide supply range or an additional supply for the bias voltage of the amplifier might be needed. Since the current required for the supply rails of the amplifier is very little, often the supply is only a resistive divider with a zener diode to limit the supply rail. If amplifiers with a very wide input voltage range such as National Semiconductors LM7301 are used, in most applications they can be attached to the input or output voltage of a design directly. The LM7301 has an input voltage range from 1.8V up to 32V and is optimized to require only 600uA supply current.

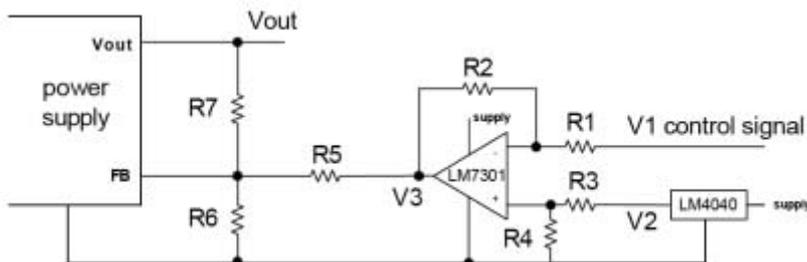


Figure 3. Amplifier in the feedback path of power supply



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Large signal behavior of the power supply

Building a power supply circuit with a varying output voltage is somewhat more difficult than with a fixed output voltage. The selection of the power path components does not only depend on the supply voltage and the output load but also on the output voltage. The usual extremes to look at in a fixed output voltage supply are Vin min, Vin max, Iout min and Iout max. With Vout changing also there is Vout min and Vout max to be considered as well. A spread sheet for the circuit design will be very helpful since there are quite a few combinations to look at.

Stability evaluation; PWM control and constant-on-time control power supplies

Regarding the control loop, it is very important to make sure that a power supply with a changing output voltage is stable under all output voltage conditions.

When using a voltage mode or current mode PWM switching regulator the feedback divider network has an effect on the gain of the control loop.

Buck regulators have a linear transfer function and the compensation will generally not have to be optimized for different output voltages. Other topologies such as the boost regulators do not have a linear transfer function and as such the optimization of the control loop will change when the output voltage or input voltage changes. When power supplies with a variable output voltage are designed, loop stability tests need to be performed throughout the whole output voltage range.

Another interesting observation is that there is a difference if the power supply's output voltage is changed by modifying the low-side feedback resistor or by injecting a current into the feedback node. Changing the low-side feedback resistor will not change the gain of the circuit if the error amplifier is a conventional opamp. So a designer can replace the low-side feedback resistor with a potentiometer and change the output voltage of the power supply without changing the feedback gain. This will not be true if the error amplifier is a transconductance (gm) amp.

When current is injected into the feedback node with a current source with internal impedance such as the circuit in figure 3, the frequency behavior of the system depends on the internal impedance of the current source (R5 in figure 3) but not on the actual current injected into the feedback node. So the closed loop evaluation can be done once for a design with one fixed R5 without needing to redo it for every possible output voltage. However this only holds true for a buck type regulator where the plant gain is independent of duty cycle.

In constant-on-time control ICs such as National Semiconductor's LM5010 which basically use a comparator at the feedback pin, stability is not a concern. The output voltage is controlled in a hysteretic

window directly with some short propagation delay. It does not require compensation components or further stability measurements. The only thing to watch out for is the requirement that in such regulators there is always a bit of ripple voltage necessary on the feedback pin. If this minimum voltage ripple is not available, the hysteretic comparator's thresholds are not cleanly crossed and the result is frequency jitter and erratic behavior. When a constant-on-time regulator is used for a variable output voltage design, the minimum and maximum ripple on the feedback pin has to be checked. There are techniques of introducing additional ripple on the feedback pin in such designs which can be taken from the individual datasheets of these ICs.

Changing the output voltage on the fly very suddenly

If the output voltage of a power supply is modified on the fly the effect is very similar to the input voltage changing with a fixed output voltage. The duty cycle will have to adapt to the new Vin to Vout ratio and the regulator will need to adjust to the new situation. Just as in input voltage changes the output might see some overshoot or delay in coming up. How fast the regulator can adapt to the new conditions and how much overshoot or delay one will observe is given by the bandwidth of the circuit. One thing that can cause surprises is in regulators that have built in output over voltage protection, a sudden reduction in the programmed output voltage can trip the OVP comparators and force the regulator to latch off. The solution with these types of regulators is to force the output voltage to move relatively slowly when moving lower.

There is no magic about it

Changing the output voltage of a power supply on the fly is not magic. There is nothing to be afraid of as long as all design aspects are considered carefully. Unfortunately changing Vout and making it a variable makes a power supply design more demanding.

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Four step guide to calculate the component values:

The following guide with numbers as an example will help to determine the right components for a circuit as described above and shown in figure 3:

1. Defining the output voltage variation as well as the corresponding variation of the control signal:

Vcontrolmax: 5V Vcontrolmin: 3V Voutmax: 15V
Voutmin: 5V Vref: 10V Vfb: 2.5V

2. Set the feedback resistors R7 and R6 according to low leakage current as well as loop regulation requirements. Select to adjust Vout max:

R7: 3k ohm

$$R6 := \frac{R7}{\left(\frac{Voutmax}{Vfb}\right) - 1}$$

R6=600 ohm

Ix is the current which will be injected into the feedback node for Voutmin:

$$I_x := \left(\frac{Vfb}{R6}\right) - \frac{Voutmin - Vfb}{R7} \quad I_x = 3mA$$

3. Resistor R5 is producing the current Ix out of Vfb and V3. So R5 defines the maximum output voltage of the amplifier as well as the internal impedance of the current source we are building:

R5: 330 ohm V3max=(Ix*R5) + Vfb V3max = 3.6V
Now we know what V3max needs to be to make the lowest output voltage.

4. To minimize the offset error due to input bias currents often R1=R3 and R2=R4 is selected. R1 usually is selected to be a large resistor so that the control signal is not loaded significantly.

R1: 200kohm R1=R3

$$R2 := R1 \cdot \frac{V3max}{Vref - Vcontrolmin}$$

R2=102.9kohm R2=R4

High Performance PFC Inductor

Core with low losses to minimize temperature rise

Devices like PFCs are boost circuits that bring current in phase with voltage, to create acceptable power factor front ends for power supplies. The role of the inductor is to store energy, and reduce ripple current.

By David Anderson, Chief Engineer - Precision

Design Requirements

International Rectifier wanted to highlight the new controller chip for their IRAC1150-300 watt demo board application. Their requirements for the new PFC inductor included: A high-performance core with low losses to minimize temperature rise, minimize audible noise from magnetostriction, maximize self resonant frequency (SRF) and provide stable inductance over the operating current range. The single-layer winding and compact size make a very good presentation on the demo board.

The Precision (and IR) Recommendation

Precision worked with International Rectifier to balance the trade-offs to develop the Inductor. Part # 019-4120-00, a very high-performance inductor, met all of the 300 Watt circuit requirements of the IR 1150 Demo Board. It is capable of 100 KHz switching frequency, a peak current of 6.2A and a continuous RMS current 3.8A. The low core loss and high SRF were achieved by selecting the right core material and winding configuration. This design also yields low audible noise and a minimal temperature rise.

During the process some options were also considered, including a number of cost and



performance variations. One of these

includes a bias winding on the PFC choke to supply power for the PFC control circuitry.

Precision's (and IR's) Design Considerations

Key considerations include: Inductance, peak current, operating frequency, ripple current, physical size, temperature rise, audible noise and cost. The trade-off's in design are driven by the priorities of the application, this effects proper core selection, wire and winding configuration.

Part of Precision's design approach begins with listening to the customer and gaining a thorough understanding of their unique application needs. The approach continues with review of the design theory and device trade-offs, samples for design verification and a review of global manufacturing and delivery alternatives. The goal is to respond with solutions on a timely basis by clearly reviewing and understanding all key considerations.

A number of considerations are examined during Precisions' design approach for PFC inductors:

- 1) Balanced Performance/Cost - Toroid Design Alternative. A lower performance core will provide inductance stability over the current range and achieve required inductance in the same physical package. This will increase the core loss and introduce the possibility of audible noise under high ripple current conditions.
- 2) Efficient Cost - Toroid Design Alternative. This design will produce low core loss with low temperature rise and good magnetostriction characteristics. Alternative core materials can yield a lower cost. A larger size may be needed to achieve the required inductance.
- 3) E-core Alternative: The variety of sizes



and materials offer a wide range of form factors. Bobbin construction simplifies manufacturing and mounting to the PCB.

A Family of New Products

Precision has PFC Inductors that are used with all popular PFC controllers. They are releasing products that encompass toroid and E-core configurations, as well as less expensive options for the IR controller. The new PFC inductor products work with a wide variety of power levels, as well as other PFC applications.

Precision has PFC inductors that are used on all popular PFC controllers. The company produces many custom PFC inductor designs for applications up to 4,000 Watts and beyond. They can provide a variety of performance and cost options for any PFC application, including lower cost/performance alternatives.

When International Rectifier wanted a high performance power factor correction (PFC) inductor that showed well on their IR1150 reference design, they turned to Precision, Inc. The two companies have successfully collaborated on a number of applications over the years. Precision has proven to be very responsive in designing and building the ideal magnetics for specific applications on a timely basis and has developed devices for use in many other International Rectifier power conversion designs.

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Switched Reluctance Drives in Weak Supply Nets

Electronic Stabilization Methods

As a low rate of torque ripple usually is one of the major design targets of switched reluctance drives it is necessary to have more than one torque productive phase at a time.

By Andreas Schramm, Universität der Bundeswehr München

Particularly when one phase current is being switched off when the respective rotor teeth reach the aligned position relative to that phase, there already has to be a second torque productive (and therefore excited) phase to prevent the output torque from decreasing. That implies that for a certain period of time the two phases have to be supplied with current simultaneously. In [1] and [2] the design of switched reluctance machines with two phases excited at a time and their high torque quality is discussed. The positive effect of phase current profiling on the machine's performance is described in [3] and [4]. In such cases the DC-link current of the power converter can reach up to twice the value of the desired phase current during commutation. In weak supply nets this can cause a drop of the DC-link voltage. In some applications, e.g. auxiliary drives in aircrafts or automobiles, this voltage drop can not be accepted, because the voltage of the on-board electrical system has to follow certain standards and therefore must not drop below some particular value. Low torque ripple on the one hand and only one torque productive phase at a time on the other hand are contradicting targets. But as a larger voltage drop could affect other indispensable functions of the system under consideration, the prevention of such a deep voltage drop is even a higher aim than a high quality of the output torque of the drive.

In the following, different electronic means for reducing the voltage drop in a system of fixed on-board net and fixed switched reluctance drive will be investigated and compared. A variety of mechanical measures for optimising a switched reluctance drive with regard to a stable DC-link voltage are discussed in [5] and [6].

Simulation model

Figure 1 shows an equivalent circuit diagram of an on-board power supply network with a multiple phase switched reluctance drive connected.

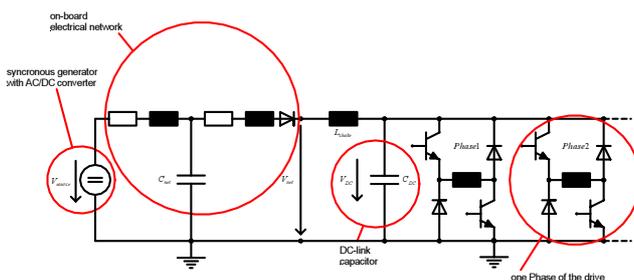


Figure 1: Multiple phase switched reluctance drive and on-board power supply network.

The displayed circuit is used for simulating the system's behaviour. It consists of a synchronous generator with a rectifier, that is in fact simulated using a DC voltage source, which is set to $V_{source} = 22V$. This is a reasonable simplification of the real system, being introduced to combine both, realistic simulation results and short computation time. The on-board power supply network including numerous loads that are not investigated in detail is represented by a number of resistors, inductivities and a capacitor. In order to keep the diagram as simple as possible, only two of the four phases of the simulated drive are shown. For the same reason the ohmic resistances of all connecting cables as well as their inductivities and capacities (if they can not be neglected anyway) are not displayed. The inductivity in each phase finally represents the respective phase winding of the reluctance machine.

