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Bodo´s Power Systems

Systems Design Motion and Conversion

February 2007

Miniaturization of Current Measurement

IGBT Module Concept

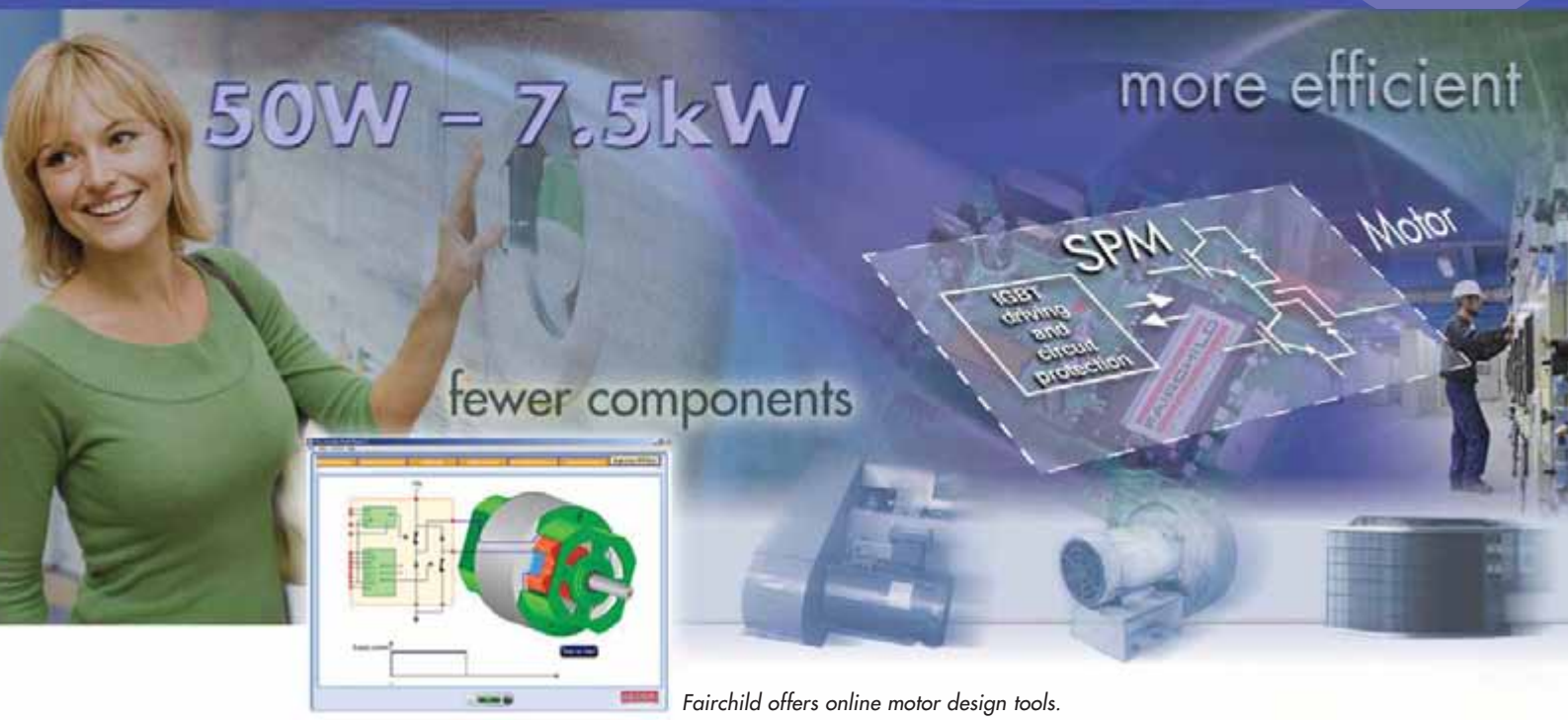
Low-Loss IGBTs f

Non Isolated SMPS

Liquid Cooling

FAIRCHILD
SEMICONDUCTOR®

Energy-saving inverter designs: 50% less cost, size and time.



Fairchild offers online motor design tools.

Integrated power modules simplify your designs

Smart Power Modules (SPM™) are just what you need to dramatically improve the performance/cost ratio of variable speed designs. Available for motor ratings from 50W to 7.5kW, every SPM includes:

- An integrated drive and protection solution built with our leading power components
- Fairchild's combined power and motion design expertise
- Best-in-class packaging technology that reduces board space while providing excellent thermal performance

SPM Series	Motor Ratings	Description
Motion-SPM	50W to 7.5kW	3-phase IGBT or MOSFET inverter
SRM-SPM	2kW	Single-phase asymmetric bridge
PFC-SPM	1kW to 3kW	Partial switching converter module
	3kW to 6kW	Power Factor Correction (PFC) module

Our SPM series includes solutions for consumer and industrial inverter designs, as well as options for switched reluctance and PFC.

If you prefer to build your own drive with discrete components, all the building blocks inside our SPM, including IGBTs, HVICs and MOSFETs are also available for your motion power path.

If energy and cost savings are your problem, Fairchild has your solution.

For more motor design information, including online design tools and application notes, visit www.fairchildsemi.com/motor.

problem **solved**

www.fairchildsemi.com

the power franchise™

Bodo´s Power Systems

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Events

2007 Motor & Drive Systems, Feb. 7-8, Dallas, TX, www.e-driveonline.com

APEC 2007, Feb. 25-March 1, Anaheim CA, www.apec-conf.com

EMV 2007, March 6-8, Stuttgart, www.e-emv.com

ELECTRONICA China 2007, March 21-23, Shanghai, www.global-electronics.net

PCIM China 2007, March 21-23, Shanghai, www.pcimchina.com

TI Power Supply Seminars Q2, www.ti.com/europe/power07-b

SMT, Hybrid, April 24-26, Nuremberg, www.mesago.de

PCIM Europe, May 22.24, Nuremberg, www.pcim.de

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

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

Green Power

Little animals can move big stuff - as you see on the cover. Tiny ants carry a heavy load and the greenery they bring home is renewed. Another tiny and powerful solution to help the environment is the LEM "Minisense" transducer – it helps conserve resources by sensing current and enabling efficiency in handling energy. This solution is a monolithic ASIC design, which helps to integrate the transducer on a printed circuit board. So the tiny Minisence carries the big washing machine to higher efficiency - another important step to environmental progress in the world.

Last month I said that renewable energy, like solar and wind power, will help develop a clean future. The P in Bodo's Power Systems became green during Christmas and New Year. I am encouraged by industry and reader interest in green Power subjects – like the one you see on the cover. My magazine is now committed to give full attention to all aspects of better environmental solutions, not just to solar and wind power activities worldwide. Technologies that enhance efficiency and reduce losses are a key focus. These areas will develop our future - important as we take a look into events in 2007.

To have information and trends ahead of time unlocks secrets that help to develop a good future. Delivering my printed magazine each month, in the first week, for twelve months of the year, is an important fact that my readers can count on. Publishing, for me, is delivering the printed magazine on time.

To deliver crucial information, as soon as the information has become valid, is a key goal for 2007. My tool is the e-News letter, which delivers real news as soon as it can be distributed.
Make sure to have editor@bodospower.com on your white list to receive the letter.

In addition to the e-News letter, my web site has news and events updated on a regular basis.

Interviewing industry leaders on a VIP level provides competent technical insight from leading edge providers – background that may show the right steps that make the little, but important, difference. Having spent a quarter of a century in design and applications helps me to ask the questions that develop our future

There are more good things coming during 2007. Structured sub pages will give market segments so that engineers can select articles they need to know on demand. And my web will have cross-links to support important conferences and shows worldwide. As a trend setting publication in Power, I am looking forward rather than reporting the past. But we need also to understand the basics of electronics and they are way back in the past. If possible, a link or hint will be given to look for basics in understanding our power world. Insight from the past should result in better designs for a green future.

Looking forward to seeing you during 2007, having the chance to chat, and your opinions.

Best Regards

To help your innovation we make ourselves small.

Minisens, FHS Current transducer

Minisens is taking miniaturization to the next level as it is a fully fledged current transducer for isolated current measurement including magnetic concentrators in an IC SO8 size. This allows you to include all the functionalities you are looking for into the space that you have available.

- Non-contact current measurement with no insertion loss
- Isolation provider
- Attractive price
- Flexible design allows a wide range of current measurement from 2-70 A_{RMS}
- +5V power supply
- Access to voltage reference
- Ratiometric or fixed gain and offset
- Standby mode pin
- Dedicated additional fast output for short circuit detection
- High performance gain and offset thermal drifts

www.lem.com

At the heart of power electronics.

LEM®

Extended Contract for Eastern Europe

Tyco Electronics Power Systems extended the co-operation with PetroInTrade as its authorised Eastern European distributor for the whole product range. The contract was finalized at the Electronica fair in Munich, where the last details were discussed between Yuri Schumilin (President & CEO), Natalia Ilyina (Marketing Director) both from PetroInTrade as well as Rainer Sendrowski (VP Power Systems), Eckart Seitter (Director Sales Electronic Modules) and Uwe Scheumann (Manager Distribution Sales EMEA) from the Tyco Electronics side.

PetroInTrade will now market and distribute Tyco Electronics Power Systems' broad range of innovative Power Conversion Products, high quality industrial Power Modules as well as state-of-the-art GPS Receivers across Eastern Europe. With this contract not only the product range has been extended for PetroInTrade, there will also be

a closer collaboration regarding combined advertising campaigns and enhanced product introductions for the East-European area.

"The expanded appointment of PetroInTrade as an authorised distributor with our complete product portfolio will strengthen Tyco Electronics' position in the East-European market even further," commented Rainer Sendrowski, Vice President of Power Systems EMEA at Tyco Electronics. "With a strong knowledge of their market area as well as high competencies in Power and Wireless, PetroInTrade is one of the leading distributors in the East-European market and will enhance Tyco Electronics' penetration of this market."

"We're very pleased that we were able to expand our co-operation with Tyco Electronics Power Systems. Tyco Electronics has developed a significant global reputation as a manufacturer of advanced, high quality products and allows us to offer an extensive range of state-of-the-art power and wireless products throughout East-Europe," said Yuri Schumilin, President & CEO at PetroInTrade. "We expect our existing strength in the region, plus the technical and market knowledge of our team, will create a long and successful partnership."

The Persons on the picture from left to right: Eckart Seitter, Rainer Sendrowski, Yuri Schumilin, Natalia Ilyina und Uwe Scheumann.

www.tycoelectronics.com

TTI announces acquisition by Berkshire Hathaway

Paul Andrews to remain Chairman and CEO; Investment seen as a long term venture; business as usual

TTI, Inc. and Berkshire Hathaway Inc. announced today that they have entered into a definitive agreement which will see the privately-held passives, connectors and electromechanical components distributor become part of the Berkshire Hathaway group of companies. The acquisition will also include TTI's subsidiary Mouser Electronics. The transaction is expected to complete by the end of Q1 2007 – terms have not been disclosed.

TTI, Inc. will operate as a wholly owned subsidiary of Berkshire Hathaway, which is listed at number 13 in the Fortune 500 list with sales of over $80Bn. TTI's management will remain in place and will continue to run TTI's day to day activities. Paul Andrews will continue in his current capacity as Chairman and Chief Executive Officer. Operations will not be affected by the ownership change.

Paul Andrews, TTI's founder, Chairman, and Chief Executive Officer, said "It is a real honor for TTI and Mouser to become part of the Berkshire Hathaway Group. Berkshire is recognized as being one of the most admired companies in the world. They take a long term view of the business and will allow TTI to continue with our growth plans. They have an excellent reputation and fit very well with TTI's values. TTI has enjoyed a successful 35 years and I am confident in our future as being part of Berkshire Hathaway."

Warren Buffett, Berkshire Hathaway's Chairman and Chief Executive Officer, stated, "Paul Andrews is a remarkable man who has built an outstanding business. We are pleased to have the opportunity to add TTI to the Berkshire Hathaway Group."

www.ttiinc.com

www.Berkshirehathaway.com

Global Supplier Award from Celestica

Avago Technologies announced it was awarded a "Partners in Performance" award from Celestica, a world leader in electronics manufacturing services (EMS). Avago is a leading supplier of innovative semiconductor solutions for advanced communications, industrial and commercial applications. This year marks the eighth time the company has received this prestigious industry award.

For the past seven years, Celestica selected Agilent Technologies' Semiconductor Products Group (SPG) for its annual award. SPG became Avago Technologies in 2005.

"Once again we are honored to be recognized by Celestica," said Jeff Henderson, senior vice president of sales and marketing for Avago Technologies. "Avago is committed to its strong customer support and technology innovation. This award demonstrates our organization's continued drive to deliver high-quality products to our global customers in a timely manner."

The 2005 "Partners in Performance" winners demonstrated a level of responsiveness, flexibility and service that contributed to the success of Celestica's business and positively impacted its customers.

"For eight consecutive years, Avago Technologies has served as a seamless extension of our business, continually contributing to Celestica's success by providing competitive advantage to our global customers," said John Boucher, chief supply chain and procurement officer, Celestica. "I congratulate Avago Technologies on the receipt of this award and commend the company for its outstanding performance."

www.avagotech.com

The Best-Selling 2-Channel IGBT Driver Core

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

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.

The driver is equipped with the award-winning CONCEPT SCALE driver chipset, consisting of the gate driver ASIC IGD001 and the logic-to-driver interface ASIC LDI001.

Chipset Features

- Short-circuit protection
- Supply undervoltage lockout
- Direct or half-bridge mode
- Dead-time generation
- High dv/dt immunity up to 100kV/us
- Transformer interface
- Isolated status feedback
- 5V...15V logic signals
- Schmitt-trigger inputs
- Switching frequency DC to >100kHz
- Duty cycle 0...100%
- Delay time typ. 325ns

Driver stage for a gate current up to ±15A per channel, stabilized by large ceramic capacitors

Specially designed transformers for creepage distances of 21mm between inputs and outputs or between the two channels. Insulating materials to UL V-0. Partial discharge test according IEC270.

Isolated DC/DC power supply with 3W per channel

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

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.

As an ideas factory, we set new standards with respect to gate driving powers up to 15W per channel, short transit times of less than 100ns, plug-and play functionality and unmatched field-proven reliability.
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.

CONCEPT

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Let experts drive your power devices

Organization Realignment

STMicroelectronics announced plans to reorganize its product segments into three main areas. Under the new structure, which divides the Company's products into Application Specific Groups, a Flash Memory Group and the Industrial and Multisegment Sector, ST's organizations are aligned to meet the requirements of the market. The reorganization takes effect on January 1, 2007.
Furthermore, in order to provide a more synergistic contribution to the Company's product requirement, ST is adding to the former MPA business its non-Flash memory products – formerly under MPG – and its Micro-Electro-Mechanical Systems (MEMS) activity, to form a new sector, called Industrial & Multisegment Sector (IMS). Carmelo Papa, who is being promoted to Executive Vice President, will lead the Industrial & Multisegment Sector. Within IMS, a new Group, the Microcontrollers, Memories & Smartcards Group (MMS), is created under the leadership of new Corporate VP Claude Dardanne.
Finally, keeping the same overall perimeter, ST's Application Specific Groups (ASG) will now be comprised of the newly created Mobile, Multimedia & Communications Group (MMC) and the Home Entertainment & Displays Group (HED) as well as the existing Automotive Product Group (APG) and Computer Peripherals Group (CPG). In connection with these changes, Tommi Uhari is being promoted to Executive Vice President and will lead the Mobile, Multimedia & Communications Group and Christos Lagomichos is being promoted to Corporate Vice President for the Home Entertainment & Displays Group. The Automotive Products Group and Computer Peripherals Group will continue to be managed by Corporate Vice Presidents Ugo Carena and Gian Luca Bertino, respectively.

www.st.com

Power Supply Design Seminars

Texas Instruments Focuses on Power Supply Design Innovation with 2007 Seminars in Europe
Building on more than 25 years of educating power supply designers with innovative design concepts, Texas Instruments has announced the European schedule for its 2007 Power Supply Design Seminar Series. TI's leading power management gurus will conduct a series of one-day seminars in 22 cities in Europe beginning April 16.
The 2007 series, the 18th since introduced by Unitrode in 1977, provides rich technical and practical presentations that combine new advanced power supply concepts, basic design principles and "real-world" application examples. For more information and to register for an upcoming seminar, see: www.ti.com/europe/power07. The registration fee may vary from country to country. See website for details.