Examined voltages

The DC-link voltage, V_{DC} , is one of the characteristic terms of switched reluctance drives. It limits the gradient of the phase currents during commutation and hence acts as a limitation of the maximum possible speed of the machine. The output voltage of the on-board power supply network, V_{net} , is the voltage that also has to follow the standards mentioned in chapter 1. These standards demand for V_{net} not to drop below 18V. Fig. 2 presents the results of a simulation for both voltages.

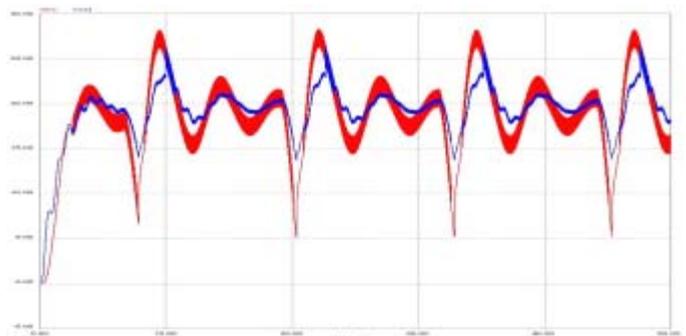


Figure 2: DC-link voltage and output voltage of the on-board power supply network.

Herein the drive is operating at low speed with a high torque demand. The firing angles of the semiconductor switches are set to values that enable the highest torque quality to be achieved, i.e. the torque ripple is as small as possible. Therefore the DC-link has to conduct up to twice the phase current during commutation, which causes the voltage drops that can be clearly seen. The fact that the



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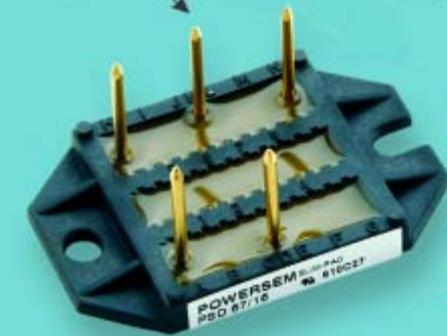
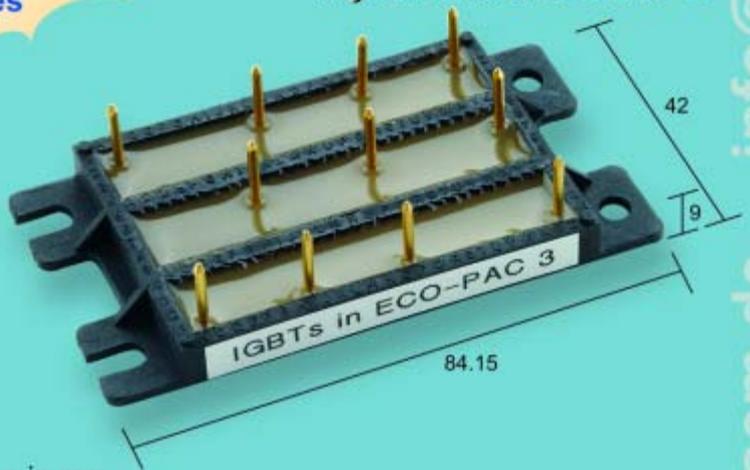


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two displayed voltages differ results from the existence of the choking coil (see Fig. 1). Although the choking coil diminishes the voltage fluctuations, it does not prevent V_{net} from dropping below the claimed value.

Electronic measures reducing the voltage drop

a) firing angles

By switching off the leading phase earlier while not changing the instant of switching on the succeeding phase, the amplitude of the DC-link current can be reduced. Fig. 3 shows the simulation results for V_{DC} and V_{net} with a slightly (0.4°_{mech}) advanced firing angle for switching off. Obviously now V_{net} complies with the standard.

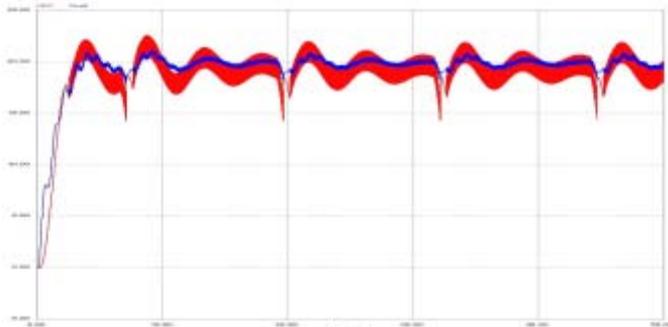


Figure 3: DC-link voltage and output voltage of the on-board power supply network for altered firing angle.

As far as the voltage is concerned, this method appears to be successful, but it has a remarkable negative effect on the torque quality (see Fig. 4). This large disadvantage of the proposed method leads to the development of the second proposal.

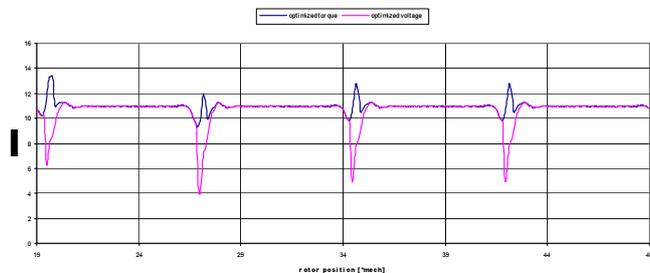


Figure 4: Output torque for different firing angles.

b) feed-forward control of the DC-link voltage

To implement such a control mechanism it is necessary to measure the voltage of the DC-link capacitor, V_{DC} , during operation of the drive. When the drop of the measured voltage exceeds a certain threshold the firing angle for switching off is adapted in that way, that the subsequent phase is being switched off a bit earlier. The instant when the capacitor voltage drops down to the lowest possible value is when the DC-link current reaches its peak value. This happens right before the moment when the phase which approaches the aligned position is being switched off, because at this very moment both phases are definitely excited. The exact point of time when this happens can be gained from the control parameters of the drive.

Of course, as the functional principle of this method is the same as the one of the method described in a), this also has a negative effect on the torque ripple rate as well as on the mean output torque. Both, the reduction of the mean output torque and the rise of the torque ripple can at least partly be compensated by increasing the nominal value of the phase current.

Figure 5 displays the behaviour of the drive using the proposed control method. The four traces show from top to bottom: output torque, phase currents, DC-link voltage and electrical input power.

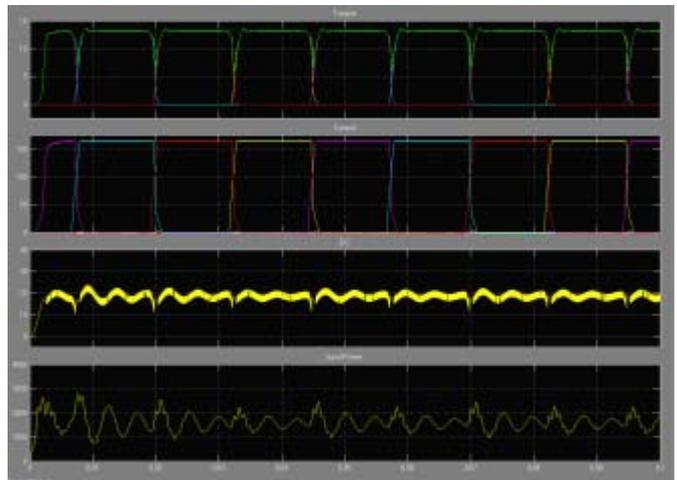


Figure 5: Switched reluctance drive with active firing angle adaptation.

Again the drop of the output torque can be recognised always when the phases commutate. The fact that the drop of torque always differs from one commutation period to the next indicates the active state of the firing angle adaptation. The positive effect of this control method on the DC-link voltage can be seen in the third trace. The voltage drop can be prevented almost completely.

c) DC-link capacitor

The third alternative to reduce the voltage drop is to increase the DC-link capacitance.

The default value of the capacitor is $C_{DC} = 8,000\mu F$. Simulation results for a capacity of $C_{DC} = 130,000\mu F$ are illustrated in Fig. 6.

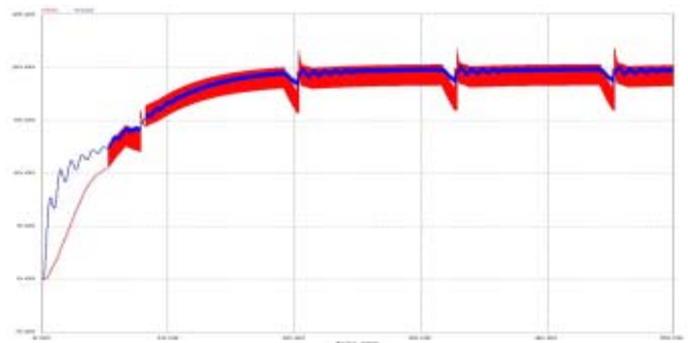


Figure 6: DC-link voltage and output voltage of the on-board power supply network for $C_{DC} = 130,000\mu F$.

This high value results from the thought, that the drop of the DC-link voltage should not exceed . To realise such a large capacitor in an environment with limited space, the use of Supercaps is recommended. As Supercaps can easily be damaged when they are exposed to higher voltages than , several of them have to be connected in series. The higher serial resistance of this arrangement has been considered in the simulation.

Conclusions

All alternatives to lessen the drop of the power supply net voltage appear to be successful, as the simulation results look very promising.

All the Power you need

The first method of coping with the problem seems to be very cost-effective at first sight, as no physical modifications, neither of the machines, nor of the power electronics have to be implemented. When taking a closer look at this proposal one should recognise, that a very exact monitoring of the angular rotor position is required to make this mechanism work properly. An expensive high resolution resolver is needed to provide that exact data, which raises the costs significantly. Moreover the large disadvantage of this method, the growing torque ripple and the reduction of the mean torque, can not be denied.

The second alternative has the advantage that no precise measurement of the rotor angle is necessary and that always the maximum possible overlap of phase excitation (evaluated against the voltage drop) is guaranteed. Thus the negative effects on the torque performance resembling those of the first method do only occur, when the decreasing DC-link voltage really requires an adaptation of the firing angles.

The third possibility should be the one to find high acceptance in connection with the most applications, as it has no negative effect on the torque performance of the drive. Of course also in this case the costs are high, which contradicts one of the main goals of developments for example in the automotive industry.

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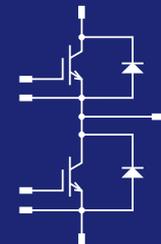
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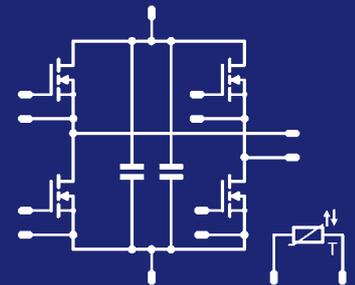
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Smart Battery Charging Systems Autonomous Power Manager ICs Simplify Li-Ion Battery Charging

Battery managers incorporates an unsurpassed level of integration

Today's high performance, portable handheld Li-Ion/Polymer battery powered products have integrated more features, enabling them to inch closer to being "all-in-one" devices for the tech-hungry consumer.

By Steve Knoth, Product Marketing Engineer, and Mark Gurries, Linear Technology Corporation

The high level of integration, combined with the desire for portability and flexibility of usage with various power sources, presents a number of challenges for the portable electronic device designer. These include accurate and efficient battery charging, reduced power dissipation, standalone operation (i.e. no external microprocessor for charge termination), autonomous power management and finally, "instant-on" operation - the ability to power the load even with a dead or missing battery. Linear Technology has developed autonomous power manager ICs to meet these functional demands. These ICs offer full-featured standalone battery chargers, integrated with PowerPath controllers and ideal diode devices that efficiently manage a wide variety of input power sources and reduce power dissipation, all with extremely small form factors.

Key Design Challenges

The following are some of the main challenges for the system designer of today's battery powered handheld devices: Minimize power dissipation; Maximize efficiency; Simplify design and Lower cost

Many of today's portable battery-powered electronics can be powered from a wall adapter, automotive adapter, a USB port, or a Li-Ion/Polymer battery. However, autonomously managing the power path control between these various power sources presents a significant technical challenge. Traditionally, designers have tried to perform this function discretely by using a

bunch of MOSFETs, op-amps and other discrete components, but have faced tremendous problems with hot plugging and large inrush currents, which may cause big system problems. More recently, even discrete IC solutions require several chips to implement a practical solution. An integrated power manager IC solves these problems simply and easily. In addition, autonomous standalone operation of the IC eliminates the need for an external microprocessor for charge termination, thereby simplifying the design even further.

With high voltage sources such as Firewire, unregulated higher-voltage (>5.5V) wall adapters and automotive adapters, the voltage difference between the adapter's voltage source and the battery in the handheld device is very large. Therefore a linear charger may not be able to handle the power dissipation. However, an IC with a switch-mode topology can improve efficiency and reduce thermal management issues. Note that a linear charger/power manager is more suitable when powering from the USB, Li-Ion/Polymer battery or adapters with <5.5V input.

PowerPath Control

A device with PowerPath control provides power to the device itself and charges its single-cell Li-Ion battery from the USB VBUS or a wall adapter power supply. To ensure that a fully charged battery remains fresh when the bus is connected, the IC directs power to the load through the USB bus

rather than extracting power from the battery. Once the power source is removed, current flows from the battery to the load through an internal low loss ideal diode, minimizing voltage drop and power dissipation. Refer to Figure 1 for details.

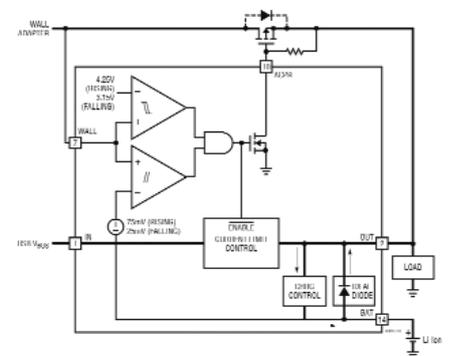


Figure 1. PowerPath Control Simplified Circuit

PowerPath Control Features

Receives power from a USB source, a wall adapter, or a battery.

Delivers power to an application connected to the OUT pin and a battery connected to the BAT pin (assuming that an external supply other than the battery is present).

Battery charge current will be adjusted to ensure that the sum of the charge current and load current does not exceed the programmed USB input current limit. Wall adapter power can be connected to the output (load side) through an external device

such as a power Schottky or FET.

Unique ability to use the output, which is powered by the wall adapter, as a path to charge the battery while providing power to the load.

Load on the OUT pin gets priority over the USB input current

Ideal Diode

A low-loss ideal diode provides power from the battery when output/load current exceeds the input current limit or when input power is removed. Powering the load through the ideal diode instead of connecting the load directly to the battery allows a fully charged battery to remain fully charged until external power is removed. Once external power is removed the output drops until the ideal diode is forward biased. The forward biased ideal diode will then provide the output power to the load from the battery. The forward voltage drop of an ideal diode is far less than that of a conventional diode, and the reverse current leakage can be smaller for the ideal diode as well. The tiny forward voltage drop reduces power losses and self-heating, resulting in extended battery life. Refer to Figure 1 for details.

Ideal Diode Features

The ideal diode function provides power from the battery when the output/load current exceeds the input current limit or when input power is removed.

Powering the load through the ideal diode instead of connecting the load directly to the battery allows a fully charged battery to remain fully charged until external power is removed, and also allows the device to operate even with a fully depleted battery.

Once external power is removed, the output drops until the ideal diode is forward biased. The forward biased diode will then provide the output power to the load from the battery.

If a battery is the only power supply available or if the load current exceeds the programmed input current limit, then the battery will automatically deliver power to the load via an ideal diode circuit between the BAT and OUT pins.

The ideal diode circuit (along with the recommended capacitor on the OUT pin) allows the IC to handle large transient loads and wall adapter or USB VBUS connect/disconnect scenarios without the need for large bulk capacitors.

A low-loss ideal diode extends battery run time by reducing the IR drop associated with the power path.

Linear Technology's growing family of power manager ICs solves the design problems outlined above. Two key new products in this arena that implement this functionality are the LTC4085 USB power manager with linear battery charger and the LTC4089 power manager with high efficiency, high voltage battery charger.

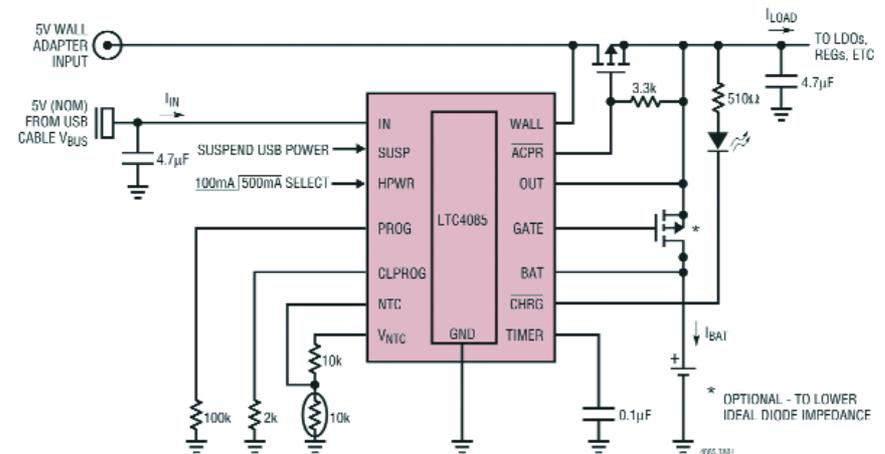


Figure 2. LTC4085 USB Power Manager

Single IC USB Power Manager, Ideal Diode Controller & Battery Charger

The LTC4085 is a monolithic autonomous power manager, ideal diode controller and standalone linear battery charger for portable USB devices. The LTC4085 features PowerPath control that provides power to the system load and charges a single-cell Li-Ion/Polymer battery from the USB VBUS or a wall adapter power supply. To comply with USB current limit specifications, the LTC4085 automatically reduces battery charge current as the system load current increases. To ensure that a fully charged battery remains fresh when the bus is connected, the IC directs power to the load through the USB bus rather than extracting power from the battery. Once the power source is removed, current flows from the battery to the load through an internal 200mOhm low loss ideal diode, minimizing voltage drop and power dissipation. Onboard circuitry is provided to drive the optional external GATE PFET hookup to reduce the overall ideal diode impedance below 30mOhm if required by the application.

The LTC4085 has the unique ability to detect the presence of a wall adapter and use it as an alternate power source to charge the battery while providing power to the system load. The LTC4085 also offers the option of

charging the battery at a higher rate (up to 1.5A) than USB specifications allow (100mA/500mA) when the wall adapter is present so that the battery can be charged much faster. Total charge time for charge termination is programmed by an external capacitor. When charging current is reduced, the charge timer automatically extends to ensure the battery is always fully charged. Additional functions include automatic recharge, NTC thermistor input, automatic switchover to battery when the wall adapter

input is removed, inrush current limiting, reverse current blocking, undervoltage lock-out and thermal regulation.

The LTC4085's float voltage is preset at 4.2V with guaranteed 0.8% accuracy from 0°C to 85°C. Charge current is easily programmed using a resistor. For battery preconditioning and qualification, fully discharged cells are automatically trickle charged at 10% of the programmed current until the cell voltage exceeds 2.8V. Finally, the LTC4085 is housed in a tiny 14-pin 3mm x 4mm DFN package with a 0.75mm profile and is guaranteed for operation from -40°C to 85°C.

USB Power Manager with High-Voltage Switching Charger

There are a number of advantages to offering USB and high input voltage power and battery-charging capability to handheld devices such as GPS navigators, PDAs, digital cameras, photo viewers, MP3/MP4 players and other multimedia devices. For instance, USB power offers the convenience of not requiring a travel adapter on the road. Devices may be powered from a laptop PC or some other device with a USB port for example. High voltage input sources, such as Firewire, 12V–24V wall adapters, or automotive car adapter outputs provide faster

charging than USB and allow charging in more locations, such as in the car. This is a key to portability.

Convenience & High Power

The LTC4089 and LTC4089-5 are autonomous power manager, ideal diode controller and standalone high voltage, high efficiency battery chargers for portable USB devices. For high efficiency charging, their switching topology accommodates various inputs, including high voltage power sources up to 36V (40V max) such as 12V wall adapters, automotive adapters and FireWire ports. In addition, they accept low-voltage power sources such as 5V adapters and USB. The LTC4089/-5 features PowerPath control that provides power to the device and charges the device's single-cell Lithium battery from the USB bus or a wall adapter power supply and also allows for instant-on operation even with a depleted or missing battery. To comply with USB current limit specifications, the LTC4089/-5 automatically reduces battery charge current as the system load current increases. To ensure that a fully charged battery remains topped off when the bus is connected, the IC directs power to the load through the USB bus rather than extracting power from the battery. Once all power sources are removed, current flows from the battery to the load through an internal 200mOhm low loss ideal diode, minimizing voltage drop and power

dissipation. Onboard circuitry is provided to drive an optional external PFET to reduce the overall ideal diode impedance below 30mOhm if required by the application, providing even higher efficiency operation.

The LTC4089's switching regulator features Bat-Track adaptive output control, which greatly improves the efficiency of its 1.2A-capable battery charger as the switching regulator's output voltage automatically

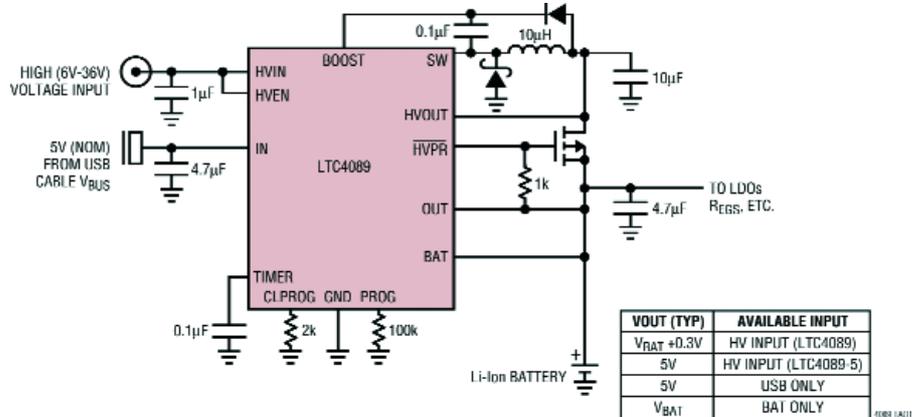


Figure 3. LTC4089's Typical Application Circuit

When the LTC4089/-5's power is supplied from a USB port, the power manager maximizes the power available to the system load to the full USB available power of 2.5W (500mA x 5V), and it automatically adjusts the Li-Ion/Polymer battery charge current with the system load current to maintain the total input current compliance within the USB limits.

tracks the battery voltage. The LTC4089-5 provides a fixed 5V output from the high-voltage input to charge single-cell Li-Ion/Polymer batteries. The battery charger's float voltage is preset at 4.2V with guaranteed 1.0% accuracy from 0°C to 85°C. Charge current is easily programmed using a single resistor. For battery pre-conditioning and qualification, fully discharged cells are automatically trickle charged at 10% of the programmed current until the cell voltage exceeds 2.9V. Total charge time for charge termination is programmed by an external capacitor, and a C/10 charge current detection output is provided. Additional functions include thermal regulation, an NTC thermistor input for temperature-qualified charging, automatic recharging of the battery, reverse current blocking, and under-voltage lockout. The LTC4089/-5 is housed in a low-profile (0.75mm) tiny 22-pin 6mm x 3mm DFN package, and is guaranteed for operation from -40°C to 85°C.

BAT-Track Adaptive Output Control

LTC4089's BAT-Track feature is a form of adaptive output control. It is the integration of a battery charger and switching regulator such that the switching regulator only generates enough voltage to support the battery charger, and no more. For linear power path products the difference between the input voltage and the battery voltage is lost in the charging process as heat.