Topics for the 2007 Seminar Series Include:
Improving Power Supply Efficiency – The Global Perspective
Green-Mode Power by the Milliwatt
Feedback in the Fast Lane – Modelling Current-Mode Control in High-Frequency Converters
Designing Planar Magnetics
An Interleaved PFC Pre-Regulator for High-Power Converters
Software Design for Digital Power – Programming 101 for Analog Designers
Designing a Digital Telecom Rectifier
New Power Supply Components

Dates and Locations:

16. April	Madrid*	Spain
17. April	Barcelona*	Spain
18. April	Paris*	France
19. April	Eindhoven	Netherlands
23. April	Edinburgh	UK
24. April	Birmingham	UK
25. April	London	UK
26. April	Limerick	Ireland
07. May	Munich	Germany
08. May	Heidelberg	Germany
09. May	Hanover*	Germany
10. May	Zurich	Switzerland
22. May	Milan*	Italy
23. May	Vienna	Austria
24. May	Prague	Czech Republic
25. May	Warsaw	Poland
29. May	Helsinki	Finland
30. May	Stockholm	Sweden
31. May	Copenhagen	Denmark
04. June	Novosibirsk*	Russia
06. June	Tomsk*	Russia
08. June	Moscow*	Russia

*Simultaneous translation facilities

www.ti.com

EMV 2007 Stuttgart

Europe's Meeting Place for the Electromagnetic Compatibility Industry
From 6 – 8 March 2007 Europe's EMC industry will meet in Stuttgart, Germany at "EMV 2007" – International Exhibition with Workshops on Electromagnetic Compatibility. More than 100 exhibitors – headed by the industry's leading companies - will show off their latest EMC products and services. To the attraction of the event add 41 practice-based workshops, which will take place parallel the exhibition. During the half-day workshops engineers and technicians involved in the planning and development of electronic systems and devices, in quality assurance and certification, as well as EMC test engineers and test lab technicians will obtain answers to the questions which tax them every day. Seven workshops will be held in English by leading EMC professionals.
The plenary talks on Wednesday, 7 March 2007, 12.30 – 2 pm will be one of the highlights of the three EMC days in Stuttgart. The presentations will address important developments in the EMC industry:
EMC and Product Safety, Ernst Habiger, Technical University Dresden
Electronic Systems – How will they develop? Gerhard Hettich, EAST Consulting, Dietenhofen
The Implementation of the EMC Directive in the New EU Member States", Gerd Jeromin, Jeromin CE Consult, Reinheim
All visitors, exhibitors and workshop attendees are welcome to join the plenary talks.

www.e-emc.com

Your Quality Partner for Power Solutions

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

New TMD Modules

6-Pack IGBT
600V : 5A - 20A
1200V : 5A - 25A

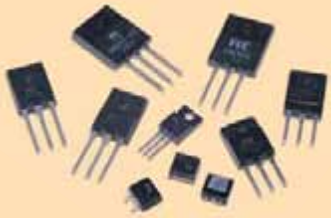
PIM IGBT
600V : 5A - 20A
1200V : 5A - 25A

High Power 6-Pack
1200V : 225A - 450A
1700V : 225A - 450A

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

FUJI ELECTRIC
DEVICE TECHNOLOGY
e-Front runners

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semi-info@fujielectric.de

www.fujielectric.de

TI Unveils Battery Management Chips to Manage and Protect Multi-Cell, Li-Ion Battery Packs

Texas Instruments introduced several new battery management integrated circuits (ICs), including its next-generation Impedance Track™ "gas gauge" chipset, to improve battery performance and protect multi-cell, lithium-based battery packs used in notebooks and other systems.

Next-Generation Impedance Track Gas Gauge

TI's bq20z90 next-generation Impedance Track battery gas gauge chipset, which integrates new state-of-the-art battery authentication technology, is designed to work with TI's newest analog front end (AFE) protection IC. Requiring a third fewer components than its predecessor, the 99-percent accurate bq20z90 chipset was designed with ease-of-use and smallest real estate in mind. The gas gauge closely monitors battery capacity, impedance, cell balance, open-circuit voltage and other critical parameters of a 7.2-V, 10.8-V or 14.4-V battery pack and reports the information to the system host controller over a serial-communication bus. See: www.ti.com/sc06160.

TI's Impedance Track gas gauge technology, launched in 2004 with the bq20z80 chipset, precisely measures changes in impedance, or resistance caused by battery age, temperature and cycle life, to accurately predict run-time of battery packs with two, three and four cells in series. An exact "starting position" is determined for instant state-of-charge, and total capacity is calculated from the amount of capacity that exists, which eliminates the need for a full-charge and discharge cycle.

The bq20z90 drives a three-, four- or five-segment LED display for remaining capacity indication. For those designs that do not require the display indicator, TI also introduced its bq20z70 gas gauge chipset without the LED display driver.

Front-End Battery Protection

The bq20z90 is designed to work with TI's new bq29330 AFE protection circuit with two integrated linear dropout regulators (LDOs) to further maximize functionality and reduce external component count. The device utilizes an I2C communications interface to allow the bq20z90 to monitor safety battery conditions such as voltage, individual cell voltages and cell-balancing data, and report the information to the host system. See: www.ti.com/sc06160b.

A designer can program critical safety parameters such as current protection thresholds and delays into the bq29330 to increase flexibility of the battery management system. The device also provides protection for overload short-circuit in charge and discharge conditions, while providing battery cell over-voltage and under-voltage protection.

Integrated SHA-1 Based Authentication

The bq20z90 integrates SHA-1, 128-bit decryption functionality, which easily identifies potentially unsafe batteries not approved by original equipment manufacturers for use in their devices. If the battery information checks out, the system can allow normal system operation with the battery pack.

A manufacturer can program the system to take action to protect the consumer if the battery pack response is not correct, or if the battery pack is not approved or determined to be defective. In addition, TI introduced a bq26100 security device for those designers who prefer a discrete implementation of the SHA-1 protection feature. See: www.ti.com/sc06160c.

Smart Battery Test Board

In addition to the new battery gas gauge chipset, TI has developed a unique development platform aimed at battery pack suppliers. TI's new bqMTester smart battery development board simplifies production of battery modules at a fraction of the cost. bqMTester eliminates the need for an onboard computer and expensive calibration/traceable power supplies and electronic loads. It calibrates and programs electronic smart battery modules based on advanced battery fuel gauges, such as the bq20z90, bq20z80 and bq20z70 devices with Impedance Track. In addition, bqMTester makes tracking battery modules in production easier by programming serial number, date, pack lot code and other defaults. The bMTester board can be ordered at www.ti.com/bqmtester.

Pricing and Availability

The bq20z90 and bq20z70 gas gauge chipsets, bq29330 protection AFE and bq26100 authentication circuit are available in volume production from TI and its authorized distributors. The bq20z90 is packaged in a 30-pin thin shrink small outline package (TSSOP), the smaller bq29z70 in a 20-pin TSSOP, the bq29330 in a 30-pin TSSOP package and the bq26100 in a tiny, 6-pin SON package. Suggested resale pricing in 1,000 piece quantities is $3.30 for the bq20z90, $2.90 for the bq20z70, $1.45 for the bq29330, and $1.30 for the bq26100.

Evaluation modules for the bq20z90 gas gauge chipset, the bqMTester development board, reference designs, application notes and technical documentation are available through www.ti.com/impedancetrack.

CONCEPT

Wir sind ein 20 Jahre junges, international erfolgreiches High-tech Unternehmen im Bereich Leistungselektronik und Gewinner mehrerer Technologiepreise. Im Bereich IGBT-Treiber sind wir Technologie- und Marktleader und definieren die wegweisenden Standards von heute und morgen.

Im Rahmen unserer Expansionsstrategie suchen wir für unseren Standort Biel-Schweiz:

Entwicklungsingenieur / Projektleiter Entwicklung IGBT-Treiber

Anforderungen
- Abgeschlossenes Studium der Elektrotechnik
- Fundierte theoretische Kenntnisse und praktische Erfahrungen mit IGBTs, IGBT-Treibern und deren Anwendungen
- Mehrjährige Berufserfahrung auf dem Gebiet der Leistungselektronik
- Ausgezeichnete Kenntnisse der deutschen und englischen Sprache in Wort und Schrift

Zu Ihrem primären Aufgabenbereich gehört
- Erarbeitung von Analysen und Konzepten für neue Produkte
- Durchführen und koordinieren von Entwicklungsarbeiten
- Ausarbeiten von Lastenheften und technischer Dokumentation

Sie unterstützen im Rahmen von Pre-/Aftersales Aktivitäten
- Technische Unterstützung der Marketingabteilung
- Erarbeitung/Mitarbeit von technischen Produktpräsentationen

Wir bieten Ihnen
- eine ausbaufähige Position mit attraktiven Anstellungsbedingungen
- einen angenehmen Arbeitsplatz mit einer Top-Infrastruktur
- die Möglichkeit zur Entfaltung Ihrer Kreativität in einem Top-Team

Fühlen Sie sich angesprochen? Wir freuen uns auf Ihre Bewerbung!
Unser Herr H. Rüedi steht Ihnen gerne telefonisch oder per Mail unter Jobs@IGBT-Driver.com für weitere Auskünfte zur Verfügung.

CT-Concept Technologie AG
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Telefon +41 - 32 344 47 47
www.IGBT-Driver.com

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Support- /Applikationsingenieur

Anforderungen
- Abgeschlossenes Studium der Elektrotechnik
- Fundierte theoretische Kenntnisse und praktische Erfahrungen mit IGBTs, IGBT-Treibern und deren Anwendungen
- Mehrjährige Berufserfahrung auf dem Gebiet der Leistungselektronik
- Ausgezeichnete Kenntnisse der deutschen und englischen Sprache in Wort und Schrift

Zu Ihrem primären Aufgabenbereich gehört
- Technische Unterstützung unserer Distributionspartner und Kunden
- Adaptierung bestehender Basisprodukte an neue Anforderungen
- Ausarbeitung von Applikationsvorschlägen und praktische Verifikation
- Dimensionierung von Leistungsteilen
- Analysen und Erarbeitung von Problemlösungsvorschlägen
- Ausarbeiten von technischer Dokumentation

Sie unterstützen im Rahmen von Pre-/Aftersales Aktivitäten
- Technische Unterstützung der Marketingabteilung
- Erarbeitung/Mitarbeit von technischen Produktpräsentationen
- Kundenbesuche, Verkaufsförderungs- und Messeaktivitäten

Wir bieten Ihnen
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- einen angenehmen Arbeitsplatz mit einer Top-Infrastruktur
- die Möglichkeit zur Entfaltung Ihrer Kreativität in einem Top-Team

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- Kenntnisse in mixed-signal und mixed-language Schaltungssimulation
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- Ausgezeichnete Kenntnisse der deutschen und englischen Sprache in Wort und Schrift

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- Identifikation, Entwicklung und Verifikation neuer Konzepte zur Integration von Smart-Power Funktionen zur Ansteuerung von IGBTs und Leistungs-MOSFETs
- Entwicklung von Smart-Power ASICs von der Definition bis zur Serienreife
- Ausarbeiten von Lastenheften und technischer Dokumentation

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Entwicklungsingenieur Testsysteme für ASIC-Tester und/oder LabView

Um die hohe Qualität unserer Produkte gewährleisten zu können, testen wir alle ASICs und Endprodukte auf modernsten Testsystemen. Die Testadaptionen und Testprogramme entwickeln wir bei uns im Haus.

Anforderungen
- Abgeschlossenes Studium der Elektrotechnik
- Fundierte theoretische Kenntnisse und praktische Erfahrungen mit Entwicklung von Testkonzepten, Testadaptern und Software für Testsysteme
- Erfahrungen mit ASIC-Testsystemen und/oder LabView
- Eventuell Erfahrung mit Reinhardt-Multifunktionstestern
- Ausgezeichnete Kenntnisse der deutschen und englischen Sprache in Wort und Schrift

Zu Ihrem primären Aufgabenbereich gehört
- Erarbeitung von Analysen und Konzepten für neue Testprojekte
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Keep Your Energy Storage Options Open

By Dr. Adrian Schneuwly, Maxwell Technologies

While battery technology continues to improve year-on-year, power engineers should not overlook the other options available to them for energy storage. As we are still only a few weeks into 2007, perhaps there is still time for a late New Year's resolution to consider other technologies and the benefits they can bring.

One obvious alternative is fuel cells which are looking increasingly attractive, particularly for larger applications such as back-up power for telecom basestations.

I'd like to focus on a technology that is perhaps less well-known: the ultracapacitor or supercapacitor. These devices have capacitances measured in Farads, achieved due to the extremely high surface area electrodes. While this means it can store a surprisingly large amount of energy, the ultracapacitor's true benefit is its excellent power density, enabling it to deliver a large amount of power for a relatively short time.

While this is technically interesting, why should engineers look at a device that can typically only provide power for seconds at a time? And aren't ultracapacitors expensive?

It so happens that the ultracapacitor's characteristics are ideally suited to a wide range of applications, that all require repeated short, high-power bursts and work in harsh environments. This is something that batteries are not well-suited to, so ultracapacitors can either replace batteries or be used to complement them, providing solutions that neither technology can achieve on their own.

Although ultracapacitors were relatively expensive a few years ago, the price has recently dropped dramatically. This has been achieved with improvements in production, engineering, and R&D, as well as the effect

of increasing volumes thanks to hundreds of applications in production today, relying on this technology.

As well as purchase price, the total lifetime cost of ultracapacitors has become very competitive, partly due to their higher reliability and longer lifetime compared to batteries. Ultracapacitors are basically maintenance-free, helping cut overall costs. Their superior low-temperature performance compared to batteries can also reduce system cost.

With the dramatic price reductions, and improvements in the technology, ultracapacitors are increasingly becoming attractive for a wide range of applications. They are already penetrating high volume markets and replacing batteries in applications such as UPS (uninterruptible power supply), wind energy, portable electronics and hybrid transit buses, to name a few.

For UPS and telecoms applications, ultracapacitors provide short-term bridge power in the event of a grid failure, and sustain the power supply while a fuel cell or diesel generator can be brought online. For wind energy, they provide the power for blade pitch control systems, which ensure power in case of an emergency situation and improve the efficiency of the wind turbines.

In the long term, the biggest potential market is the automotive segment. In this market, ultracapacitors are used for braking energy recuperation, which reduces fuel consumption and pollution, and for electrical network power systems to satisfy growing loads created from sub-systems such as braking and steering.

The same principle of energy recuperation from braking applies to heavy transportation, such as buses and trucks, and light rail applications. Energy storage can also help meet peak power demands in transportation. This can improve reliability in rail applications by avoiding voltage drops when demand is highest, for example when more than one train is accelerating away from a station at the same time.

I hope I have convinced you that ultracapacitors have some useful characteristics, and have the potential to replace or supplement batteries in many applications. While they are perhaps unfamiliar to some engineers, they have a long track record of reliable operation in many different applications and environments. With suppliers continuing to improve their products, and to design ultracapacitor modules and cells that are easier to design in, perhaps now is the time to evaluate them.

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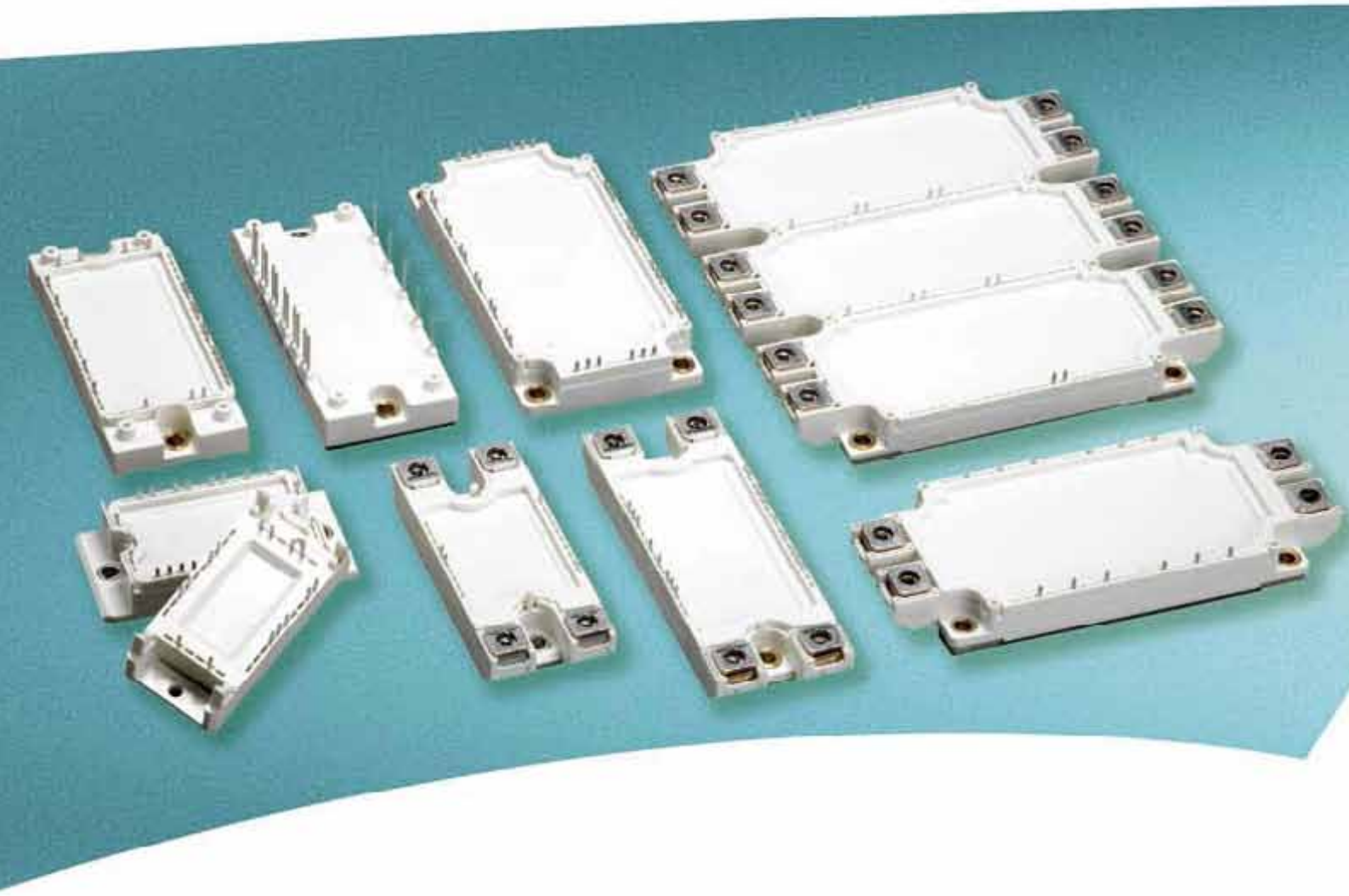

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THE LENNOX REPORT

ELECTRONIC COMPONENTS INDUSTRY

SEMICONDUCTORS

Through October 2006 worldwide semiconductor market growth was reported by the **WSTS** as 8.8% over 2005 but ten-month sales in Europe remained essentially flat at 0.2% in dollars and +1% in Euros while according to the **ZVEI** the important German market showed a 3% decline in Euros for the same ten-month period, a drop also forecast for the entire year 2006.