When a switching regulator is implemented, it is advantageous to drop as much voltage as possible across the switcher, since it can be done with high efficiency (drawing less

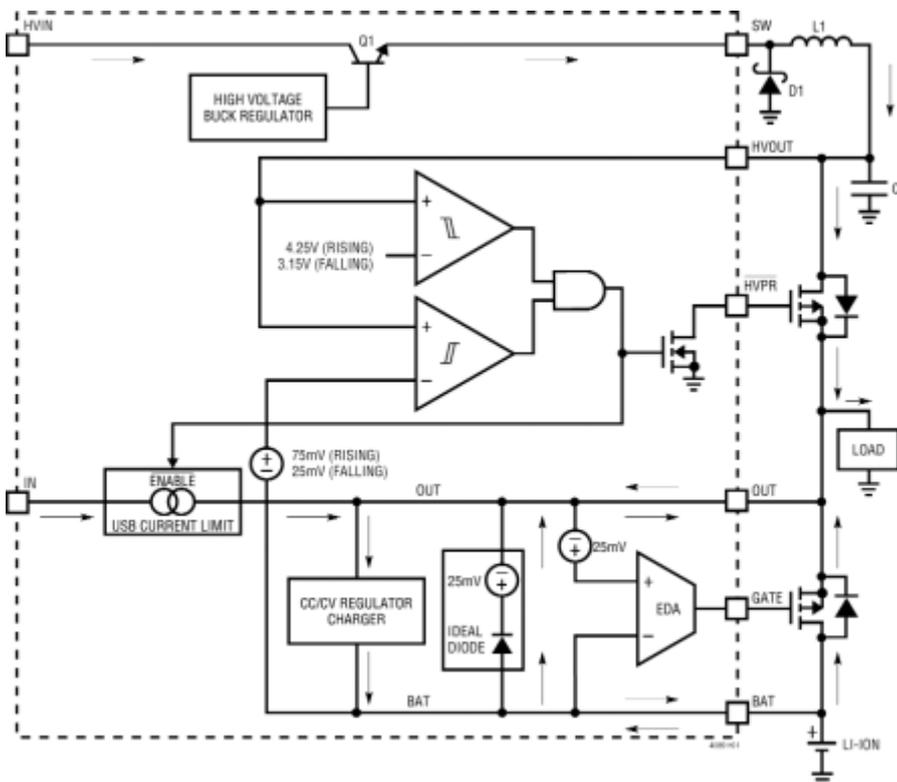


Figure 4. LTC4089's PowerPath Control Simplified Circuit

current from the input than is supplied to the charger). The BAT-Track feature senses the BAT voltage and adjusts the switching regulator output V_{OUT} to be 300mV higher than the battery's voltage V_{BAT}, minimizing power lost to heat. Therefore, the battery can be charged adequately and minimize the overall power dissipation. This greatly improves the efficiency of the battery charger. For example, given charge current I_{BAT}=600mA with V_{BAT} = 3.7V and a charger input voltage of V_{IN}=5V, then the charger efficiency (by term substitution) is

$$[1] 100 * P_{OUT} / (P_{OUT} + P_{DIS}) =$$

$$[2] 100 * (V_{BAT} * I_{BAT}) / (V_{BAT} * I_{BAT} + P_{DIS}) =$$

$$[3] 100 * (V_{BAT} * I_{BAT}) / (V_{IN} * I_{IN}) = (3.7V \times 600mA) / (5V \times 600mA) = 74\%.$$

Instead, if the charger input voltage is 300mV higher than V_{BAT} the charger efficiency is

$$[3] 100 * (V_{BAT} * I_{BAT}) / (V_{IN} * I_{IN}) = (3.7V \times 600mA) / ((3.7V + 0.3V) \times 600mA) = 92.5\%.$$

V _{OUT} (typ)	AVAILABLE INPUT
V _{BAT} +0.3V	HV INPUT (LTC4089)
5V	HV INPUT (LTC4089-5)
5V	USB ONLY
V _{BAT}	BAT ONLY

Table 1. LTC4089's Output and Input Characteristics

This efficiency difference will reduce power dissipation significantly. Furthermore, if the battery is excessively discharged and V_{BAT} falls too low, the minimum V_{OUT} is 3.6V to ensure the system load gets an adequate supply.

Conclusion

Consumer demands for small size, reduced cost, and convenience via acceptance of multiple input power sources for their battery powered handheld devices results in a variety of challenges to the system designer. However, there are solutions readily available to these problems. Linear Technology's

growing family of PowerPath battery managers incorporates an unsurpassed level of integration and feature standalone, autonomous operation. They effectively manage the seamless transition between multiple power sources, such as automotive adapters, Firewire inputs, wall adapters, USB ports, and the battery itself. Accurate programmable current limits maximize power available from the USB and low on-resistance ideal diodes produce less heat. "Instant-on" operation allows the end product to operate immediately when plugged in, regardless of the battery's state of charge. LTC4085 and LTC4089 are two new products in this arena, providing a high level of integration and multiple features to benefit the IC designer of today's portable USB-powered handheld devices.

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Tailor-made Lithium Polymer Batteries

Flexible in Shape and Size

The growing use of mobile electronic devices is generating an ever-increasing demand for high performance primary (disposable) and secondary (rechargeable) batteries. Applications with special needs regarding performance and design of the electrical energy storage unit call for solutions, which cannot be provided by standard battery products.

By Dr. Peter Gulde, Integrated Power Systems, Fraunhofer Institut für Siliziumtechnologie

Standard battery products are available in large quantities for high volume products in information and communication technologies (e.g. mobile telephones). High energy density (long operating time), but particularly the price plays an important role. If, however, specific requirements regarding electrical performance, design or application requirements are placed on the electrochemistry energy storage unit then the battery, like all other system components, must be specially designed and manufactured to match these very specific profiles. The Fraunhofer Institut für Siliziumtechnologie (Fraunhofer ISIT) offers a construction kit for the design of application optimized lithium polymer secondary batteries.

Battery Construction Kit

Experts at the Integrated Power Systems division of the Fraunhofer Institut für Siliziumtechnologie (Fraunhofer ISIT) in Itzehoe, Germany have developed a construction kit for tailor-made lithium polymer batteries, which makes 'rapid prototyping' possible. This construction kit addresses industrial customers with requirements that cannot be matched by standard battery products, but instead call for a battery with specific characteristics e.g.:

- a customer specific electrical performance profile (e.g. voltage requirements, energy density, operating environment),
- specific reliability requirements (e.g. long-term stability, cycle stability, self-discharge),
- safety requirements (thermomechanical stability, short-circuit safety, leakage safety),
- a housing technology and/or design to match the usage profile,
- a high degree of environmental compatibility and
- a safe and cost-effective production.

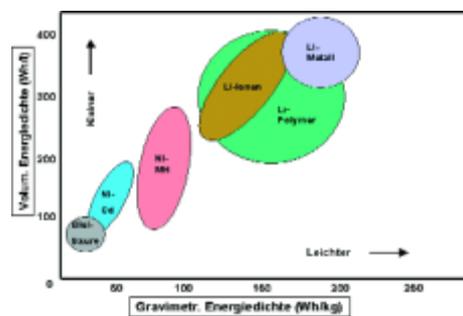


Figure 1 Comparison of different battery technologies in terms of volumetric (Wh/l) and gravimetric (Wh/kg) energy density

The Fraunhofer Institut offers complete services ranging from design consultancy to prototype production of lithium polymer (Li-Polymer) batteries Table 1. The first step is the definition, and as far as possible the quantification of the most important characteristics of the electrical energy storage unit in close cooperation with the customer. Following this, the specialists prepare a feasibility study with the goal of finding an optimal solution to meet the stipulated priorities and technical realization of the respective application.

ISIT offers:

- consultancy for specification and design of electrochemistry
- design of customer specific rechargeable batteries
- prototype production
- transfer to volume production
- system integration support
- reliability analysis, electrical characterization

Table 1: Capabilities at Fraunhofer ISIT

The Fraunhofer Institut's flexible production system is unique. It encompasses, for example, the design of new electrode foils and the prototype production of the batteries in various shapes and sizes. Format changes can be performed very simply, because only a few tools need to be replaced. Fraunhofer ISIT can manufacture, test and - if required - characterize up to 100 samples. For an industrial scale production, the design is transferred to Leclanché Lithium GmbH, a recently established company from a Fraunhofer-ISIT spin-off.

Lithium Battery Technology

Compared with other battery types, lithium battery systems offer a high energy density (Figure 1). Lead acid batteries, which are mostly used in automobiles, are particularly inexpensive, but their energy density is in the lowest range. Environmental concerns cause a gradual disappearing of nickel cadmium batteries from the market. However, because of their high performance capability and good low temperature characteristics they are currently still the first choice for some applications. The outstanding energy density of rechargeable Lithium batteries is a result of higher voltage in combination with a very good charge density (energy = voltage x charge). A number of compounds containing lithium allow for an utilization of a wider range of the electromotive series and therefore, depending on the choice of the electrode materials, a particular discharge voltage (e.g. system graphite/LiCoO₂ with 3.7 V per cell).

A rechargeable lithium battery consists of a positive cathode (ion source), generally a lithium metal oxide, and an anode, usually graphite (Figure 2). A separator in between

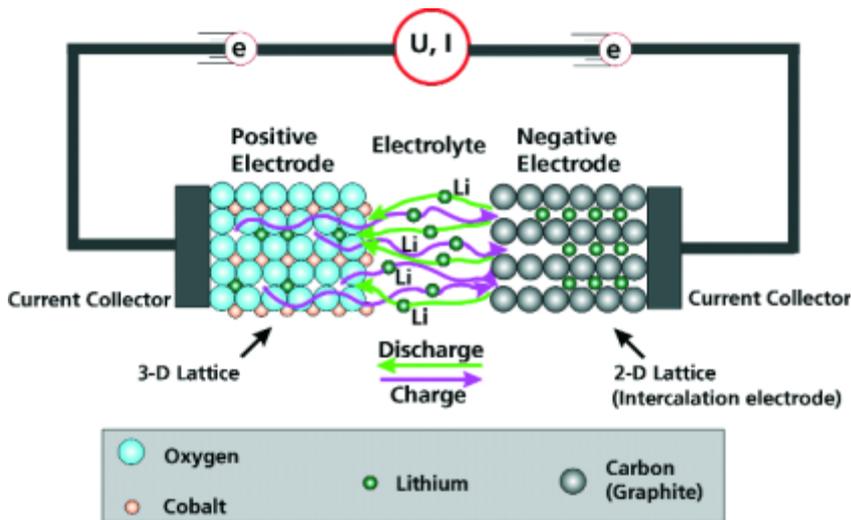


Figure 2 Functional principle of lithium ion, 'rocking chair' battery

separates anode and cathode and only allows ions to travel through it, but not electrons. The thickness of this ion conducting separator, ranging from 10 μm to 50 μm , defines the distance between anode and cathode. In the charge mode of the battery, positive lithium (Li^+) ions travel from the cathode through the separator to the anode. Simultaneously, negative electrons migrate through the external circuit from the cathode to the anode. In the discharge mode of the battery, the external electric current is used to power electronic devices.

The Lithium Ion Battery

Lithium ion batteries use a wound 'jelly roll' construction. The anode, cathode and separator are wound up on a reel core. A liquid electrolyte, consisting of organic solvents in which lithium salt is dissolved, is used in lithium ion batteries to achieve high ionic conductivity. This solvent is, however, very sensitive to moisture and the battery must therefore, be hermetically sealed. A rigid metal casing is usually used to prevent leakage and ensure a good electrical contact of the layers. In addition to the shape and size restrictions related to this technology there is also, particularly for smaller batteries, a weight disadvantage.

Lithium Polymer Batteries – Flexible Form Factor

Lithium polymer batteries consisting of foil layers contain active material, which is embedded in a polymer matrix. These foils are arranged like a 'sandwich'. The so-called bicell design consists of a central anode coated on both sides. This electrode is covered by separators, which ensure the separation from the outermost cathode (Figure 4). This configuration substantially increases the energy density of the battery. Experts at

the Fraunhofer Institut use a specially developed, robust separator, which is filled with ion conducting ceramic and therefore, increases the effect of the liquid electrolyte. The foils are laminated. Following this, the battery cell is packed in a multi-layer aluminum plastic foil, whereby the metal terminals for electrical contact to the collector are brought outside of the foil packaging (Figure 3). This is then filled with a liquid electrolyte, which is completely absorbed just like in a sponge. The electrolyte cannot leak out, even if the light weight, flexible housing is mechanically damaged. The collectors are metal wire mesh so that the electrolyte can distribute itself in the battery cell very quickly and evenly, also in large area batteries.



Figure 3 Set-up of lithium polymer battery with foil material

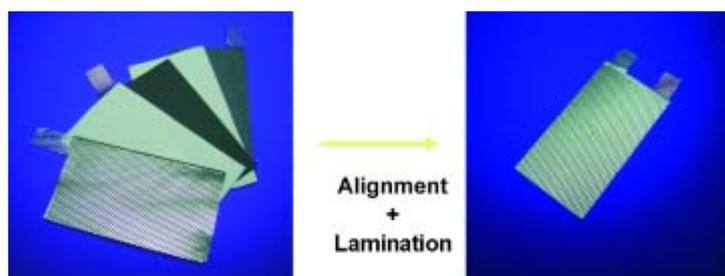


Figure 4 Electrode films and pre-processed collectors for the production of 'sandwich type' lithium polymer batteries

Due to the layered construction, lithium polymer batteries with completely flexible designs and in very large formats are possible. Additionally, the systems designed by ISIT are very robust. They are bendable up to a battery thickness of approximately 1.5 mm. This is an important feature for many new applications, for example in smart clothes.



Figure 5 Rechargeable lithium polymer battery for hearing aid

Batteries for Medical Applications

The Fraunhofer Institut ISIT currently offers two lithium polymer battery systems, which differ in the anode materials used. 3.7 V (nominal discharge voltage) optimized batteries with a high energy density of greater than 350 Wh/l and a high performance density use a graphite anode and cobalt oxide cathode. They are suited for applications requiring high energy content with a small size, e.g. hearing aids (Figure 5). When robustness and durability are the main criteria, the 2.3 V system with a lithium titanium anode is the preferred choice. The cycle stability of this system is better than 85 % / 4,000 cycles and the self-discharge is well below 5% per month. These rechargeable energy storage units have been designed for medical applications, such as implants, where a minimum lifespan of 10 years is required.

www.isit.fhg.de

Void Free Soldering with Vacuum

From laboratory level to mass production

Vacuum application in the soldering process reduces the void rate in the soldered joints considerably, typically to below 1%.

By Klaus Roemer, Sales Director, PINK GmbH Vakuumtechnik

Shrinking package sizes of electronic devices require a perfect thermal management thus, void free soldering. Voids reduce the electrical and thermal conductivity and cause hot spots. In addition, lead free solder escalates the formation of voids. The only reliable method available to remove voids from the liquid solder is the use of vacuum. The patented inline soldering system with vacuum – VADU – by PINK eliminates voids. Heating and cooling is based on contact heat transfer. The temperature gradients are adjustable by distance regulation between the heating plate and the substrate. A controlled application of vacuum at any time improves the heating process by possible reduction of spluttering. Vacuum applied in the liquid phase of the solder, removes voids to zero, respectively to below 1%. Any product, independent from its thermal mass, can be soldered void free, with temperature profiles according to customers specifications, or IPC / JEDEC recommendations.

History

The VADU was developed already in the mid 90's, based on a customer's request for an inline soldering system with vacuum. The task was void free soldering of large surface connections in the power module manufacturing. The VADU soldering process with vacuum is meanwhile well established through many years of serial production and is protected by worldwide patents.

Soldering process

Basically all usual solder materials such as solder paste or preforms can be handled and high temperature solder can be processed up to 400 °C. An efficient flux management system steadily removes all flux residues and protects the process chamber as well as the vacuum pump from contamination. Flux free soldering is possible by using forming gas or formic acid for activation. Combined processes, such as die attaché with solder paste and DBC to base plate soldering with preforms and formic acid for activation are also possible in one step.

Heat transfer and temperature gradients

The applied heating method by contact heat transfer and distance control is very efficient and flexible. The heating gradient is adjustable and is independent from the thermal mass of a product. Even heavy mass substrates (i.e. 1 kg) can be heated up and cooled down with the usual IPC / JEDEC gradients. This heating method by contact also allows an interruption of the heating profile and a "holding time" at any temperature range, to allow a soft escape of gas bubbles and to avoid critical "volcano effects". For example in case of hygroscopic solder paste, the moisture changes immediately to vapour and expands explosively at about 100°C. A second critical phase is at approx. 180°C, caused by other volatile properties of the solder paste.

Flexibility of all process parameters

All process parameters such as temperature gradients, vacuum profiles, applied process gases and process time in the individual chambers, are very flexible and can be set via program. A mixed production with smallest batch sizes and very different process profiles can be handled by using an identification system, such as barcode reading. It is therefore possible to handle a batch with lead free solder paste, followed by a batch with lead solder, followed by flux free soldering and vice versa. The best possible process conditions for every product can be developed and utilized with the result of reliable and reproducible void free soldering connections.



Figure 1:

Vacuum application

Vacuum is used in every process chamber for:

- Preparation of the chambers by removal of oxygen and purging with nitrogen in order to create an inert atmosphere. By this, the residual oxygen is reduced from 22% (ambient), to 3 or 5ppm, depending of the nitrogen quality used by a customer.
- Process improvements during preheating, for removal of out gassing.
- Void removal from the liquid solder

Heat flow and thermal stress for the assemblies

The heating plate of the VADU has a constant high temperature. Heating of the substrates is done by contact between the heating plate and the base plates of the substrates. The heat flow is therefore from the bottom side, the heavy mass part of the product. Only after these heavy mass parts have reached their wetting temperature, the heat is transferred to the substrates and components on top and the solder starts

melting. The total time, in which the sensitive parts, such as dies, are exposed to the high soldering temperatures, is therefore very short and overheating is excluded.

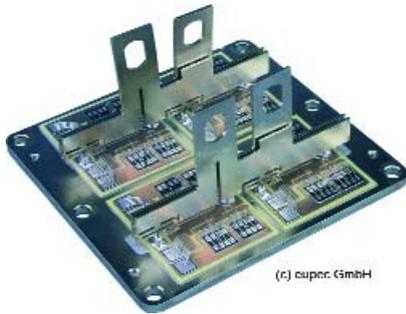
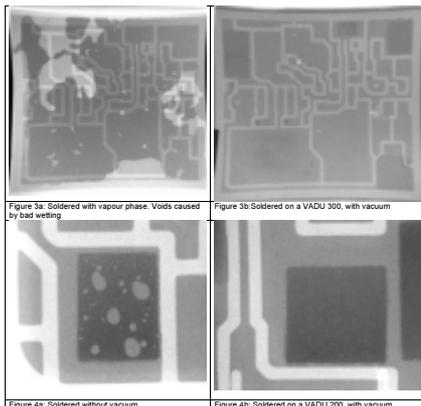


Figure 2 : Module Example from eupec

In case of conventional heating methods the entire assembly heats up simultaneously. This means that all parts involved are exposed to the high soldering temperatures during the entire heating process. The solder starts melting before the heavy mass base plates have reached wetting temperature. This causes areas of "bad wetting" and additional serious voids.

Traceability

The entire process takes place under controlled and reproducible conditions. The temperature profile and the process atmospheres as well as the vacuum profiles can be pre-set. The actual data can get permanently collected and recorded and can be assigned to an individual batch for traceability.



Figures 3a-4b : Possible quality improvements with the PINK VADU technology.

Customers benefits of the patented VADU- technology

- Void free soldering
- Inline operation (VADU 300 only)
- Temperature profiles in accordance with IPC / JEDEC
- Adjustable temperature gradients
- Separate process chambers for heating and cooling

www.bodospower.com

- Process temperatures up to 400°C
- Soldering with preforms or solder paste
- Flux free soldering possible
- Operation with formic acid or forming gas
- Consistent process control and traceability

Product range:

VADU technology is available in different sizes, for different throughput requirements, from the small, laboratory type VADU 100, to the VADU 200, for serial production, to the high speed VADU 300 for inline operation. All systems offer the same concept of technology and identical process performance. The only difference is the possible throughput. Soldering and vacuum processes developed on the small VADU 100 can directly be transferred to the high speed inline VADU 300XXL.



Picture 1: VADU 300
Standard inline system for serial production.
Loading and unloading of products either manual or automated.



Picture 2: VADU 100
For laboratories and small batch sizes.

The x - ray examples of typical products demonstrate the advantage of vacuum solder process technology.

www.pink.de

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Find the Right Competence for Your Team

The wrong candidate cost you more than his salary

htc-network specializes in the identification and qualification of senior managers as well as specialists in the high-tech industry.

By Klaus Nolte, htc-network, Munich

Professional recruitment consulting is based on an intense assessment combined with high transparency to all sites: candidates and customers.

The problematic nature of recruitment <source DDI>:

- Four out of five companies have problems in identifying and retaining suitably qualified specialists and management.
- Approximately 50 percent of all executives fail within the first 2 years of starting a new job.
- Less than half of all high-tech companies have a clearly defined process to identify and develop talents.

The standard response to this challenge:

Recruiting service starts with the definition of customers needs, followed by the identification, the qualification process and finally the selection process in cooperation with candidates and clients. This brings us to the first question of any search:

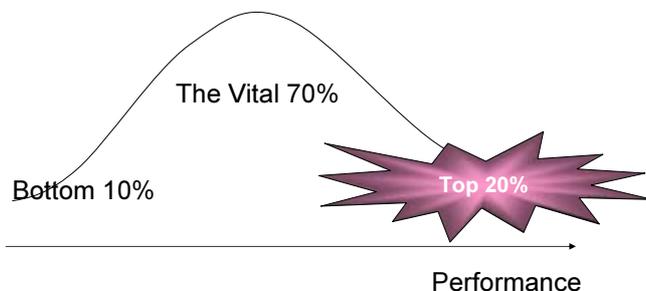


Figure 1: Performance distribution

Who are the right candidates?

It is not a question of finding the best person for the job, but the right one – someone who is the perfect fit for the company, and its culture. This is why the quality of the identification and assessment process is so important in the search to fill an executive or specialist position.

The first step: Ensure the recruiter fully understands the profile of the candidate, the client really needs. Sometimes the search profile is radically different from the original brief – we work with our clients to insure, that we get this right upfront.

The profile of each open position should include personality, job specific experience and management competence defined in close cooperation with the client.

How do we find the right candidates?

Managers and specialists are usually identified via Career Networks

(Monster, Stepstone,.....) Open Networks (openBC, LinkedIn,.....) and preferable an established network of the recruiter or the "Direct Search". Professional consulting will focus on individual consultation, rather than simply screening a range of candidates who might be the right match and supply CV's of those, who are currently available.

The search should not only address candidates with the best fit for the job but more important those, who have the right chemistry to work successfully with their peers and managers, and to fit in with the company culture. htc-network is able to offer this value-add since our team is led by executives, who have enjoyed successful careers in the high-tech industry, and can therefore draw on their own experience in helping to assess companies needs, and the suitability of potential candidates for new openings.

Qualification of the right candidates

An intensive qualification process consists of structured and non-structured interviews covering each candidate's background and personality, their professional career and aspirations, their management potential – including job-specific competency tests – and a candidate presentation.

However, even the most thorough assessment by a third-party recruiter is no match for the subjective appraisal by the person, who will become the new employee's direct supervisor. To address this need, htc-network has developed the unique Candidate Video-CD. This CD enables all people, who are involved in the decision-making process, to make an individual assessment of candidates suitability for the position. Since our candidates are presented on a Video-CD, each decision-maker can review individual candidates suitability at a time convenient to them, without having to schedule a full day of qualification interviews. No other recruitment consultancy offers this transparency.

Of course the candidate will also receive his own personal Candidate Video-CD after the interviews. This will give him an excellent opportunity to review his performance during htc's assessment and learn from it.

Documentation:

Each Candidate Video-CD contains Video files of all interviews (complete – not modified or cut) :

1. Interview focused on the candidates CV and biography
2. Interview examining the individuals experience and competence for the role, including job specific tests
3. The candidate presentation.