As concerns the **outlook for the current year** the WSTS sees 2007 at a 8.6% global growth, essentially flat with last year but forecasts an optimistic 6.8% increase (in dollars) for Europe. Future Horizons bets on 10% to 16% hoping for improved pricing while iSuppli also goes for a 10% worldwide increase as does SEMI. It should be noted that memory sales in 2006 were estimated by some as up 22% worldwide which would leave a 4.7% increase for all other semiconductors with no important mix changes anticipated for 2007.

Members of France's **SITELESC** report November 2006 semiconductor sales down 1.5% sequentially with exports up 11.7% but sales in France a –7.2%. Eleven months sales still show a slight plus of 1.4%, all in Euros. Overall the data confirm a slowdown already noted by various producers.

The **Taiwanese government** has given the green light to its semiconductor producers to use 0.18 micron technology in their Chinese plants with TSMC the first beneficiary and Powerchip and ProMos also applying. The previous restriction to 0.25 micron technology has seriously handicapped the Taiwanese firms.

Infineon is said likely to hold on to its 86% stake in Qimonda not least in view of the memory producer's third quarter sales leap of 61% to € 1.23 B as profits increased almost six-fold to € 156 M. Infineon is free to reduce its equity to just above 50% but any further reduction would be subject to negotiations safeguarding existing license agreements. The firm has presented its OptiMOS® 3 claimed to improve on existing power supply semiconductor solutions and has tested its first device using a 65 nm multi-gate transistor architecture.

NXP raised nine-month 2006 revenue 10.6% to € 3.77 B at a net profit of € 2 M compared to a € 132 M loss in 2005. Sales to Philips have declined to 6.6% from 8.5% in 2005. The firm continues its strategy to operate in five market segments such as home, mobile, automotive, ID (sales doubled in 18 months) and multi-market, is enthusiastic about LEDs it sees as replacing all light bulbs. A joint venture is planned with Sony to promote contactless smart card applications in mobile phones.

Not unexpectedly **Japanese car parts suppliers** are following their customers abroad as they continue to establish plants in the Americas, Asia and Europe adding competitive pressure on local suppliers of both parts and electronic components. Consolidation is also continuing with the latest involving Japan's Elpida and Taiwan's Powerchip in a joint DRAM venture at an investment of $ 13.6 B over 4 years. It is planned to start with a plant now under construction in Taiwan to be followed by three other plants eventually placing the two firms in the N° 2 place behind Samsung and ahead of Qimonda, Hynix and Micron.

NEC Electronics is partnering with Sony and Toshiba in developing LSI circuits with a 45 nm process and a 98% yield and expanding its Kumamoto plant to produce microcontrollers for car brakes and airbags. NEC's automotive semiconductors should grow 65% to ¥ 140 B by 2011 while the market is expected to increase 23% to ¥ 700 B. Current fiscal year sales are forecast to grow 7% to ¥ 695 B at a loss of ¥ 25 B compared to a ¥ 98.2 B in the prior year.

Sharp reports electronic component sales up 9.7% for the half year ended September 30, 2006, foresees total corporate revenue growing 7.3% in the current fiscal year and has begun mass production of blue-laser diodes used in both DVD formats, Blu-Ray and HD-DVD.

According to the Prime Research Group the **IC-Tester market** is dominated by Advantest with a 2005 share of 40.9% up from 37.4% in 2004 while Teradyne declined to 19.4% in 2005 from 21.7% in the prior year. Other players include Agilent 11.7%, Yokogawa 9.3%, Credence 8.9% and LTX 3.6%. Advantest dominated the memory test market with 68.5% followed by Yokogawa and Agilent.

CONNECTORS

Bishop's November 2006 Connector Industry Business Index declined 3.7% sequentially reflecting reduced order input though Europe was less pessimistic. But connector prices are believed (hoped ?) to increase in the coming half year. Bishop puts the 2006 world connector market at $ 39.95 B, +12.6% with Europe up 5.4% to $ 9.32 B. The 2007 world market is seen as growing 8%.

ABB Entrelec is planning to increase its use of parent ABB's worldwide sales network, sees Phoenix as one of the technology leaders while **Tyco International** has named Thomas Lynch CEO of Tyco Electronics. Dr. Gromer continues as president of the $ 12.2 B (2005) sales division which, as previously reported, will become a separate company this year.

Deutsch Connectors has been bought by Wendel Investments, a major shareholder of France's Legrand.

PRINTED CIRCUIT BOARDS

Wider applications are favoring the acceptance of **Molded Interconnect Devices (MID)** strongly promoted by German producers in the industrial market at the recent MID 2006. Despite Asian low-cost competition niche PCB producers are still to be found throughout Europe.

The **ZVEI** estimates the 2006 German PCB and hybrid market at € 2.05 B, up 4.6% but foresees a slowdown of 2.1% for the current year. As previously reported **Sagem** will stop volume PCB production but plans to continue to serve niche markets such as medical, defense and aerospace.

DISTRIBUTION

According to Philippe Djeddah, VP global supplier marketing PEMCO at Arrow Electronics, the 2006 European passive connector and electromechanical **distribution market** should have grown by about 15% to € 2.96 B with Asia up 20%. For this year Mr. Djeddah predicts a 2% to 3% European DTAM increase, about 10% in Asia and 3% to 6% worldwide.

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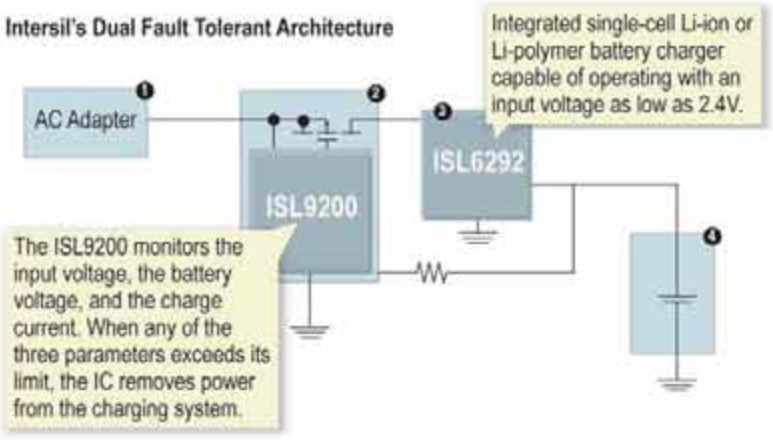
Intersil's Dual Fault Tolerant Architecture



Dual-Fault FMEA (Failure Mode and Effects Analysis)

POTENTIAL FAILURES				Consequence of Dual Failure
1	2	3	4	
●	●			3 will fail but the protection module in the battery pack will protect the battery cell.
●		●		Both 2 and 4 will protect the battery cell.
●			●	3 will limit the battery voltage. 2 has an additional level of protection.
	●	●		The protection module in the battery pack protects the cell.
	●		●	3 will limit the battery voltage to 4.2V, within 1% error.
		●	●	2 will sense an over voltage case and remove the power from the system.

- User programmable overcurrent protection threshold
- Input overvoltage protection in less than 1µs
- Battery overvaltage protection
- High immunity of false triggering under transcients
- High accuracy protection thresholds
- Warning output to indicate the occurrence of faults
- logic warning output to indicate fault and an enable input to allow system to remove input power.
- Small, thermal enhanced DFN package.
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High Power Drives AC-DC Market

Digital control can lead to higher efficiency

Traditionally, the embedded ac-dc power supply market is one of the more staid segments in the power electronics industry. Several significant trends are making this market more dynamic, however, including the use of higher-wattage power supplies, power factor correction, digital control, and the need for energy efficiency.

By Linnea Brush, Senior Research Analyst, Darnell Group

Consumer devices are driving increased unit sales, but bringing down the average selling price of power supplies. Additionally, the consumer devices market is shifting from captive to merchant production. Combined worldwide merchant and captive embedded ac-dc power supply unit sales are expected to grow from 933.0 million units in 2007 to 1,134.4 million units in 2011, an annualized growth rate of 5.0% (see Figure 1). During the same period, merchant revenue is projected to rise from $11.8 billion to $14.8 billion, at an annualized rate of 5.8%.

Most unit sales are found in desktop PCs, home audio, CRT TVs (although this is a declining unit market), set-top boxes and DVD players/recorders. The most revenue is in desktop PCs, wireline communications, and industrial applications. The fastest-growing applications include blade servers, Power-over-Ethernet sourcing equipment, large-screen LCD TVs (>23"), and plasma TVs.

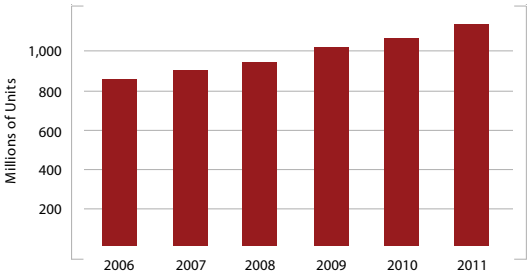

Figure 1: Worldwide Embedded AC-DC Power Supply Market (merchant and captive)

When looking at unit sales for both merchant and captive production, consumer devices hold the majority of sales. In 2006, consumer accounted for nearly 52% of the total worldwide market. While this figure is projected to slide slightly to 48%, the consumer segment continues to dominate the market. The computer segment followed closely behind at nearly 34% of unit sales in 2006, which is expected to remain steady through 2011. So-called "entertainment PCs" will continue to drive demand for higher-performance graphics cards. This will push PC power supplies higher than their typical wattages today of 250W and 300W.

The increasing use of higher-wattage power supplies, particularly in the broad computer market, is placing increased focus on the efficiency of embedded ac-dc power supplies. Greater server density in data centers has created severe thermal problems. Although blades have taken the server market by storm, they are contributing to problems with cooling. Each of IBM's blade server chassis can require over 4kW of power. With a couple of chassis per rack, the power requirements of the rack rise quite quickly. The ability to dissipate the heat created has become one of the biggest challenges to the blade server market. Since original equipment manufacturers want to limit the thermal problems that their customers face, they will be motivated to use higher-efficiency power supplies, giving power supply companies more opportunities.

Ac-dc power supplies in the 101-300W range will see the greatest amount of revenue, due largely to sales of PC power supplies, and the 300W+ segments will have the fastest growth rates (see Figure 2). Rising power levels and energy costs have prompted the US Environmental Protection Agency's Energy Star Program to draft standards that include specifications for embedded power supplies. Driven by regulations or not, the rising cost of electricity, thermal issues with high-power racks in data centers, and trying to avoid water cooling will all contribute to increased efficiency in ac-dc power supplies.

Blade servers offer strong revenue growth opportunities for ac-dc power supply makers, because these power supplies not only come at higher wattages but also require features that tend to increase the average dollars-per-Watt. These power supplies often support n+n redundancy and hot-swappability, which provide additional revenue opportunities. In a typical blade server setup there are four power supplies per blade server chassis and approximately 10 blade servers per blade server chassis. Additionally, blades in a large data center would be powered at the rack level rather than at the chassis level, which will provide for greater opportunities for rack-mounted ac-dc power supplies.

Digital power management and control will be a disruptive technology. Control loops in ac-dc front ends have a potential market penetration rate of 35%-60% in five years, with power factor correction being a major driver for adoption. Digital products have already been released by ROAL, Tyco, Astec, Power-One, and Valere, and many more are expected in the next year or two. Digital control can lead to higher efficiencies, since digital parameters under software control can be varied to meet instantaneous needs. Output voltages and other parameters can be "programmed," leading to fewer part numbers. Improved facilities operations lead to lower operating costs and lower supply chain costs.

While these goals will continue to drive innovation, the digital ac-dc power supplies available today have focused more on digitally

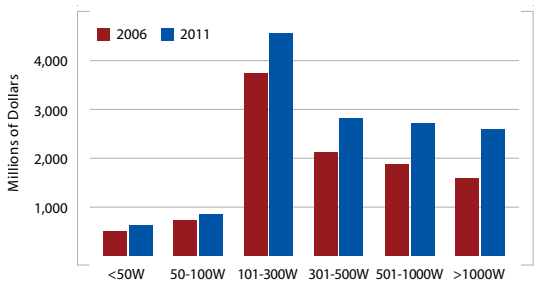

Figure 2: Worldwide Embedded AC-DC Power Supply Market by Wattage (merchant)

setting the output voltage, output sequencing, various monitoring functions and similar capabilities. As a result, the introduction of digital technologies into standard ac-dc power supplies will reduce the market for modified-standard products. For instance, Astec Power introduced its iMP series of modular ac-dc power supplies. The iMP features digital management capabilities including the ability to use I2C control to program output voltage, output enable/sequencing, module inhibit/enable polarity, dc ok thresholds, output current limit and over-temperature threshold. Astec claims that the ability to program these features would have reduced over 90% of the modifications made to its earlier non-digital MP line of modular power supplies. While this is only one product, it could illustrate the wave of the future for modified-standard products.

Power factor correction (PFC) is increasingly being used as the average wattage level of applications increase. The embedded ac-dc power supplies used in desktop PCs have been targeted as one of the better opportunities for PFC implementation, due to worldwide regulations such as EN61000-3-2 and the size of the market. Ac-dc power supplies offer a wider range of power levels and greater flexibility when introducing new PFC products.

PFC is currently used primarily in 75W to >4kW, single-phase applications. Traditionally, PFC has been used in motor drives, pumps and lighting; but a number of applications using embedded ac-dc power supplies can also benefit from PFC, including servers, desktop/workstations, storage, industrial equipment, PoE, communications and similar higher-wattage devices.

Active PFC is a requirement for Server System Infrastructure (SSI) compliance. According to the ERP12V (Entry Redundant Power) Power Supply Design Guide, posted on the SSI Forum website (www.ssiforum.org), "The power supply modules shall incorporate universal power input with active power factor correction, which shall reduce line harmonics in accordance with the EN61000-3-2 and JEIDA MITI standards."

Regionally, Asia and China have become a larger share of the embedded power supply market, but China's market share, in particular, is leveling out. North America and Europe will be large markets for power supplies used in higher-end applications, typically with higher wattages. Formerly captive applications are being served by merchant suppliers, further broadening the overall market.

Finally, although the broad economic picture provides promise for ac-dc power supply makers, the economic trends of the power supply market itself pose greater threats. The market has recently entered a period of consolidation, especially for the major players. Within the past couple of years, three of the top five power supply companies have been involved in a major acquisition: Lambda Power, ranked fourth in worldwide market share, was acquired by TDK Corporation; and Artesyn, ranked as the fifth-largest power supply maker worldwide, was acquired by Emerson Electric, which is the parent company of Astec Power, the third-largest power supply maker worldwide.

These mergers give the new companies greater economies of scale. This can take the form of greater buying power from their suppliers, which reduces their costs, or it can provide the ability to operate on thinner margins and set lower prices. As a result, market share of the largest few continues to grow. This is an increasing threat to the other power suppliers in the market and is likely to prompt more consolidation in an attempt to level the playing field.

www.darnell.com

Interview on Power Supply Technology

with Doug Bailey, VP Marketing, Power Integration

By Bodo Arlt, Editor BPSD

Bodo Arlt:
What end markets will drive power supply technology?
Doug Bailey:
Most major consumer product categories are becoming subject to regulations that require them to manage power use to minimize standby power losses and maximize operational efficiency. I believe that the need for good power management will be driven in the short term by external chargers, set-top boxes, other AV equipment, PCs, printers, and LCD monitors. Future drivers will include appliances and anything else requiring an active standby rather than a hard on/off switch. Power Integrations is well-positioned to meet this requirement because our product line is efficient down to very low power levels – we can provide 75 percent of the input power to the output when the power budget is 1 W for standby in say, a printer or STB. Our ON/OFF control scheme means that we can react quickly to provide full power during wake-up and avoid overshoot.

Bodo Arlt: What does Power Integrations bring to these end markets besides its range of IC solutions?
Doug Bailey:
Our technology and inventions are not limited to implementations in silicon. We have developed novel techniques for transformer shields to reduce EMI and we have numerous application circuit inventions that we share with customers via our website at www.powerint.com/ip.htm.

BodoArlt:
What technologies and innovations does PI have a leadership position?
Doug Bailey:
We're seeing much more of a market need for power supplies that have high efficiency across the entire load range. Partly this is because many standards require efficiency measurements at 25 percent, 50 percent, 75 percent and 100 percent load, but also because many applications with a standby power budget really like to have as much power available as possible for that budgeted figure. For example, a STB is allocated 1W in standby by the California Energy Commission (CEC). That's fine for the ON/OFF switch only, but if the unit needs to light a vacuum fluorescent display with a clock, watch for signals from a remote, or poll its networking connection, then having 750mW available from a power supply that is efficient across the load range is pretty handy.
Another differentiating technology is performance at peak power ranges. If a power supply is designed to operate at maximum power at all times, but its application requires maximum power for only a very short period of time, then the supply is likely to have an overdesigned transformer, MOSFET, and output diode, and maybe a few other components, too. We designed the PeakSwitch specifically to address the needs of designs in which peak power is required infrequently and for short periods. The printer paper-advance function illustrates the application very well, but there are many other examples.

Douglas Bailey, Vice President, Marketing, Power Integrations

Mr. Bailey joined Power Integrations in November 2004 as vice president of marketing. Prior to joining PI, Mr. Bailey served as vice president of marketing at ChipX, a structured ASIC company. His earlier experience includes Business Management and Marketing Consultant for Sapiential Prime, Inc.., Director of Sales and Business Unit Manager for 8x8, Inc., application engineering management for IIT, Inc. and design engineering roles with LSI Logic, Inmos, Ltd. and Marconi. Mr. Bailey holds a B.Eng. from the University of Birmingham with a concentration in microelectronics and microwave devices

Bodo Arlt: Is it more in silicon, or is it part of packaging technology?
Doug Bailey:
Power Integrations has some basic and very fundamental silicon technology that enables our devices to be highly effective in their monolithic form. However, I'd say that most of our recent innovations have been achieved by adding features and improving operating and standby efficiency.
Bodo Arlt: What makes Power Integration different from traditional IC suppliers?
Doug Bailey:
I might disagree somewhat that Power Integrations is non-traditional. TOPSwitch celebrated its 10th anniversary last year, and the device and spin-off versions have shipped in the hundreds of millions of units. Using Power Integrations is definitely a tradition among power supply designers.
That said, we are different from other companies. Few of our competitors follow the fabless model, and in power semiconductors, owning your own fab was pretty much de rigueur until PI showed how successful a fabless model could be. Also, we are a very focused company. We only make power supply chips, and fully one-third of our employees are dedicated to supporting customers with their power supply designs. To my knowledge, no other power semiconductor company offers this level of support commitment to its customers.

Bodo Arlt: How much is Power Integrations involved in the end-customer applications?
Doug Bailey:
This depends on the needs of the customer. We have a substantial FAE force, and they touch as many designs as they can to help customers get to production quickly and easily. Even so, we have far more customers than even our team can address personally, and so we have developed the PI Expert software tool to fill the need. PI Expert is not just a fancy spreadsheet, it's actually an expert system that optimizes a power supply design in the same way that an engineer does – iteratively. Also, it has a number of our patented transformer design techniques built in – it's rather like having access to an expert FAE 24/7.
We also maintain an online "Ask a PI Engineer" capability which is a direct channel to corporate applications engineering support. Sometimes only an answer from an engineer with detailed internal understanding of the product can resolve a particularly difficult problem. We like to ensure that everyone who uses a PI product is successful and the technical support channel is a key to ensuring that none of our customers is struggling and unable to get help that they need.

Finally, and this is particularly exciting, we have just launched a transformer winding service. The toughest part of building a power supply is getting a custom transformer designed and prototyped. Our Rapid Transformer Sampling Service is aimed at helping engineers to be successful even if they have never wound a transformer before.

Bodo Arlt: How much is Power Integrations involved in motion applications using the advantage of IGBTs?
Doug Bailey:
PI does not have any IGBTs or chips that drive them. However, we are aware that the motor control market is growing rapidly because our LinkSwitch-TN non-isolated integrated switcher is used as the bias supply for motor control systems. Many appliances don't need isolation and the bias supplies need only a few hundred milliamps of current – a perfect application for our family of low-cost offline bucks.

Bodo Arlt:
Do we expect more monolithic solutions?
Doug Bailey:
Absolutely. As the name Power Integrations implies, we believe in integrating as much onto a single piece of silicon as possible. Integration simplifies the power supply substantially because it enables us to include thermal protection and SOA protection for the MOSFET, almost all of the feedback loop circuitry and the start-up circuitry into one die. This obviously saves the customer money by eliminating components – but there are non-obvious benefits, too. Reducing the component count increases production line throughput, reduces purchasing and component inventory headaches, increases reliability by eliminating sources of failure, and makes the board smaller, which can often save costs or add flexibility in the enclosure.

Bodo Arlt:
Do we expect to see more high-voltage IC technology in the line voltage range?
Doug Bailey:
PI's bread and butter is our high voltage technology and all of our products include it. The lowest voltage product that we currently make is a 200V device used for DC/DC conversion and for PoE. It turns out that PoE only really needs a 150V MOSFET, but our customers appreciate the extra safety margin.

Bodo Arlt: Who are your competitors you believe will stimulate the race for leadership?
Doug Bailey:
I'd rather not make personal predictions regarding our competitors. However, generally, I believe those who innovate and who provide the best customer support will have the best chance of influencing customer designs.

Bodo Arlt: Are you ready for 2007?
Doug Bailey:
Yes. We see 2007 as being another solid growth year for PI. We introduced a number of new products in 2006 that have been designed into major applications and expect to see substantial revenue being generated from these introductions in 2007. We have more new products coming that customers can look forward to building into their designs. Energy efficiency and meeting the new regulatory challenges at reasonable cost continue to be drivers for product development, and we are looking forward to working to convert more inefficient linears to highly efficient switchers over the coming months.

Bodo Arlt: Thank you, Doug, for the time and we look forward to a successful future for power management.
Doug Bailey:
Thank-you Bodo. Congratulations on the launch of your new magazine, it's a great read.

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Taking Miniaturization of Current Measurement to the Next Level

Energy savings for applications by enabling current control

Today's Power Electronics world is experiencing a trend towards a greater degree of integration with a lower components count. This orientation can be seen everywhere, not only for electronic components, but also for the other areas of power electronics, like heat sinks, magnetics and coils.

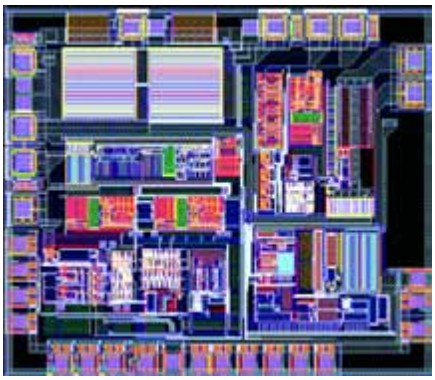
By Stéphane Rollier, Bernard Richard, David Jobling / LEM

In this field, MEMS (Micro-Electro-Mechanical-Systems) is rising as a key technology. We have already seen some good examples in the sensing field and this is an invitation to look at assemblies differently in the future.

In order to respond to the market demands Power Electronics products -such as drives - will push new technologies resulting in integration, cost savings, and size reduction. This will lead to an easier integration of larger sub-systems at a cost effective price. Finally, the only limitations will be from the external constraints of creepage, clearance and isolation levels.
Working within these driving forces, smaller and lower cost transducers can help to improve the total innovation and integration of the system, offering more cost effective solutions to the consumer.
These transducers are becoming interesting for applications in which this criteria is essential such as white goods or air conditioning.
Until today, due to their designs (size) and costs, traditional transducers were not able to address these markets.
To achieve these goals, some compromises in performances were necessary.

An initial step towards miniaturization was made when LEM produced its first **ASIC** (Application Specific Integrated Circuit) at the heart of the famous LEM LTS current transducer.
The main advantage was undeniably the size for a PCB mounted current transducer using Hall Effect Closed Loop technology (22.2 L x 10 W x 24 H mm).

A few years later, more new products were issued for dedicated use with Hall Effect Open Loop technology. A multitude of current transducers were launched based on this special ASIC version, the smallest measuring only 18.7 L x 16.7 W x 10.7 H mm.
The ASICs (Picture 1) utilized were an important step towards the miniaturization, thanks to the electronic integration onto one unique chip.



Picture 1: LEM ASIC with Hall effect cells.

The ASICs selected integrate a vital part of the electronics taking the traditional current transducers (field sensing elements, all active electronic components such as amplifier, transistors, diodes, Zener, voltage reference, ect) into an integrated circuit. Thanks to the use of silicon technology, some specific functions and improved performances such as better offset and gain drifts have been possible.
The core elements of current transducers like the magnetic circuit and the case (encapsulating the whole parts of the transducer) are not part of the miniaturization as they have to be added around the ASIC itself.

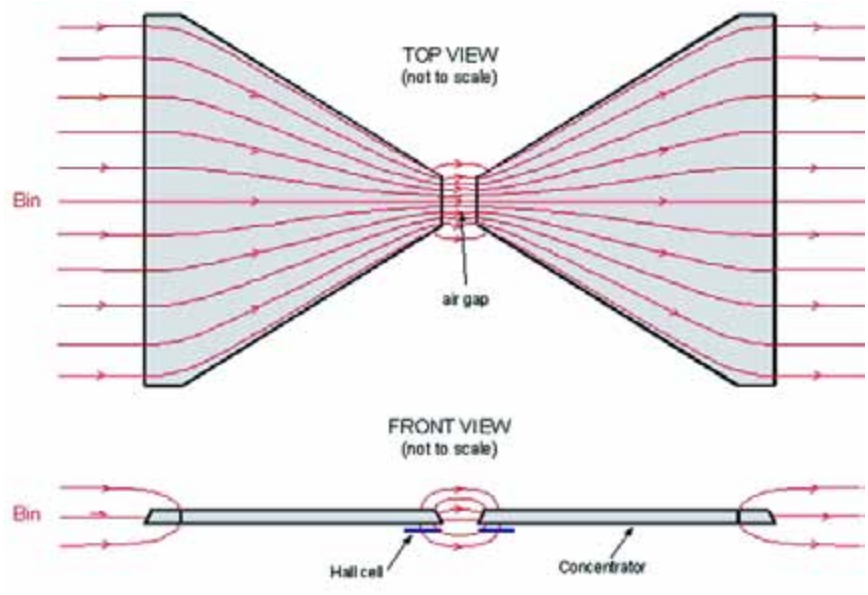
The next step towards miniaturization was to include these remaining core elements into the ASIC. This is what LEM achieved with **Minisens / FHS** model (Picture 2).

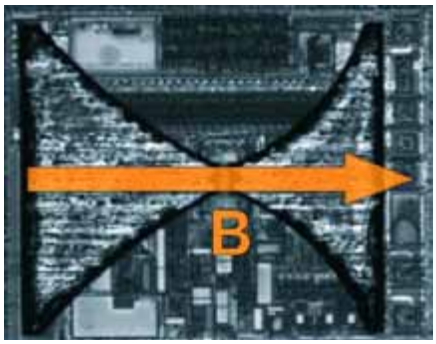
Picture 2: LEM Minisens / FHS model

Working principle :
LEM has developed an integrated circuit (IC) current transducer called **Minisens / FHS** model which converts the magnetic field of a sensed current into a voltage output. This 'primary' current flows in a cable or PCB track near the IC and is electrically isolated from it.

Hall Effect devices integrated in the IC are used to measure the magnetic field, this field being focused in the region of the Hall cells by magnetic concentrators placed on top of the IC (see Figure 1a, 1b, 1c and 1d).

The shape of the concentrators has been optimised in terms of sensitivity (gain) and linearity for the magnetic fields that will be





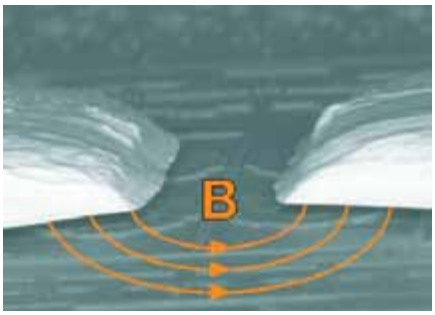


*Figure 1a, 1b, 1c & 1d: Magnetic concentrators used in **Minisens***

encountered with the current levels to be measured in typical PCBs.

The concentrators produce a noise-free gain of about factor 8. The output of the Hall cells is upconverted in frequency by spinning techniques so that low magnetic fields may be detected without problems of offsets or 1/f noise. The IC sensitivity to the magnetic field of the primary current is 600 mV/mT max.

This is the basic working principle of the Hall Effect Open Loop technology but brought into a concentrated IC.

The current sensed can be either positive or negative, no restriction. The polarity of the magnetic field is detected to generate either a positive or negative voltage output around a voltage reference defined as the initial offset at no field. As standard, 2.5 V (internal reference) is the initial offset. When external reference is used between + 2 to + 2.8 V (user choice), this last one represents the initial offset at no current.

Example :
Let's take a simple case to illustrate the current => magnetic field => output voltage conversion.
An infinite long and very thin conductor generates a flux density around it:

$$B = \frac{\mu_0}{2\pi} \cdot \frac{I_P}{r} \quad \text{(T)}$$

where
I_P: the current to measure (A)
r: the distance from the center of the wire
μ_0: the permeability of vacuum (physical constant, $\mu_0 = 4 \cdot \pi \cdot 10^{-7}$)

If Minisens is now placed in the vicinity of the conductor (with its sensitivity direction collinear to the flux density B : Figure 2), it will sense the flux density and the output voltage will be:

$$V_{OUT} = G \cdot B = G \cdot \frac{\mu_0}{2\pi} \cdot \frac{I_P}{r} = 1.2 \cdot 10^{-4} \cdot \frac{I_P}{r}$$

where G is the sensitivity of the FHS 40-P/SP600 model (FHS model with a field sensitivity programmed at 600 V/T)

Hall Effect cells usually are sensitive to perpendicular magnetic fields where it is the opposite the **Minisens** (parallel sensitivity). This is the result from the concentrator's action.

The resulting sensitivity for the current measurement is therefore:

$$S = \frac{V_{OUT}}{I_P} = \frac{1.2 \cdot 10^{-4}}{r} \text{ (V/A)}$$

This is of course valid for a conductor located underneath or above the **Minisens**.

Figure 3 shows how the output voltage decreases when r increases.
Note that the sensitivity also depends on the primary conductor shape.

The measuring range limit (IPM) is reached when the output voltage reaches 2 volt. This limit is due to electrical saturation of the output amplifier. The input current or field may be increased above this limit without risk for the circuit. Recovery will occur without additional delay (same response time as usual).

The maximum current that can be continuously applied to the transducer (I_{PM}) is only limited by the capacity of the primary conductor.

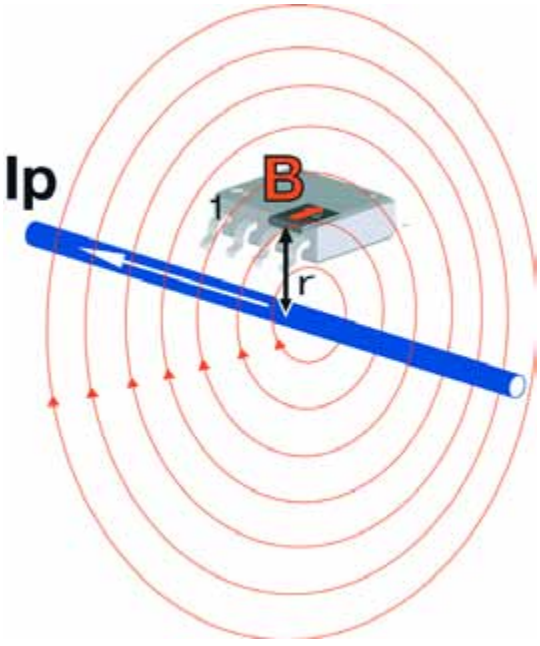


*Figure 2: **Minisens** orientation to measure the magnetic field generated by a current along a conductor.*

This is the theory of the working principle, but this does not really explain the reality where the conductors are not round and thin.
The most common way to utilize the Minisens is to locate it on a PCB track where the current that needs to be measured is flowing.
Some simple rules need to be applied with regards to the track dimension, in order to optimise the function of transducer.

According to the PCB and tracks configuration, it is possible to measure different current values from some Amps such as 2 Amps up to 100 Amps, by ensuring various needed insulation levels.
Among all the various configurations, it is possible to have the current track right underneath the IC with a single track.
Let's call this design **"Design 1"**(Figure 4).