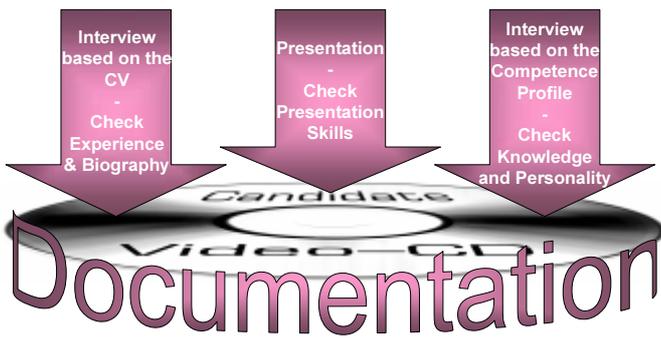


Figure 2: The 3 major elements of a qualification/assessment process

Our Candidate Video-CD provides htc-network clients with decisive advantages, especially as it allows hiring managers to examine how candidates present themselves. Our interview process, with questions asked by an experienced consultant from within the industry, is more intensive than a round of face-to-face interviews. Our Video-CD ensures that all participants in the decision-making process can see how candidates perform in the same interview situation, which is much more objective than individual, subjective interviews. The interviewer will avoid potential observation mistakes like:

- First impression
- Selective observation
- Prejudice
- Projection
- Contrast effects
-

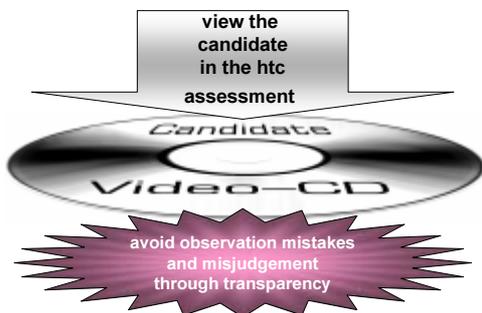


Figure 3: View the candidate in the htc-assessment

Video files are compatible with all Windows PCs and do not require the installation of any additional software. Video clips also give interviewers the chance to study candidates more intensively, as individual sections can be replayed – something that is simply not possible in an individual interview, but is of great benefit, because even the most experienced interviewer can sometimes miss a clue during a face-to-face interview.

Questions and answers on the htc-network consulting process:

- Why should a manager take the effort to preview his candidate 2 hours on the CD ?
 - o We recommend to have a quick check, based on time points we set during the interview. In case the candidate is a fit for of the hiring manager, than 2 hours are little investment to find the right candidate. Always have in mind the alternative, the wrong candidate cost you more than just his salary, may be:
 - a significant part of your revenue
 - your organization
 - your career
 - may be even your job

- 2 hours – no one has so much time!
 - o Traveling; breaks on airports, railway stations,...lots of opportunities to review the candidate on a notebook, PDA or any other mobile terminal!
- Does anyone use this tool?
 - o First reaction of customers are probably critical on the benefit of our tool. As soon they start working with it and see the results, they won't miss it anymore!
- This seems to be an expensive tool, especially for small companies?
 - o Having a camera running during the interview isn't any investment, neither in time nor financial!
 - o Producing the Video CD is inexpensive!
 - o Reviewing the CD is a time investment, but think about the return, especially taken into consideration above mentioned risks, when hiring the wrong candidate!
- Even htc's method won't detect all secrets of the candidate!
 - o True, but even candidates respond to us very often like: "I have never seen myself like this, the videos of my htc-interviews helped me a lot in self assessment & improvement!"
- How do candidates respond on htc's method?
 - o Candidates like the process, because they learn a lot about themselves in a professional assessment process. Also they like the transparency of our process to all parties involved.
- Why does htc-network believe in this process?
 - o Our process is a significant investment into the future of our candidates and customers. Their satisfaction is our capital.
 - o The pre screening of candidates will become more efficient and the candidates will be a better match – not only with their professional skills but also with their soft skills!

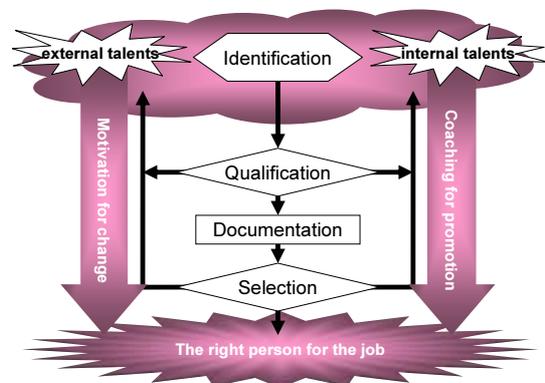


Figure 4: Search – alternatives

Summary:

The retention rates for candidates placed by htc-network are well above industry averages. This ensures that our clients do not need to go through the expensive and time-consuming cycles of recruiting fresh candidates – and avoid the business disruption caused by vacancies in critical positions. After two years, more than 95 percent of specialists and management placed by us remain with the company, and many have been promoted internally.

Our process is suitable for the identification and qualification of external as well as internal talents. The motivation to move talents to a new employer or the coaching of internal talents for promotion within their company are the most challenging and exciting tasks for any professional recruitment consulting company!

A 20-Cent PoE Interface for VoIP Telephony

Meet the requirements of IEEE 802.3af

PoE enabled hubs, routers and switches are becoming standard equipment. Consequently, many OEMs are designing their wireless access points, VoIP telephones and closed-circuit security cameras to be powered from the communications network

By Andrew Smith, Power Integrations

A leading provider of network management solutions was looking to simplify the power conversion stage for its next-generation Voice over Internet Protocol (VoIP) products. Power Integrations (PI) developed a discrete Power over Ethernet (PoE) interface circuit for the phone, enabling the OEM to meet its design and cost objectives.

PoE enabled hubs, routers and switches are becoming standard equipment. Consequently, many OEMs are designing their wireless access points, VoIP telephones and closed-circuit security cameras to be powered from the CAT-5 cable that connects them to a communications network.

The DC-DC power conversion stage of powered devices (PDs) must communicate its power requirements to the power sending equipment (PSE) so that the PSE can energize the cable (see Figure 1). The converter

must step down and regulate the cable voltage and be able to accommodate the considerable line voltage drop (especially at higher power loads) associated with CAT-5 Ethernet power transmission. This raises several design issues.

A Simple, Cost-effective, Reliable PD Power Solution

After considering their client's BOM cost target for an interface and power conversion stage to support Class 2 and 3 PDs, PI based the DC-DC converter design on a member of its DPA-Switch family of highly integrated power conversion ICs – resulting in a highly reliable solution. The simplified design process afforded by the use of DPA-Switch and the cost reduction realized by using the discrete interface circuit enabled the OEM to meet their objective without sacrificing functionality, reliability or robustness. The resulting parts count reduction helped to keep the overall solution cost down while

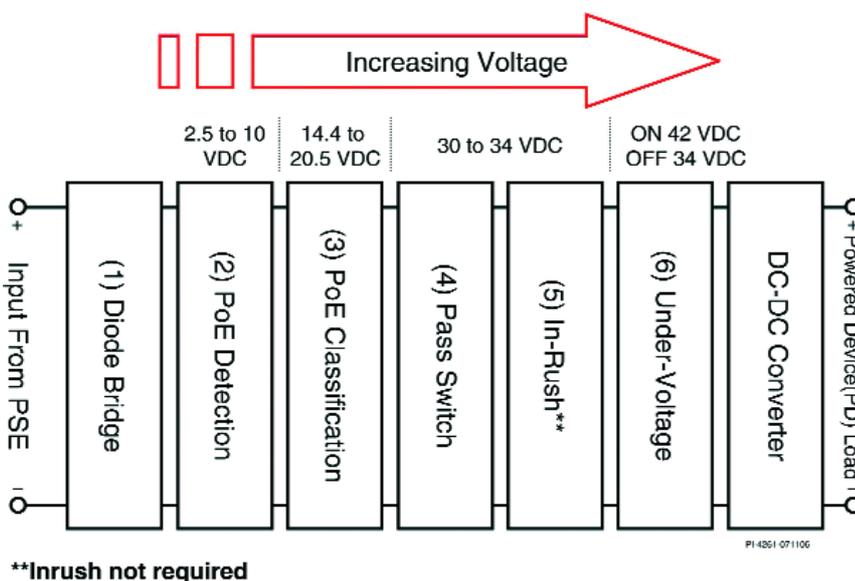
improving the mean time between failure (MTBF) rating and the reliability of the DC-DC converter stage.

A Flexible 20-cent Solution

It takes only a few, discrete components to implement a PD/PSE interface that meets the requirements of IEEE 802.3af, and the following 20-cent solution is also flexible, enabling the PD to classify itself as a Class 0, 1, 2 or 3, with the change of a single resistor value.

The DPA-Switch family of ICs combines a high-frequency power MOSFET, a PWM controller and numerous protection functions fabricated on a single CMOS chip. This simplifies the design process while reducing the component count of the DC-DC converter stage. DPA-Switch family members feature MOSFETs of varying sizes, so the output power can be scaled by changing the IC used.

For the VoIP application under consideration, PI chose to design the DC-DC converter stage around its DPA423P device. Since the VoIP phone only required a single 3.3V output and a maximum of 2A, the converter was designed as a flyback (see Figure 2), to minimize cost. Initially, VR31 and VR32 inhibit the Classification and PWM circuits until the signature phase has been successfully completed. Following Signature identification, the voltage delivered to the PD rises until Zener diode VR31 begins to conduct. A constant current source then turns on to provide the Classification current signal that is read by the PSE. Class is determined by the value of resistor R34. Once Classification has been successfully determined, voltage again ramps turning on Q35 via VR32 and the power converter stage begins operating. The constant current classification circuit is disabled via R35 to reduce power consumption.



**Inrush not required

Figure 1: Communicate its power requirements

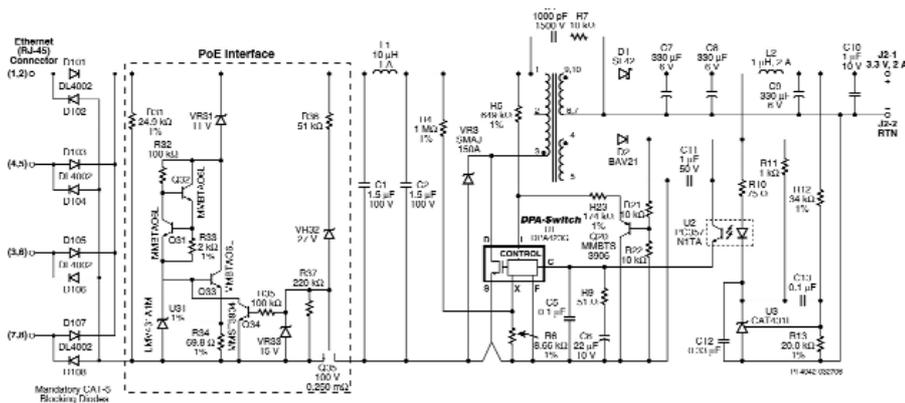


Figure 2: The converter was designed as a flyback

The input bulk capacitance (C1 and C2) is split in two to form a simple pi (δ) filter, to attenuate differential mode conducted EMI. Resistors R4 and R6 lower the internal current limit of the MOSFET and make the maximum duty cycle scale with input voltage, for true maximum (output) power limiting. This approach simplified the design of the converter and meant that a lower voltage and current (30 V, 4 A) Schottky diode could be used for the output rectifier. Resistor R5 activates U1's input under-voltage lockout (UVLO) and overvoltage shutdown functions,

while R21, R22, R23 and Q20 extend the hysteresis of the UVLO function to accommodate the large line voltage sag encountered with IEEE802.3af Ethernet power applications.

The DPA-Switch auto-restart function limits the supply's output power to about 4% of full load—whenever the output voltage goes out of regulation—instead of depending upon the loss of the VDD supply to the IC. This provides robust protection for both the supply and the load.

Conclusion

To be truly universal, PoE PD solutions must meet the requirements of IEEE 802.3af. PI's simple PD design has been verified by the University of New Hampshire Interoperability Consortium (UNH-IOC) – an authority on IEEE 802.3af – and tests show that the design not only meets the requirements for IEEE 802.3af, but also operates correctly with all available PSE. Copies of the UNH-IOC test reports and a list of the PSE that were shown to work with the PI solution can be found at www.powerint.com/PoE.