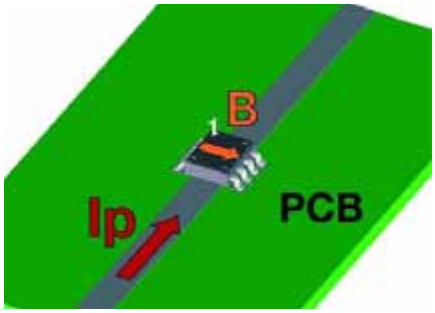


Figure 4: One possible PCB design, the track is located underneath the Minisens

In these conditions, the situation for Minisens is as follows:

- Isolation is provided by the PCB itself.
- Possible current from 2 to 20 A.

To improve the insulation capacity, it is possible to place the track just underneath the IC, but on the opposite side of the PCB leading to a different sensitivity (mV/A).
Various PCBs can be considered, 1.6, 2.4, 3.2,... mm thickness, as various thicknesses are also possible for the tracks, 35, 70, 100... µm (inner or outer layout).These elements are part of the sensitivity (mV/A) calculation, as they directly influence the distance between the sensing elements (located into the IC) and the position of the current (primary conductor).

The sensitivity (mV/A) depends on the distance between the sensing elements and the track carrying the current.
It also depends on the width of the track as represented in **Figure 5**.
It is important to notice that the thinner the width is, the greater the sensitivity becomes.

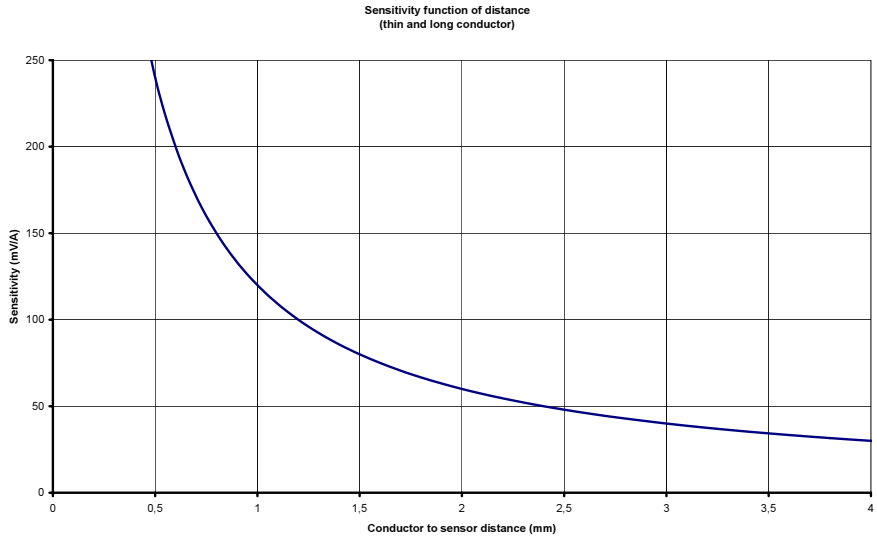


Figure 3: Minisens sensitivity versus the distance between the sensing elements and the primary conductor

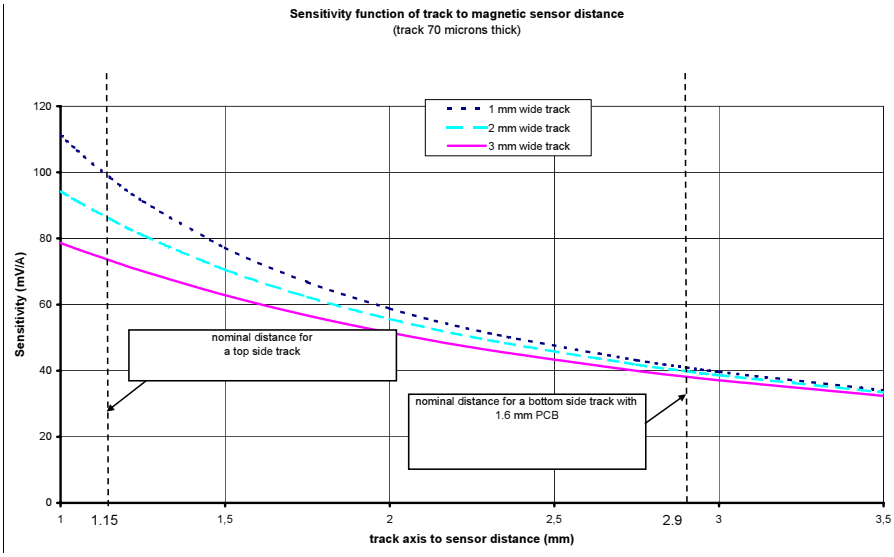


Figure 5: Sensitivity (mV/A) versus track width and versus distance between the track and the sensing elements.

However, the thinner the track is, the quicker the temperature rises.

The maximum current that can be safely applied continuously is determined by the temperature rise of the track. The use of a track with varying width gives the best combination of sensitivity and track temperature rise.
The copper temperature is limited by the PCB material glass transition temperature (135°C), when the Minisens' maximun operating temperature is of 125°C. For precautions and safety margin reasons, it is best to work with a maximum temperature at the track level of 115°C (UL advises a limit at 100°C).

To keep these temperature levels, the track design is really important and many widths, thicknesses, shapes can be thought to optimise them.

For low currents (under 10 A), it is advisable to make several turns with the primary track to increase the magnetic field generated by the primary current.
As with a single track, it is better to have wider tracks around the **Minisens** than under it (to reduce temperature rise) : Let's call this design **"Multi-turns" design (Pictures 3 and 4)**.

For example, it is possible to have a 4 turn tracks design (Figure 6 + Picture 4) underneath the Minisens on the opposite side of the PCB, resulting in a high insulation configuration.

Another way to increase the sensitivity is to use a narrower track.

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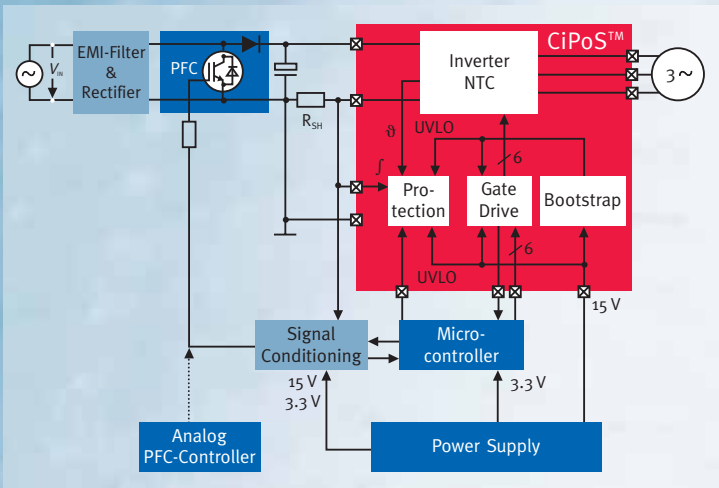

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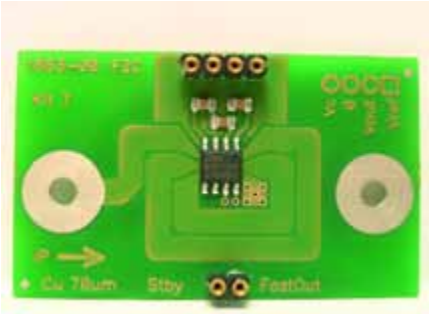

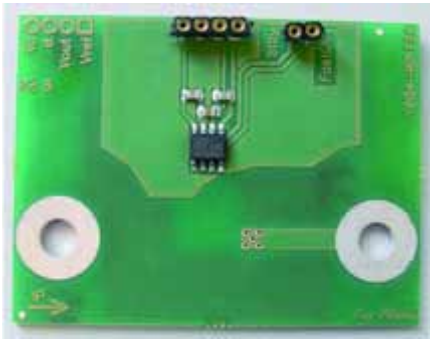

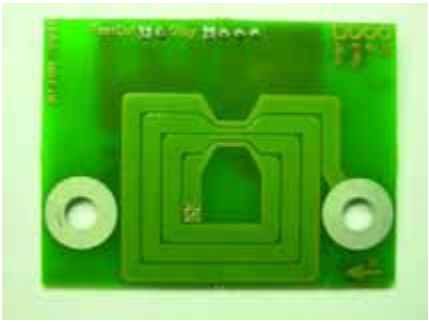

Pictures 3 and 4: Possible "Multi-turns" designs.

The high insulation results from the improved creepage and clearance distances, as the primary conductor (4 turn tracks) is located on the reverse side of the PCB vs the low voltage parts of the electronics. In the present case, 8 mm for both distances are ensured (PCB characteristics: 1.6 mm / 70 ìm Cu) (Track width: 0.78 mm under Minisens, 3 mm elsewhere).
With this design, you can measure up to 5 A as nominal primary current with a 85 °C ambient temperature (Conditions: Natural convection, 30 °C track temperature rise). The measuring range is of +/- 15 A, with a sensitivity of 130 mV/A as 2 volt are reached at the output for 15 A current raising.

To further increase the sensitivity other designs are possible, such as the use of a "jumper" (wire) going on **Minisens** to create a loop with the PCB track. It is also possible to realize multi turns with different PCB layers, or to measure larger current by positioning the primary conductor further from the IC.

Designs are unlimited, under PCB designers control, and can lead to needs for insulation, nominal current to measure, sensitivity optimisation ect: **This is full design flexibility.**

Parameters:
Many parameters in the **Minisens** may be configured by an on-chip non-volatile memory to adjust the transducer's gain, offset, polarity, temperature drift and gain algorithm (proportional to, or independent of, VDD).

Two outputs are available: one filtered, to limit the noise bandwidth, and one unfiltered which has a response time under 3us, for current short-circuit or threshold detection. This is the output from a sample and hold circuit, and the discrete sample values are not filtered.

Minisens operates from a + 5 V power supply. To reduce power consumption in sensitive applications it has an optional input from an external signal which places it in a standby mode. It is manufactured in a standard CMOS process and assembled in a SO8-IC package.

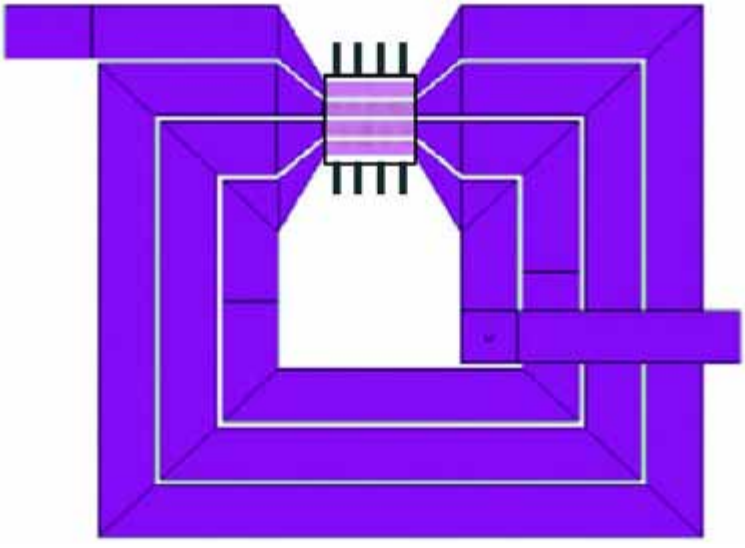

Figure 6: 4 turn track design / High insulation configuration : LEM's Kit n°: 8.

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

- The sensitivity (V/T) error (+/- 3 %)
- The tolerance on the initial offset at no field (+/- 10 mV)
- The non-linearity error (+/- 1.5 %)

this does not represent the accuracy in the final application.

When we speak about the accuracy, it has to be seen in the overall conditions of use that means when the transducer **Minisens** is soldered on the application PCB. Then, several other parameters that influence the accuracy and are not linked to **Minisens** itself have to be taken into account such as:

- The distance and shape variations of the primary conductor vs the IC as well as the IC placement error on PCB (let's call them the "mechanical design parameters"),
- The adjacent perturbing (stray) fields.

The final sensitivity (V/A) is directly depending on the "mechanical design parameters".

Each inaccuracy or change in its "mechanical design parameters" will lead to a change into the final sensitivity (V/A) vs the initial expected one, what could be considered as an error.

As "mechanical design parameters" that result mainly from varying dimensions in an industrial production, we can list:

- The solder joint thickness
- The copper tracks thickness
- The PCB thickness
- The primary track width
- The positioning of the IC along the Y axis
- The rotation of the IC around the X and Z axis

In order to be able to reproduce the same accuracy in the final application for each similar mounting, the position and shape of the primary conductor and **Minisens** location have to be always the same or the nearest ones.

The use of in-circuit calibration of the Minisens is a possible way to avoid most of these errors such as those coming from the

"mechanical design parameters", the sensitivity, the tolerance on the initial offset (The existing micro controllers can be a tool for ASIC programming).

If we look along a defined temperature range, then, 2 other parameters have to be taken into account : The temperature drift of the **Minisens**' sensitivity given at +/- 300 ppm/K, and, the offset drift given at +/- 0.15 mV/K.

To conclude here is a summary of the undeniable advantages brought by the transducer:

- It is compact and mounted as part of a standard PCB assembly process. This is really helpful in applications where space and weight are limited
- It does not cause losses in the primary, and being electrically isolated, it is independent on the level of the primary common mode voltage. The degree of electrical isolation can be determined by the PCB design – for example, a primary track on the opposite side of the board to the Minisens gives best isolation. No need for additional components to achieve the required isolation (no additional costs due to the need of an opto-isolator or isolation techniques)
- A track on the same side gives the highest sensitivity. The sensitivity, expressed in terms of the IC output voltage, can be in the range of 20 mV to 200 mV per ampere of primary current,
- Low dv/dt sensitivity, low noise, low thermal drifts (gain and offset) and really good linearity.

Several PCBs have been developed to demonstrate **Minisens** as a current transducer in different applications, and to validate simulations which were made to predict the transducer sensitivity. These are available on request for application testing.

LEM design guides are available to orientate and advise PCB designers in the building of their PCBs when using **Minisens**, in order to optimise the use of the transducer.

The combination of different **Minisens** configurations and different PCB designs results in a very versatile and inexpensive current transducer. This opens the opportunity to benefit from isolated current measurements in new applications where it was previously not feasible such as the motor control of household appliances applications or for current overload detection. Low cost UPSs as well as battery chargers can benefit from Minisens to ensure the current control as well as the fault protection or to detect current presence.

This fault protection function has to be fulfilled for electrical shutters, door openers and equipments of that nature.

Minisens will enable energy savings for applications by enabling current control. The precise data provided by **Minisens**, will allow power electronics to drive the motor more efficiently and with less losses.

Minisens meets EN50178 standard, the reference for industrial applications.

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High Power IGBT Module Concept

Extended temperature range for modern converter design

The PrimePACK™ family is a new power module concept that is specifically designed to be integrated in modern converter setups. The most important electrical improvements concern the modules stray inductance as well as its interface to the driver board and the connection to the load circuitry. The design also focuses on improving mechanical aspects resulting in benefits regarding thermal shock test and power cycling. The operation temperature $T_{vj,opmax}$ is increased by 25K to 150°C. Studies on the device performance based on measurements are presented.

By G. Borghoff, H. Ludwig, O. Schilling, M. Wölz, Infineon

Introduction

The IGBT has become the most common semiconductor in modern converter design. From the beginning, the development of housing concepts has been pursued in parallel to the progressive evolution of the silicon components. The housing has to fulfil mechanical, electrical and thermal requirements in order to form a proper interface between the silicon chips and the converter surroundings. Well established designs for example are half-bridge and single-switch modules with 62mm baseplate width or the IHM standard that evolved in 1993 (1) and is employed under industrial and rolling stock conditions. The Econo based housing-principle (2) is characterized by its flat geometry and the higher degree of integration with up to three phase legs in one module. The concept has been developed further, leading to the well established EconoPACK™+ standard in 2000 (3). In this work, the PrimePACK™ concept with its main data and family line-up is presented. The succeeding parts of this paper deal with the improvements the thermal, electrical and mechanical features of this newly developed module.

PrimePACK™ module line-up

The following table summarizes the range of types that is realised within the PrimePACK™ family, based on 1200V and 1700V IGBT4 chip technology (5,6). The current range from 450A…1400A/1200V and 450A…1000A/1700V is covered by two module sizes. The rating is referring to the electrical configuration of a half bridge. Thus, PrimePACK™ power modules are suitable for medium power range converters, driving up to approximately 540kVA for the smaller PrimePACK™2 or 800kVA if the larger version PrimePACK™3 is considered.

	V_{CES}=1200V, Half bridge	
I_c[A]	PrimePACK™2	PrimePACK™3
450	FF450R12IE4	
600	FF600R12IE4	
900	FF900R12IE4	
1400		FF1400R12IE4
	V_{CES}=1700V, Halfbridge	
450	FF450R17IE4	
650	FF650R17IE4	
1000		FF1000R17IE4

Table 1: PrimePACK™ module line-up for 1200V and 1700V.

The module height is 38mm in accordance with the height of the worldwide established IHM-type. The footprint exhibits a rectangular shape; the baseplate can be fitted tightly to the heatsink by screws in close distance. The smaller PrimePACK™2 has ten, the larger PrimePACK™3 even fourteen mounting locations. On top of the module, AC and DC terminals can be attached to an inverter busbar by means of M8 screws providing a reliable joint with a large contact area. Figure 1 contains a sketch of the two housings.