This solution not only met the customer's requirements for a simple, reliable, robust, approved and cost-effective circuit, but the versatility and scalability of the DPA-Switch family has allowed the customer to quickly and easily adapt this solution for use in other PD applications.

www.powerint.com

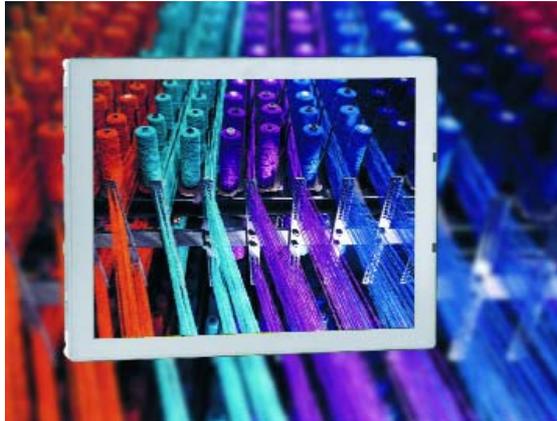
automotiv.tlmatics.sensors.infotainment.safety.

7.5 inch Strong2 LCD

With the new 7.5 inch LCD Sharp is introducing a particularly light-intensive and temperature-resistant display for portable industry applications, thus extending its heavy-duty display series

Sharp Microelectronics Europe is adding the 7.5 inch TFT LCD LQ075V3DG01 - a new and robust medium-format display - to its Strong2 product series. The LCD is characterised by high image quality, an extended temperature range and low power consumption. These modules are therefore particularly designed for mobile applications in the industrial sector and are used, for example, as a portable measuring device or medical handheld.

The Strong2 LCD offers excellent clarity even in poor ambient light - a particularly important benefit for mobile use. With a display



luminance of 400 cd/m², 260,000 colours and a contrast ratio of 600:1, the LCD also satisfies the highest requirements for outdoor use. Sharp achieves the high contrast ratio with the Strong2 LCDs thanks to an optimum pathway of the pixels' voltage potential when the appliance is switched on.

The display is also designed for lower power consumption.

The Strong2 modules are considerably more resistant to changes in temperature and are more shock-resistant than conventional displays. Both in operating and off mode the panels are able to withstand temperatures of -30 to +80° C thanks to improved polarisers and RGB filters. This is particularly relevant for outdoor use and also in industrial applications in which the displays are exposed to strong fluctuations in temperature due to process and waste heat. The display is also less sensitive to shocks. For new

materials and a new design of the housing of the LC display ensure that jolts and vibrations can be specifically absorbed.

www.sharpsme.com

New PCB Connectors

ABB Entrelec presents its new product range, composed of very popular PCB terminal blocks and connectors. Iml connectors and terminal blocks mounted on printed circuit boards ensure the link between the sensors and the instruments on the machinery and equipment.

RoHS* compliance and economical performances is given fact.

In the universe of PCB connection, ABB Entrelec offers Standard Range products which are competitive in the market, compatible with the international standards and which respect the environment. The Standard Range has been developed to

answer all these needs, complementing the existing ranges of expert, adapted and customized products. Basic applications on PCB where standard products can be integrated without any constraint are served.

PCB blocks : Screw cage, spacing 3.5, 3.81, 5.08 mm in 2 and 3 poles with dovetails.

Screw cage with tap, spacing 5 mm in 2 or 3 poles with dovetails.

PCB connectors : Screw female plug in spacing 5.08 mm from 2 to 12 poles.

Male socket in spacing 5.08 mm from 2 to 12 poles, horizontal or vertical, with open or closed sides.

Electronica Hall B4. booth 351



www.abb.com/lowvoltage

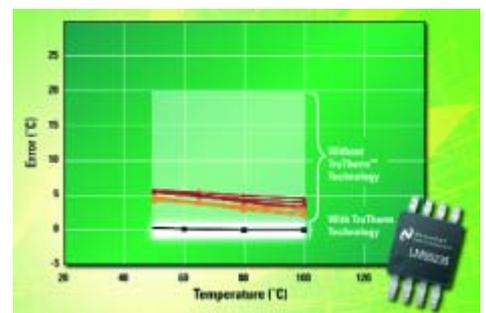
Precision Temperature Sensors

TruTherm Technology with Transistor-Mode Beta Compensation Provides Pinpoint-Accurate Temperature Readings for Microprocessors Developed on 65 nm, 90 nm Processes

National Semiconductor introduced a family of high-precision, remote-diode temperature sensors that employ National's TruTherm™ thermal management technology with transistor-mode beta compensation. These new sensors are specifically designed for applications such as notebook and desktop computers and servers that are powered by high-performance microprocessors manufactured on 65 and 90 nm processes. National pioneered beta compensation tech-

nology and was the first to bring it to market, with the introduction of TruTherm technology in the spring of 2005.

TruTherm technology solves the problem of inaccurate remote temperature readings caused by variations in the internal diodes in deep sub-micron microprocessors, microcontrollers, application-specific integrated circuits (ASICs) and field-programmable gate arrays (FPGAs). Inaccurate remote temperature readings can lead to higher acoustic noise and reduced system performance. National's TruTherm thermal management products improve the accuracy of temperature readings, allowing



designers to achieve higher performance and efficiency in their applications, while lowering cooling-fan speed, reducing acoustic noise and extending system life.

www.national.com

Boost converter with Dynamic Voltage Programming

Whilst operating, lighting and display functions in portable products can consume a significant portion of a Lithium-ion battery's available power. Finding ways to optimise power dissipation and maintain display quality brings real value to the customer's application. AnalogicTech's AAT1232 boost converter is tailor-made for these cost-sensitive applications by combining output voltage programming with high output current drive

in space-efficient packaging. Rated at 24V at 100mA, the AAT1232 is the latest addition to AnalogicTech's rapidly growing family of boost converters targeted primarily at cost-sensitive OLED, LCD, and CCD applications. The device offers substantial output drive capability in an extremely compact footprint. Operating at a switching frequency up to 2MHz, the AAT1232 reduces PCB footprint by using small-value external inductors and

capacitors. For example, the device operates with 2.2µH inductors that are approximately ten times smaller than many competitive boost converters require. Small TSOP and TDFN packages and fewer external components also help reduce system cost.

Electronica Hall B5. booth 36

www.analogictech.com

12 Bit Digital Output Magnetic Flux Sensor

IXYS Corporation announced that its Clare Micronix division has developed a new 12 Bit Digital Output Magnetic Flux Sensor, the MX868. The sensor is a complete sampled data subsystem that includes a unique adjustable digital filter that significantly improves signal to noise performance while also reducing signal bandwidth. The MX868 is powered from a 4.5 to 5.5 volt supply and converts a magnetic flux intensity of +/- 500 Gauss full scale into a 12-bit digital

output word. It operates as a slave on a standard serial interface bus and is compatible with daisy chain expansion in a multiple device serial bus configuration. The MX868 can be mounted onto a PCB or incorporated into a magnetic assembly and then calibrated in-system through the serial interface. This integrated circuit is designed to sense the magnetic field generated in power systems as a result of electrical current, as well as in motor control applications. Designers

can use this IC for sensing of electrical current, and thus sense power level, with digital signal output to facilitate digital power control.

www.claremicronix.com

www.ixys.com



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Transponder Coils for Automotive

With its newly developed transponder series, Epcos has expanded its broad range of inductors with a series of high-performance

and robust products. In addition to their outstanding electrical properties, these components are distinguished by their high



mechanical strength, making them ideal for demanding applications such as immobilizers and tire pressure monitoring systems (TPMS). For the immobilizer, the coils are incorporated in the car key and in the TPMS, they are directly in the wheel, where they are exposed to high mechanical and dynamic stresses.

This extrusion-coated series designated

B82450A* was developed in close cooperation with the automotive industry and has significant stability advantages over competitor products. Their automated and flexible, manufacture also allows a rapid response to customer-specific demands. Apart from these two applications in automotive electronics, the coils are suited for other application areas that also require high mechanical ruggedness.

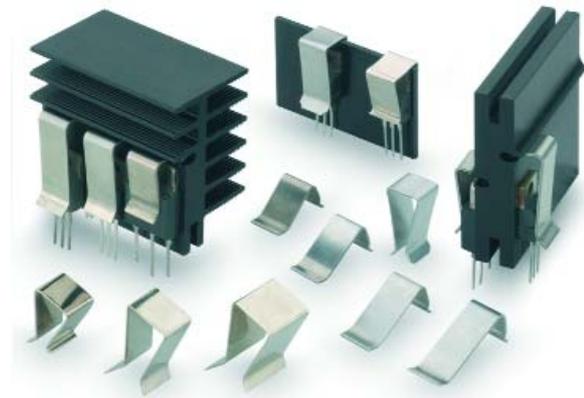
The transponder coils are designed for a frequency of 125 kHz and can be operated in the temperature range from -40 to +125 °C. They are RoHS-compatible, suitable for lead-free reflow soldering to JEDEC J-STD-020C and can be processed with automatic SMD placement systems.

www.epcos.com/transponder

Springs for Transistors

Rapid and easy installation of semiconductor components, e.g. transistors on heatsinks,

considerably reduces the assembly costs. For their existing range of heatsinks with



special integral groove geometry, Fischer Elektronik have developed further suitable retaining springs. For fitting transistor assemblies to the heatsink, these springs are fastened in the groove, together with the component, simply by locking-in.

These new lock-in retaining springs for transistors permit the safe fastening of almost all types and sizes of current housings TO220,

TO218, TO247 etc., various SIP, Multiwatt and MAX types without holes on the heatsink in a simple and secure manner and with optimum heat transfer characteristics. Another novelty is spring clips, which are not screw-fastened but clipped onto a plate, onto a wall of the housing or onto the PCB, which keep the transistor safely in place.

The range of both versions of retaining springs and the appropriate types of heatsinks is being continuously extended. We will be pleased to advise you on customized versions.

www.fischerelektronik.de

High-Voltage ICs simplify HID Ballast

International Rectifier has launched the IRS2453D family of integrated 600V self-oscillating full-bridge driver ICs for HID ballast applications including general lighting, outdoor street lighting and projectors.

The new ICs utilize IR's proprietary high-voltage integrated circuit (HVIC) technology, integrating two high-side and two low-side gate drivers. This process allows improvements in device capabilities, tighter specifications, temperature stability and the integration of previously unavailable features. The IRS2453D features a simple RC network to program the oscillator, eliminating the need to synchronize two half-bridge drivers. In contrast, solutions using 2 SO-8 driver ICs require a separate oscillator to drive

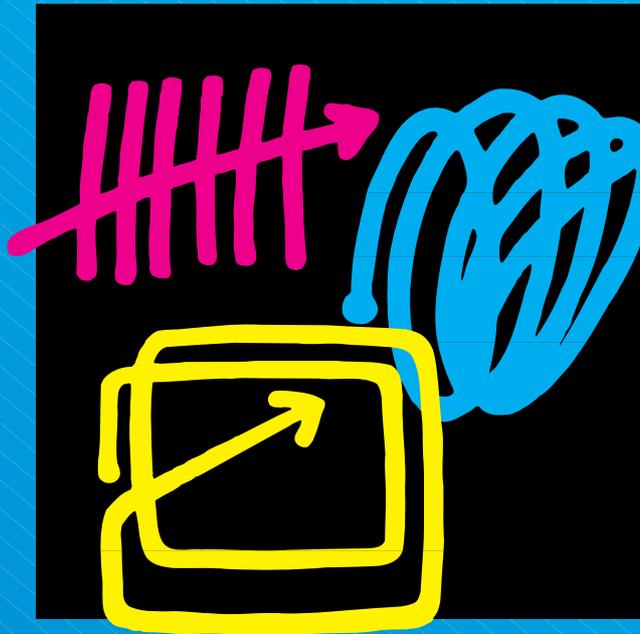
each half-bridge, resulting in unsymmetrical voltages across the load due to mismatching of the on-time states caused by tolerances and temperature. In lighting applications, this can cause mercury migration shortening lamp life. The IRS2453D overcomes this problem by driving both half-bridge drivers with a single oscillator to guarantee accurate matching over the complete temperature and supply voltage range.

Greatly simplifying overall design, the IRS2453D integrates both a latched and non-latched shutdown input, and eliminates up to seven components. The latched shutdown allows for implementation of various protection features such as cycle-by-cycle



over-current, open-load or short-circuit detection without additional components, while the non-latched shutdown allows for easy interface to a microcontroller for use in a wider variety of power management applications.

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www.mesago.com/sps



Flexible PWM Controller

Texas Instruments introduced a highly flexible, power management integrated circuit (IC) that turns power supplies in data centers and telecommunications equipment into fully scalable, stackable power systems with greater load-handling capability and maxi-

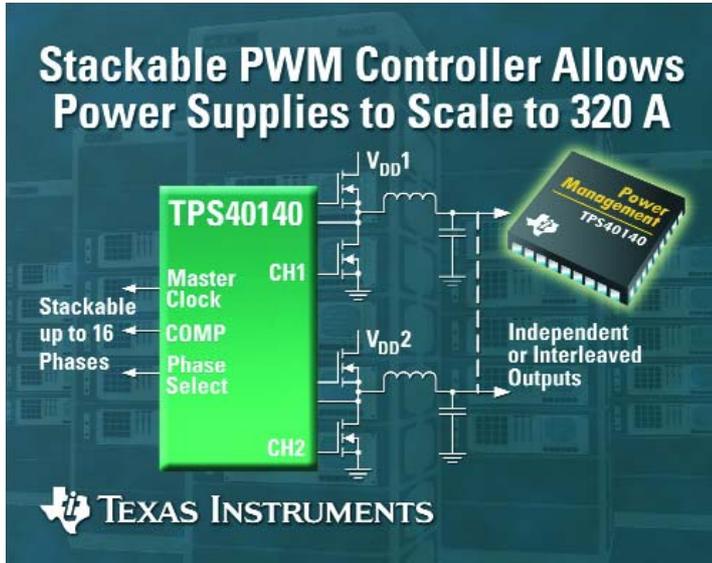
imum efficiency. See: www.ti.com/tps40140-pr.

TI's TPS40140 synchronous, pulse-width modulation (PWM) controller operates as a stand-alone device that generates two outputs, or as a two-channel, multi-phase con-

greater power efficiency with today's power stage components.

"Power supply designers for high-performance data center and 3G base station applications face challenging requirements for higher power density, scalability, and high-efficiency operation," said Stephen Anderson, vice president of TI's system power management business. "TI's new stackable controllers will enable customers to meet those demands in an easy-to-use, modular approach."

In applications such as high-density telecom and wireless systems, the TPS40140 significantly increases load-handling capability and simplifies power system design. For 3G base stations driven by 1-GHz digital signal processors (DSPs) like TI's new TMS320TCI6482, the TPS40140 offers greater energy performance, low noise and low power. For data center servers, the controller gives designers the opportunity to more easily develop a complete multi-phase power system with high efficiency operation.



troller. Using the device's advanced capabilities, designers are now able to "stack" multiple devices together to create a high-density power supply that can generate up to 320 A of output current and support up to 16 phases. In addition, the system can maintain

www.ti.com

Temperature Sensors up to 650 °C

KOA offers a range of commercial, precision and high temperature thermal sensors.

Surface mount, wire bond, leaded and custom style packages are available.

Technologies comprise of thick and thin film as well as platinum. The focus of the product portfolio is on linear PTC's and Platinum sensors. Many of KOA's temperature sensors feature small size and weight, and thus offer a fast response to temperature changes. The products exhibit excellent mechanical stability and are available in a wide resistance and B-constant range. The thin film platinum sensors offer precise ther-

mal sensing solutions in a broad temperature range up to +650 °C. Application exam-



ples include virtually all circuits that require a temperature compensation or temperature measurement of some

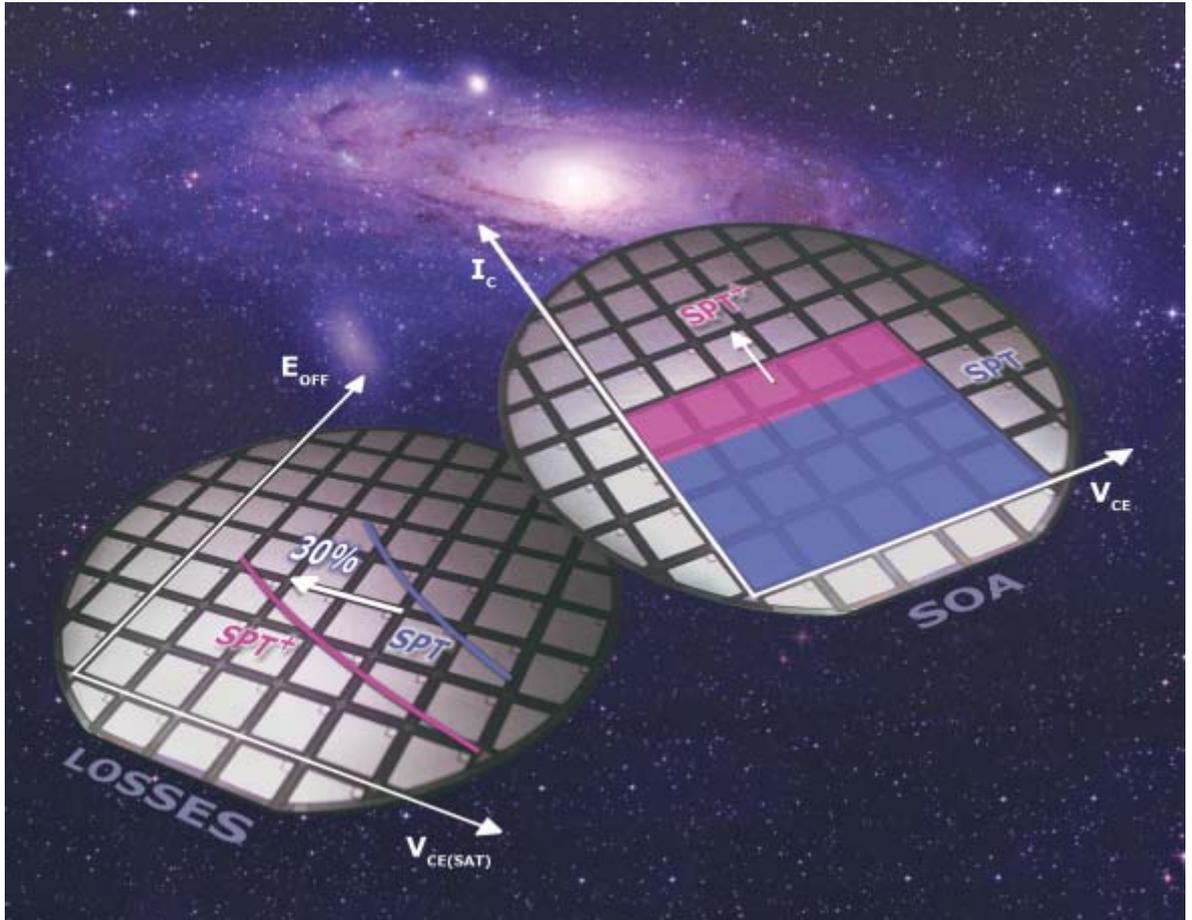
kind. Typical applications would be hall sensors, electronic scales, optical data transmission, motor control, instrumentation, cold junction temperature compensation, mass air flow sensors, ECU, LED headlight, oil temperature sensor, battery monitoring, and various other circuits.

www.koaeurope.de

ADVERTISING INDEX

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The final frontier...



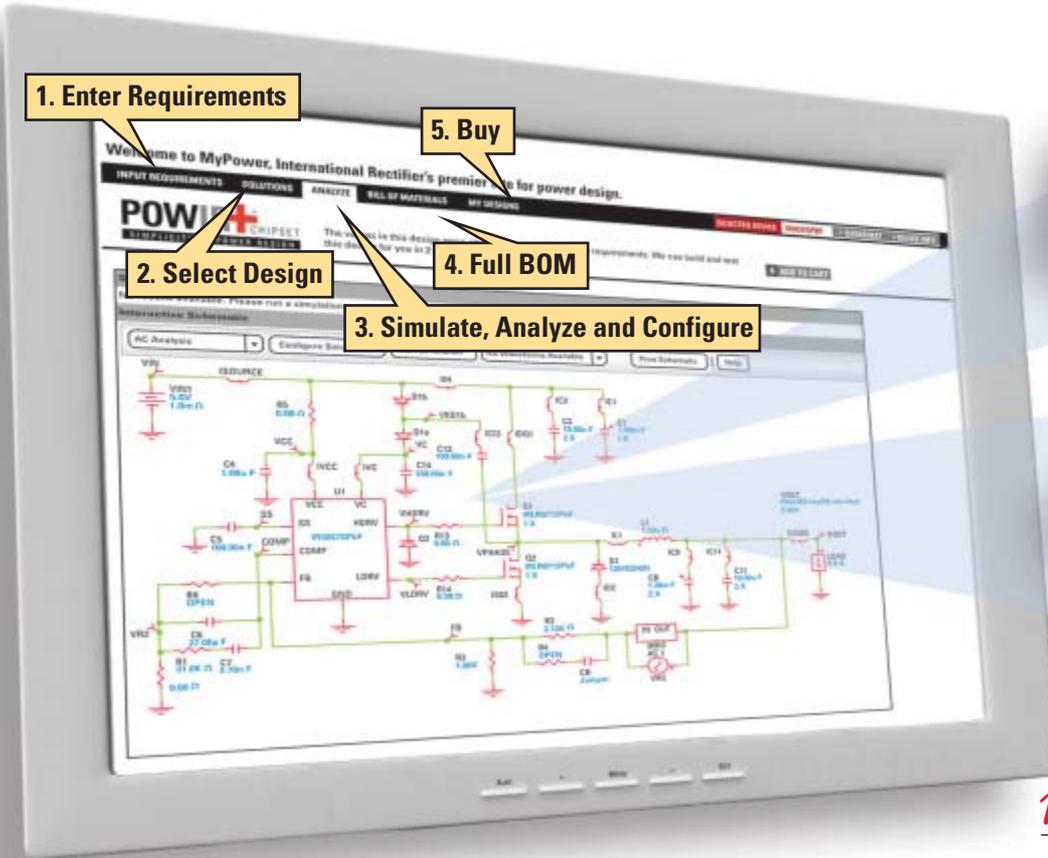
... low loss **and** high SOA

You can have it all with **SPT+ IGBTs** from ABB.

Simply Light-Years ahead!

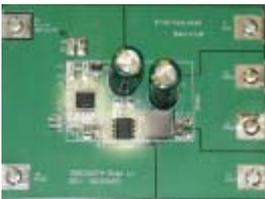
DESIGN IT YOUR WAY... 6A,12A,18A, YOU CHOOSE

myPOWER™ Delivers Optimized Performance, On-line Hardware Customization and Simulation



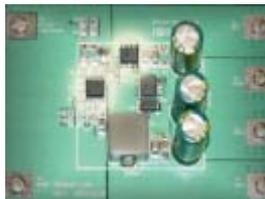
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online design

IRPP3637-06A



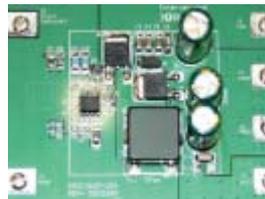
5V_{in} / 1.25V_{out}
@ 6A & 600kHz ~1.0in²

IRPP3637-12A



12V_{in} / 1.8V_{out}
@ 12A & 400kHz ~1.5in²

IRPP3637-18A



12V_{in} / 3.3V_{out}
@ 18A & 400kHz~2.0in²

International Rectifier's new expanded myPOWER™ online design tool now includes chipsets that offer dependable reference designs and enhanced on-line design service. The first chipsets are based on IR's IR3637S and IR3637AS controllers, targeted at single-phase synchronous buck converter applications.

IR3637 IC Features

- 1% accurate, 0.8 V reference
- Internal 400 kHz/600 kHz oscillator
- Soft-start function
- Short circuit protection

Part Number	Input Voltage	Output Voltage	Output Current	Switching Frequency	Power Semi BOM	Delivery Time	Comments
IRPP3637-06A	5V	1.25V	6A	600kHz	IR3637AS, IRF8910	24-48Hrs	Standard Ref Design Fixed BOM
IRPP3637-12A	12V	1.8V	12A	400kHz	IR3637S, IRF7823, IRF7832Z		
IRPP3637-18A	12V	3.3V	18A	400kHz	IR3637S, IRLR8713, IRLR7843		
IRPP3637-06AC	3.0V to 13.2V	0.8V to 5.0V	Up to 6A	400kHz or 600kHz	Various	1-2 Wks	Customizable Ref Design BOM configurable on-line. Operating range defined is NOT possible with one BOM
IRPP3637-12AC			Up to 12A		Various		
IRPP3637-18AC			Up to 18A		Various		

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