Figure 1: Mechanical outline PrimePACK™2 on the left and PrimePACK™3 on the right side. Both types form a half bridge configuration with 3 con-nections: DC+, DC- and AC output.

Figure 2: PrimePACK™2 with active booster stage mounted.

Either a driver or a booster board can be mounted on a separate plateau at the front side of the PrimePACK™. The plateau is 15mm below the level of the load terminals thus enabling a busbar to be guided above the driver board. The mechanical and electrical attachment of the PCB is done by M4 screws that guarantee safe contact even under rough conditions like mechanical vibration. Furthermore the possibility to demount the PCB e.g. for maintenance purpose is given. Figure 2 shows a picture of an active booster mounted to a PrimePACK™2.

Increased temperature range

Any increase in current density in the dies leads to additional losses and, in turn, to an increase in the temperature. Today modules

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cope well with up to 125°C, but further up ratings in current density will lead to exceedance of the 125°C limit. Copious investigations of the IGBT4 have been done and have proven its robustness under high temperature conditions. The graph in figure 3 depicts the relation of chip robustness in dependency of the junction temperature.

The measurements done clearly show, that the electrical robustness of the silicon at 150°C junction temperature is sufficient.

However, the higher temperature results in increased stress to the mechanical components of the module as well. Today's test conditions for reliability tests are displayed in table 2. The current values for standard industry modules, marked as "old", have been changed to the values marked "new" for the PrimePACK™ family:

	Temperature Range	
	old	new
	125°C	150°C
Thermal Shock Test	-40°C-125°C ΔT=165K 20 cycles	-40°C-150°C ΔT=190K >20 cycles
Thermal Cycling	T_{Cmin}=25°C ΔT_C=80K 2000 cylces	T_{Cmin}=25°C ΔT_C=80K >4000 cylces
Power Cycling	T_{jmax}=125°CΔ T_j=80K 130k cycles	T_{jmax}=150°CΔT_j =80K >130k cycles

Table 2 : Comparison of thermal test specifications for 125°C and 150°C modules.

The increase in mechanical stress appears in the larger temperature swing during thermal shock test, the higher number of cycles during thermal cycling and the higher upper temperature limit during power cycling tests. As a 25K raise will reduce the lifetime by half, the 150°C module has to be twice as robust as the 125°C module to achieve the same lifetime.

The power cycling capability gains, if the temperature swing is reduced or, at the same temperature swing, the lower temperature limit is decreased. The 130.000 cycles targeted for the PrimePACK™ are not reached for ΔT_j=80K and T_{jmax}=150°C considering present-day standard industry modules.

Additional constructive measures have to be taken. These concern the bondwires, the solder joints between DCB and baseplate as well as connections to the load terminals to fulfil the new specifications and allow the PrimePACK™ to be operated with $T_{vj,opmax}$ of up to 150°C. Raising the operating temperature level allows different ways of optimization:

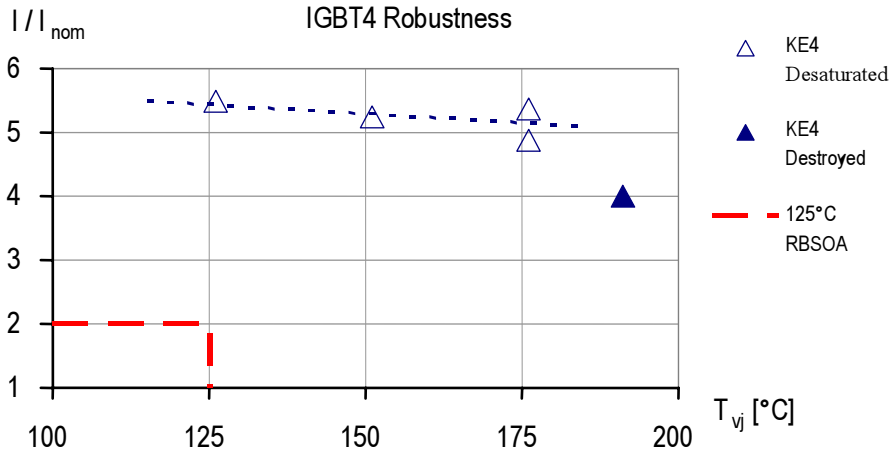

Figure 3: IGBT4, Chip robustness at V_{GE}=±18V and R_G= R_{Gnom}

At customer side, higher current ratings at the same chip dimensions leads to increased inverter output power, smaller heatsinks at the same current level reduce inverter size and costs making use of the 25°C gained, operation at 125°C rated module temperature level increases the margin towards overtemperature, improving the reliability.

As increasing the current density of an IGBT inevitably leads to increased losses, a trade off is necessary. The increased losses as a result of the higher current density are tolerable, as the usability of the chip is increased due to the higher temperature allowed for the junction. The higher temperature allows a larger amount of losses to be extracted from the module which in turn allows the module current to be increased. At a case temperature of T_C=80°C, a switching frequency of f_s=1kHz and a 50% duty cycle the module usability can be increased by 25% as illustrated in figure 4:

As shown in the diagram, with an operating temperature of 150°C, the module current can be raised from 800A to 1000A without exceeding the specified temperature limit.

Electrical features and measurements

A survey is made of the latest demands that result from the behaviour of state of the art silicon technology and from customer feedback concerning the means to control the switching performance of modern devices. As pointed out before, the PrimePACK™ concept is introduced in combination with IGBT4 for 1200V and 1700V technology implying field stop devices and trench gate IGBT cells. Modern silicon devices focus on reducing both, static losses and switching energies, a target that is achieved by increasing the switching speed. This means a higher challenge for control strategies as voltage peaks due to parasitic stray inductance become more pronounced. A number of works point out, that additional effort has to be spent in driver development (9,10). Therefore, a major requirement is to focus on a low inductive module design that fits into a low inductive circuitry.

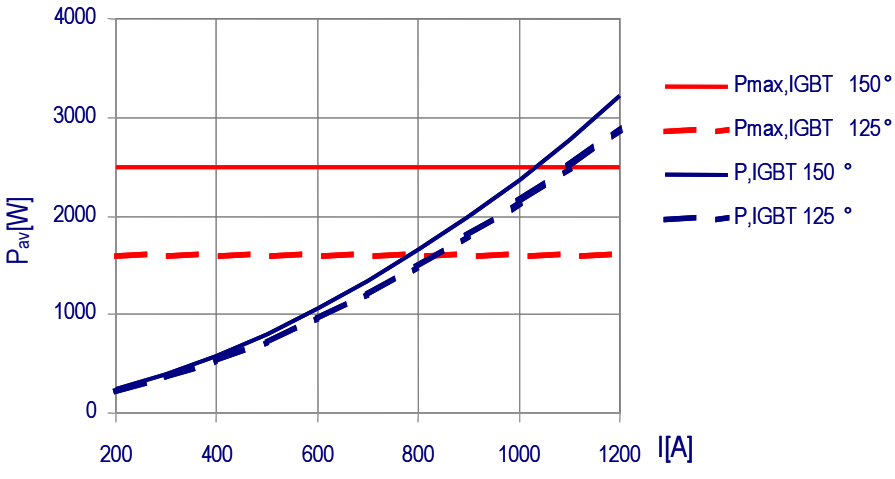

Figure 4: Module losses as a function of current at constant junction temperature

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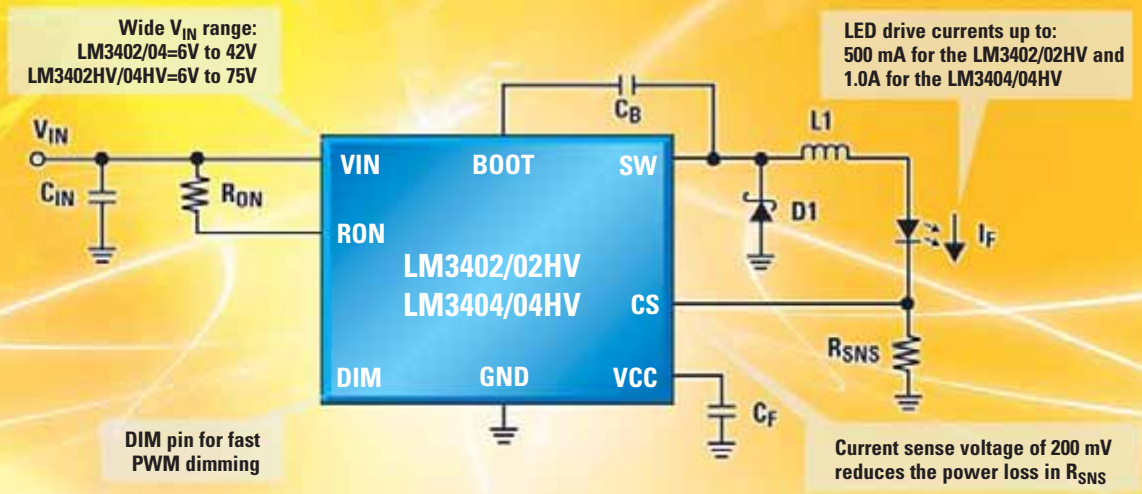

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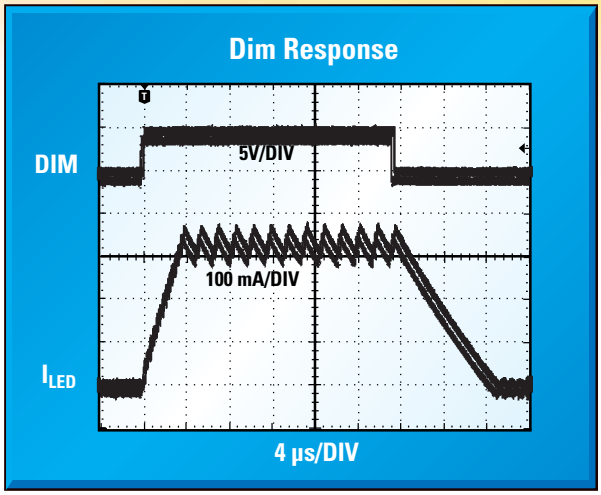
- Constant on-time control with voltage feed-forward for nearly constant switching frequency over the full line voltage range
- Low 0.2V feedback reference minimizes power losses
- Low shutdown current when R_{ON} pin held low
- High voltage capability supports long strings of LEDs
- Choice of 0.5A or 1.0A peak current capability (LM3402/LM3404)



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The Sight & Sound of Information

The most widespread converter concept is based on the 2-level inverter that consists of three half bridge legs producing output current for three phased applications. The effective stray inductance is defined by the loop inductance from the DC-link capacitor through one respective half bridge. Parasitic inductances from the DC-link as well as inductances inside the module contribute to the overall stray inductance of the set up. The schematic circuitry for one phase leg, including the parasitic inductances, is given in figure 5.

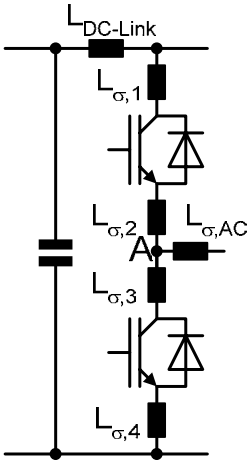

Figure 5:Schematic of one half bridge leg including the parasitic inductances.

The minimization of the parasitic inductance at commutation is achieved in the PrimePACK™ concept by two means:

- The point of commutation marked “A” in fig. 5 is shifted as close to the silicon dies as possible, reducing $L_{\sigma,2}$ and $L_{\sigma,3}$ to below 1nH.
- The inductances of the DC terminal contact, $L_{\sigma,1}$ and $L_{\sigma,4}$ in fig. 5 are reduced to less than 10nH for the PrimePACK™3 by applying alternating finger shaped terminals.

Both rules explained above are realized in the larger version, the PrimePACK™3. From the measurements done, $L_{\sigma} \leq 10nH$ is confirmed for one phase leg of a half bridge.

In order to ensure safe switching under a variety of conditions, hard switching investigations are done on a module type FF1000R17IE4 PrimePACK™. The results are given below. The displayed waveform in figure 6 is a turn-off event at a current of IC=900A and a typical DC-link voltage UDC=900V, which is commonly used in the application of 1700V modules.

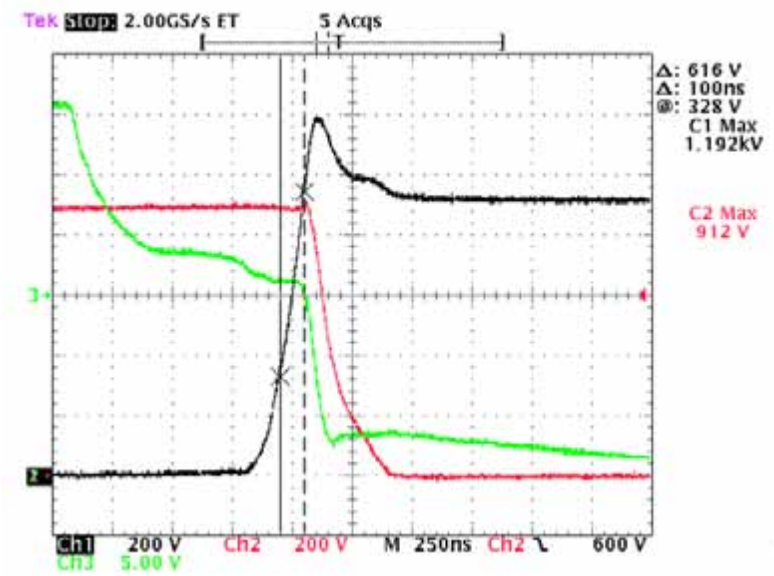

Figure 6: IGBT turn-off at T=25°C, UDC=900V, IC=900A. DUT is FF1000R17IE3
Red: I_C, black: U_{CE}, green: U_{GE}

The turn-off curves are smooth and agree with demands resulting from EMC compatibility. The gate resistor is chosen to achieve a high du/dt of ~5kV/µs which is necessary to limit switching losses. The overvoltage peak is well controlled, does not surpass 1200V and stays safely below the device limit of UCES=1700V. This is an immediate consequence of the low inductive design characteristic.

The turn-on behaviour has also been studied and an example, also recorded at rated current IC=900A and UDC=900V, is presented in figure7. It confirms the smooth switching behaviour and the fact, that the module layout supports the device performance of modern IGBT3 very satisfactorily. Again the gate resistor is chosen to achieve a comparably high di/dt of about 7500A/µs, enabling the reduction of turn-on losses and demonstrating, that safe switching is possible even under extreme conditions.

As a conclusion it can be stated that the electrical performance meets the targets set from the beginning. An outstanding feature is the low value of the internal stray inductance of the presented design. Of course an according low inductive inverter design is necessary to fully benefit from this device feature. The feature of Tvjopmax=150°C maximum allowed junction temperature leads to increased current density pushing the limits for modern inverter power density even further.

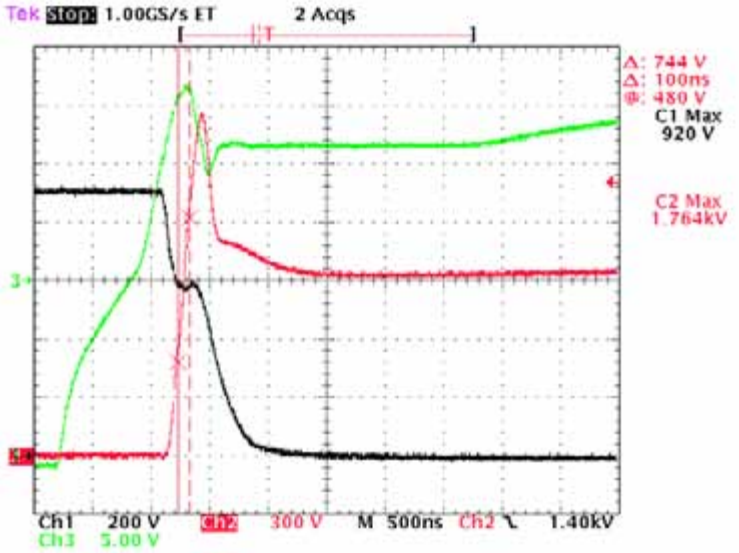

Figure 7: IGBT turn-on at T=25°C, U_{DC}=900V, I_C=900A. DUT is FF1000R17IE4.
Red: I_C, black: U_{CE}, green: U_{GE}

Integration in a modern converter

A modern converter design has to comply with technical and economical criteria. The new module offers the possibility to utilize the installed current to a high degree and it makes control of fast commutation easy as pointed out in the preceding parts of this work. Furthermore it offers many flexible solutions as far as the connection to the converter busbar and the heatsink of the converter is concerned. In figure 8 and 9, side views of two possible integrations of the PrimePACK™ into a power converter are shown. Figure 8 depicts how the new module can be integrated in a converter if a laminated three layer busbar is preferred for the external electrical load connections. Since the plateau that carries the driver PCB is on a lower level compared to the load terminals of the module, a busbar can be guided above the driver PCB.

It depends on the level of DC supply voltage in the load circuit whether an additional insulation on the bottom side of the lower layer is necessary to ensure safe insulation towards the driver.

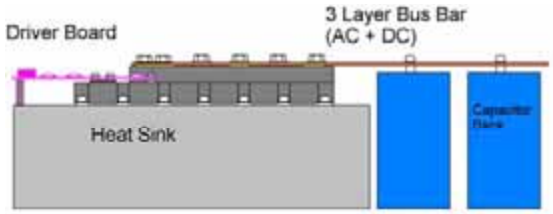

Figure 8: PrimePACK™3 linked to a 3 layer busbar containing DC and AC load connections.

Multi layer busbars are liable to increase the system costs. An economical solution that employs only a 2 layer busbar is sketched in figure 9. The AC load terminal is excluded from the busbar system and is made of a simple copper connector. The PrimePACK™ also supports this solution because the AC load terminal of the housing is spatially separated from the DC-connectors.

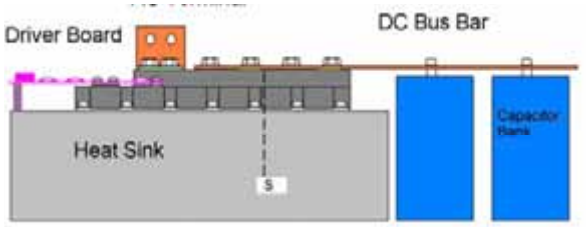

Figure 9: PrimePACK™ linked to a 2 layer busbar. The AC load terminal is screwed to a separate load connector.

For the sake of clarity the components of the inverter are lined up in one orientation in figure 8 and 9. A further reduction of total stray inductance could be achieved, if the capacitor was orientated at the long side of the IGBT modules.

Finally the PrimePACK™ concept offers a lot of flexibility. The user has the freedom to apply both versions in one inverter design. If the Inverter supports the mounting of the PrimePACK™3 as presented in figure 9, the PrimePACK™2 can be used in the same inverter periphery because the distance between baseplate screws and the position of the load terminal screws is identical for both types. This is illustrated by the dashed line “S” in figure 9 that indicates the termination of the PrimePACK™2 if it was used in the same inverter. The application of both PrimePACK™ versions in one inverter family is furthermore simplified, because the geometry and position of the auxiliary terminals on top of both housings stays the same for both types as depicted in figure 1, which makes it possible to use one driver PCB-geometry for both modules.

Conclusion

The PrimePACK™ design is characterized by a slim geometry of the power module. It has advantages both in thermal and electrical respects. It supports enhanced heat spreading inside the module and from the module baseplate to the heatsink. Additionally, it focuses on a low internal stray inductance of ~10nH for the whole commutation loop if the large version is considered. The housing concept is flexible and offers economical solutions concerning the mechanical integration into a power converter. Inverter output power gains from the feature of operating the device with up to 150°C junction temperature.

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Low-Loss IGBTs for Sub-2.5kW Inverter Applications

Better trade-off between device electrical performance and ruggedness

New depletion-stop trench IGBT technology combines low switching losses with the traditional IGBT advantage of low conduction loss for applications such as voltage domestic- and industrial-motor drives in the 2-30 kHz range.

By Vijay Bolloju, Chiu Ng, and Jie Zhang, International Rectifier

<IGBTs have traditionally addressed applications requiring high-voltage and -current ratings and relatively slow switching frequencies. When the switching frequency is low, the inherently low conduction losses resulting from the device's low VCE(on) (collector-to-emitter saturation voltage), which derive from the IGBT's minority carrier operation, outweigh the traditionally poor switching performance, enabling high overall operating efficiency. Mains-voltage applications such as energy-saving variable-speed motor drives can benefit from IGBTs' low on-state losses, which are lower than the corresponding losses in a power MOSFET. However, hard-switching designs operating at frequencies from 2-30kHz require improvements to the traditional IGBT's switching performance.

IGBT loss mechanisms

The latest-generation IGBTs, which benefit from depletion-stop trench technology, address the requirement for low conduction and switching losses, and carry up to 60% more RMS current than the previous generation of devices. This results in smaller discrete IGBTs and IGBT modules, and enables designers to reduce heat sink size significantly.

Switching losses in IGBTs result from the slow dispersal of holes in the drift region after the gate-emitter voltage falls below the threshold voltage to turn the device off. Either the holes recombine or a voltage gradient sweeps them out. Until this process completes, the IGBT exhibits a tail current, which slows the switching speed and increases switching losses. The PT (punch through) IGBT introduced a buffer layer adjacent to the drift region to quickly absorb remaining holes during turn off and, thereby, eliminate the excessive tail current.

However, this enhanced switching performance is at the expense of higher VCE(on). In addition, PT IGBTs do not display the short-circuit-withstand capability most motor-control applications require.

Depletion-stop trench IGBTs

This lost conduction performance can be regained by adopting a trench structure to increase channel density compared to the traditional planar IGBT structure. Other factors that enhance VCE(on) performance include enhanced accumulation-layer injection and elimination of the parasitic JFET resistance inherent in the planar IGBT structure. Introducing a low-dose field-stop layer to the trench IGBT enhances the trade off between VCE(on) and switching loss still further, due to a reduction in the n-base thickness.

The depletion-stop trench technology now enters the next evolutionary stage in this progress toward low IGBT conduction and switching losses. The new depletion-stop layer allows further thinning of the n-base as well as a higher transistor gain and switching speed. In addition, the optimised device displays highly efficient anode properties, enabling enhanced control over minority carrier injection and a lower tail current at turn-off, delivering a further reduction in turn-off losses.

This new thin wafer, depletion-stop trench IGBT technology offers improved efficiency while maintaining the smooth turn-off characteristics and robust SOA (safe operating area) that hard-switching applications demand. VCE(on) and ETS (total switching energy) are both considerably lower than for planar PT and NPT type IGBTs. This combination of low saturation voltage and low total switching energy reduces power dissipation and improve current handling in applications operating at switching frequencies up to 30kHz. These devices also provide higher power density and reduce heatsink dimensions. Some applications can entirely eliminate the heatsink.

A schematic of the depletion-stop trench IGBT device shows emitter N+ regions adjacent to the trench (Figure 1). The fabrication process grows an oxide layer on the trench walls and then deposits polysilicon, filling the trench volume. The base contact and channel form through a P-base diffusion and a heavy P+ implant, respectively. The deep trench extends below the P-base junction to form a gate-bias-induced channel between N+ emitter and N- drift region. The P+ region in the backside of the wafer enhances anode efficiency. The combination of this device construction and the trench structure's high channel density produces a high carrier density in the drift region and a low forward voltage drop.

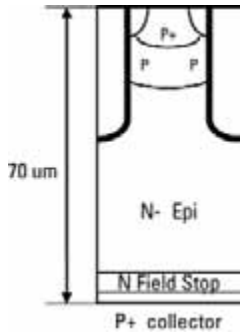

Figure 1: Schematic cross-section of the depletion-stop trench IGBT

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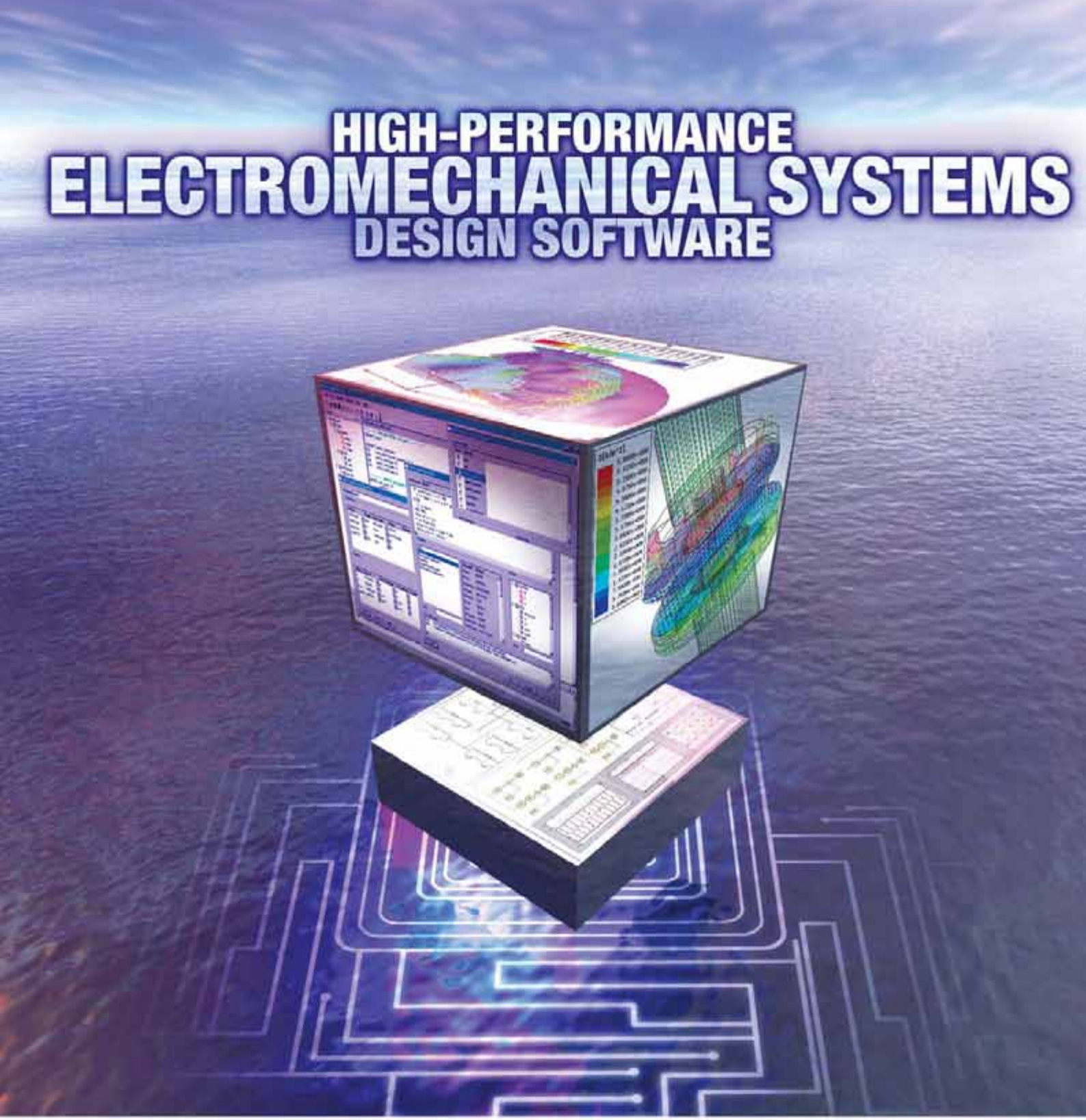

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International Rectifier has developed the depletion-stop trench technology with the aim of maximising IGBT switching performance for appliance- and industrial-drive applications. The device designs optimise carrier lifetime in the drift region, as well as carrier lifetime and doping concentration in the depletion-stop region near the anode. Leakage current and device breakdown voltage both increase with decreasing lifetime in the drift region.

In addition, IR uses a 70-micron-thick wafer, which permits lightly doping the anode. This helps to reduce the total stored charge thereby improving the device's switching performance, especially at higher temperatures.

Optimising the construction, geometry, and doping in this way leads to lower VCE(on) and lower switching losses than the previous PT and NPT IGBT devices. In practical applications, depletion-stop trench IGBTs reduce losses and deliver up to 60% more RMS current than previous generation devices. For a given current, these devices require roughly 50% smaller heat sinks. The technology is suitable both for discrete IGBTs and for emerging families of smart power modules that combine driver circuitry with 600V IGBTs to simplify appliance-motor-control design. Depletion-stop trench IGBT technology enables a typical size reduction of 25% for such integrated modules.

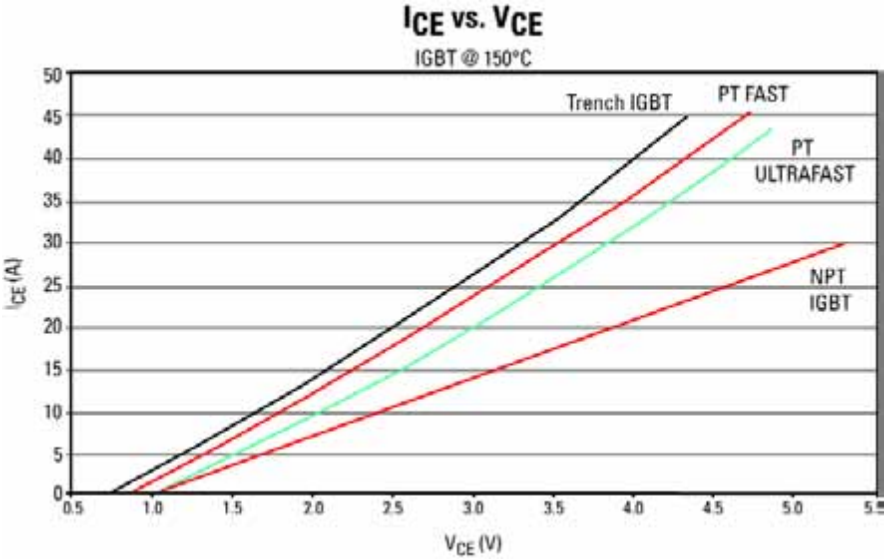

Figure 3: Forward voltage characteristics of various IGBT technologies

First silicon

International Rectifier has fabricated a 600V depletion-stop trench IGBT with a typical threshold voltage of 5.25V and typical VCE(on) of 1.6V. Figure 2 shows the typical depletion-stop trench-IGBT switching waveforms for turn-on and turn-off. In addition to lower losses, the diagram also highlights the much smoother turn-off waveform, smaller tail current at turn-off, and lower turn-off voltage spike for the depletion-stop trench IGBT, leading to reduced EMI. As a result, depletion-stop trench IGBT technology delivers a better trade-off between device electrical performance and ruggedness.

Performance comparison

The new 600V trench IGBT offers lower VCE(on) than previous generation PT and NPT devices, resulting in lower conduction losses (Figure 3). A comparison of switching characteristics again shows that the depletion-stop IGBT operates with smaller losses than previous generation devices (Figure 4).

Designers wishing to take advantage of the new IGBTs need not change their gate-drive circuits because the threshold and maximum gate voltages for these devices are in the same range as for PT and NPT devices. The trench IGBT also has lower total gate charge, shorter propagation delays, and shorter turn-on and turn-off transition times. Thus no modification is needed to the controller's dead-time or minimum-pulse-width settings.

Faster switching brings the risk of spurious turn on of an inverter's low-side device, which fast dV/dt transients can cause. Spurious turn on can result in shoot-through currents that may impair inverter reliability and lead to early failure. However, depletion-stop trench IGBTs display a high ratio of gate-to-emitter capacitance (CGE) to reverse transfer capacitance (CRES), which provides immunity to high dV/dt induced spurious turn-on. This ensures robust performance even at high dV/dt switching conditions.

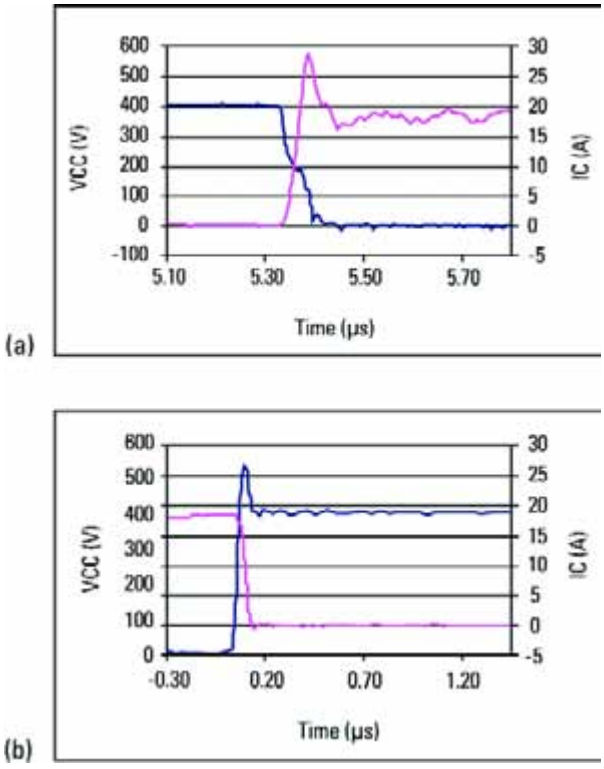

Figure 2: Typical switching waveforms (a) Turn-On and (b) Turn-Off (VCC=400V; IC=18A; L=200µH; RG=22W; TC=25°C)

In terms of forward voltage, switching energy, and RMS current versus frequency characteristics, trench IGBT devices offer improved performance compared to planar IGBTs. The depletion-stop trench IGBT devices clearly show lower conduction and switching-energy losses, leading to greater efficiency in inverter applications operating at high switching frequencies.

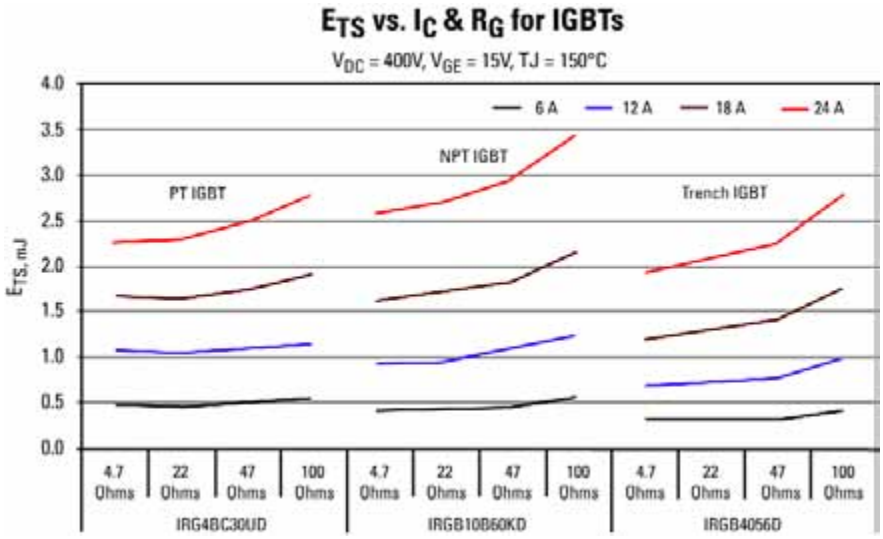

Figure 4: Switching energy characteristics of various IGBT technologies

Reduced stress for enhanced reliability
Further benefits of the depletion-stop trench IGBT include a number of features that provide more-robust performance in motion-control applications. One example is the IGBT's smooth turn-off characteristics under short-circuit conditions, which reduce voltage spikes and stress on the IGBT.

Another benefit is the absence of gate over charging during short-circuits. This can occur in older IGBT structures, leading to an over-current spike that stresses the device and impairs the reliability of the inverter. The trench IGBT's square RBSOA characteristic also enhances robustness by allowing safe switching under severe overload. This, along with high peak turn-OFF capability and good short-circuit rating, will allow more robust and reliable inverters suitable for a wide variety of applications.

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Design Software for Non Isolated SMPS

Using the new VIPer12A and VIPer22A software

To supply the large number of electronics components required for home appliances, different power supply topologies can be used. We focus our attention on small appliances such as washing machines and white goods using non isolated SMPS.

By Giacomo Mercadante, STMicroelectronics

The worldwide home appliance market will increase to about 500 million units by 2010, greatly increasing the number of electronics components inside. New appliances have to be more and more user friendly and flexible. To cope with the constant market change driven by consumer demand, electronic designers are continuously researching new advanced solutions.

To supply the large number of electronics components required for home appliances, different power supply topologies can be used. If we focus our attention on small appliances such as washing machines and white goods, due to the physical layout of these applications, non isolated power supplies can be used.

Switch Mode Power Supply is a very common approach to meet the power needs of today's appliances. In the case of low power applications, a non isolated buck converter (or buck-boost) is the best solution.

STMicroelectronics provides design software to simplify the design of non isolated switch mode power supplies. The user can easily develop an SMPS to control output power up to 17W. Using the VIPer12 and VIPer22, the user can build power supplies with a positive output voltage in buck topology or negative output voltage in buck-boost topology. The software, which has a very friendly GUI, calculates the main electrical and physical parameters, the total dissipated power, plots the main electrical waveforms of the converter and provides the Bill of Materials (BOM).

The user must first insert the input and output data: minimum input voltage, maximum input ripple voltage, input voltage line frequency, hold-up cycles (NH), output power (current and voltage) and output voltage ripple. Starting from the output power, the software will select a part number belonging to ST's VIPer family and depending on the input data it will return the input bulk capacitor value CIN, using the following formula:

$$C_{IN} = \frac{P_{OUT} \cdot \left(\frac{1 + 2 \cdot N_H}{f_L} - 2 \cdot \frac{\arccos\left(\frac{V_{IN(MIN)}}{V_{PK(MIN)}} \right)}{2 \cdot \delta \cdot f_L} \right)}{\eta \cdot \left(V_{PK(MIN)}^2 - V_{IN(MIN)}^2 \right)}$$

During the design, the user can change the part number suggested by the software.

A buck or buck-boost converter works in continuous mode (CCM) or in discontinuous mode (DCM). Which mode to use depends on different factors: the drop voltage between input-output, the switching frequency and the inductor value. Usually DCM is preferred to CCM because it guarantees better system stability, lower switching losses, smaller size and uses a less expensive inductor. Compared to CCM, the major drawback of DCM is the higher peak current, thus more stress on the devices. The software moves from DCM to CCM based on the following formula:

$$I_{O(BOUND)} = \frac{V_{OUT}}{2 \cdot L \cdot f_{SW}} \cdot \left(\frac{V_{IN(MIN)} - V_{OUT}}{V_{IN(MIN)}} \right)$$

For a given output current, the operating mode switches from CCM to DCM if the inductance value decreases, the output power decreases or the input voltage increases.

For given input and output data, the user selects the operating mode and the software automatically returns the inductance value. Conversely, the user can deselect the flag 'automatic inductor calculation', choose the inductor value, and the operating mode will be automatically selected depending on the other boundary conditions.

The function of the capacitor in the output stage of an SMPS is to store energy. The output capacitor value of the buck converter is usually selected to limit the output voltage ripple versus the needed value. This is not an ideal capacitor, but it has a series inductance (ESL: equivalent series inductance) and a series resistance (ESR: equivalent series resistance).

In order to evaluate the output voltage ripple, all series components should be considered. If the switching frequency is lower than approximately 300kHz, the ESL can be neglected and the voltage ripple can be attributed to the capacitor and the ESR. If the user selects the power output stage, the frequency and the inductor value, the software (through appropriate equations) returns the output capacitor value, the ESR value and the RMS ripple current. The calculated ripple can be checked by the output stage software window. If needed, the user can adjust the ripple to the needed value and the software will return the new capacitor and ESR values.

The supply voltage of the VIPerx2 (VDD) can easily be obtained by connecting a diode and a capacitor (CVDD) to the output voltage. The diode voltage rating depends on the input voltage, while the current rating is not an issue. The capacitor value has an impact on the start-up time. Moreover, after a short circuit event, the VDD voltage falls and if the off level of the converter (VDDON - VDDhyst) is reached, a new start-up phase will be enabled. Therefore the time during which the switch is properly supplied changes according to the CVDD capacitor value.

The software returns the CVDD through the following equation:

$$C_{VDD} \geq I_{DD0} \cdot \frac{4C_{OUT}V_{OUT}}{I_D \cdot V_{DDhyst}}$$

The VIPer setting window (see figure 3) provides the calculated value of power losses (PDISS) and the device temperature (TDEV). The total power losses are given by the sum of conduction losses, switching losses, and bias losses. Given the VIPer junction-case resistance (RJC), the device temperature can be calculated by the following equation:

$$T_{DEV} = T_{AMB} + P_{DISS} \times R_{JA} = T_{AMB} + P_{DISS} \times (R_{JC} + R_{CA})$$

In the VIPer selection window, if needed, the user can adjust the ambient temperature and the case-ambient resistance.

An example of a buck converter schematic with a single output is shown in figure 2. The power circuit consists of the input rectifier, a bulk capacitor, the VIPer12A power switch, a free-wheeling diode and the output LC filter. A detailed project BOM can be printed in a text version and the schematic can be saved in JPEG format. Moreover, the mains power supply waveforms (drain current, drain-source voltage and power dissipation) can be displayed and printed (see figure 4). The software comes with documentation and a detailed guide, helping the designer in the step-by-step design of an SMPS using the VIPer12 andVIPer22.

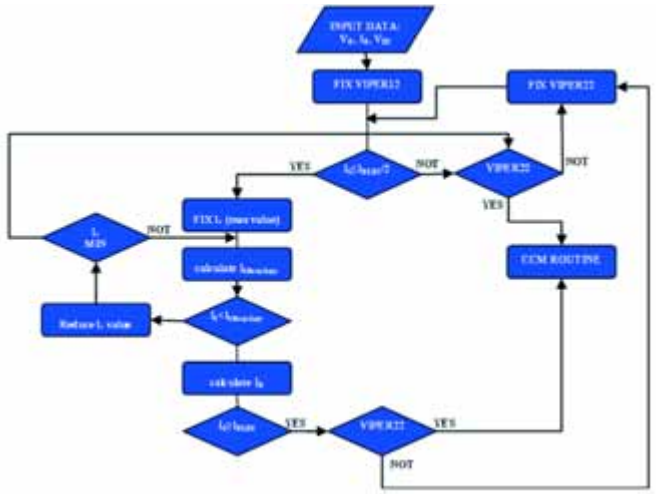

Figure 1. Software architecture

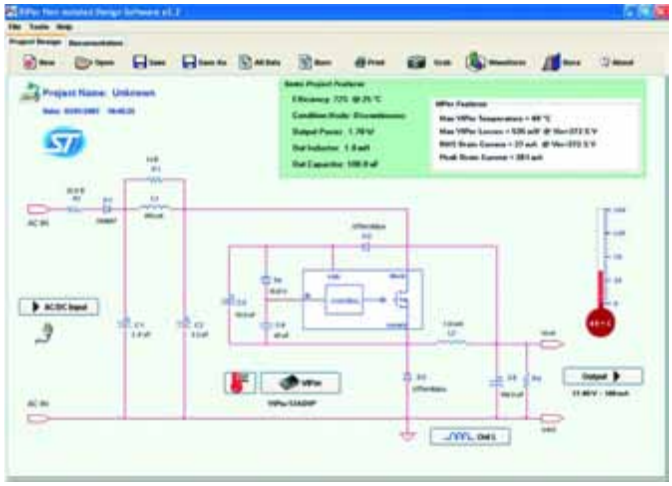

Figure 2. Software schematic window (buck converter)

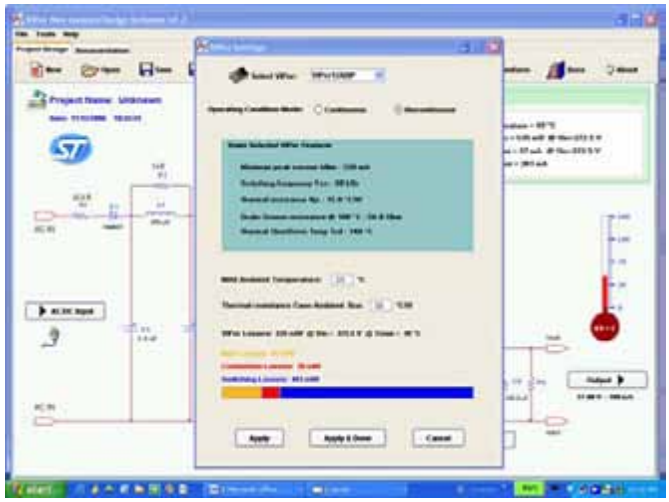

Figure 3. VIPer setting window

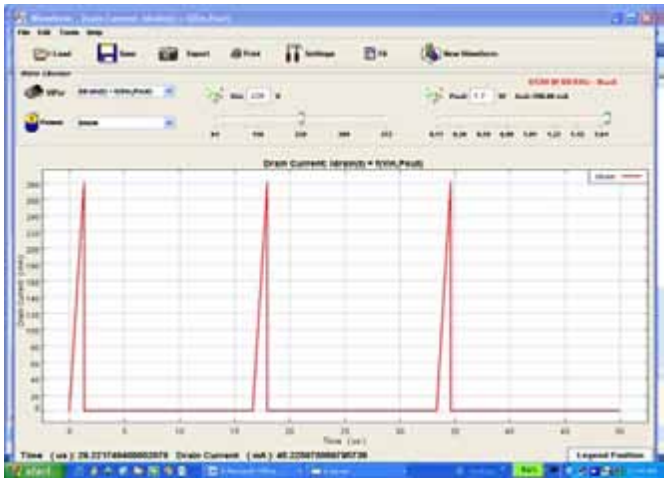

Figure 4. Waveforms plot window

Thermal Management Takes Another Look at Liquid Cooling

Micro-structure heat exchanger should be optimally designed

Recent technical advances are driving the commercial acceptance and use of liquid cooling systems for high heat flux processors in computers and workstations

By Girish Upadhya, Ph.D., Director, Thermal Design & Applications Development
Cooligy, Inc., Mountain View, CA

The thermal characteristics of high-power-density CPUs in today's high-end computing applications are rapidly outpacing the cooling capabilities of most commercially available strategies. The problem lies in three compounding trends: higher total chip power, higher local heat flux in chip hotspots, and smaller system enclosures. Meeting these thermal needs with conventional cooling systems poses a number of challenges, including:

- Eliminating heat with high average heat density, above 100W/cm^2;
- Maintaining consistent die temperature in the presence of local hot spot zones of 1-2mm^2, with power densities of 500W/cm^2 or above;
- Increased system noise due to high-volume air flow;
- Reduced system reliability due to increased numbers of high-speed fans.

Typical solutions include multiple heat pipes, vapor chambers attached to fan heat sinks and optimized fan heat sinks with new designs. Of these, however, none scales for heat flux higher than 100W/cm2, revealing the need for an alternative cooling solution.

Recent pumped-liquid cooling system (LCS) technology advances represent a promising alternative, available today, for cooling high-power-density processors. However, successful implementation requires innovation and careful attention to design details to optimally cool high heat flux chips within a targeted system volume. Key system elements must include (1) a micro-structure heat exchanger capable of high heat flux removal, (2) a reliable mechanical pump for delivering fluid with the required flow rate and pressure, and (3) an efficient liquid-air radiator heat exchanger.

Cooling elements

Optimizing the physical dimensions of the liquid cooling system's heat-exchanger channels, liquid flow rate through the channels, radiator fin surface area, and airflow available for heat rejection can result in very high thermal performance from low airflow volume. This in turn enables system fans to run at lower speeds and more quietly, and where fan noise is not of concern, higher airflow results in even better performance.

A closed-loop LCS for a typical dual-CPU cooling application is shown in Figure 1. In operation, cold liquid enters the micro-structure heat collector at a specific volumetric flow rate, driven by the mechanical pump. The liquid absorbs heat from the CPU, exits the heat exchanger, flows into a fan-cooled radiator, then repeats the process. The pressure drop of the liquid as it flows through the system is managed by an appropriate fluid-delivery mechanism built into the design of the individual components. This concept is readily adaptable to single-CPU configurations, racks, servers, graphics chips, and high-output LEDs, as well as voltage regulators, isolated gate bipolar transistors (IGBTs), power semiconductors and field effect transistors (FETs).

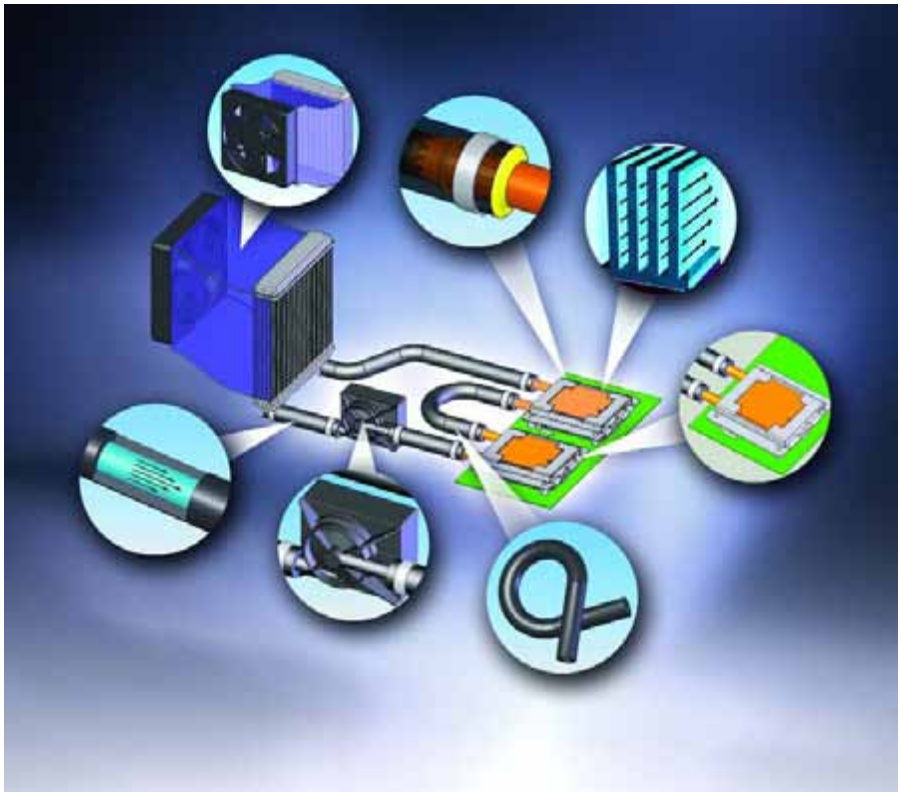

Figure 1. Main system elements of the Cooligy closed-loop Active Micro-Structure Cooling System from Emerson Network Power (insets clockwise from 12 o'clock): leak-free sealed joint; micro-structure heat collector; die attachment mechanism; low-permeability flex tubing; mechanical pump; system coolant; fan-cooled radiator.

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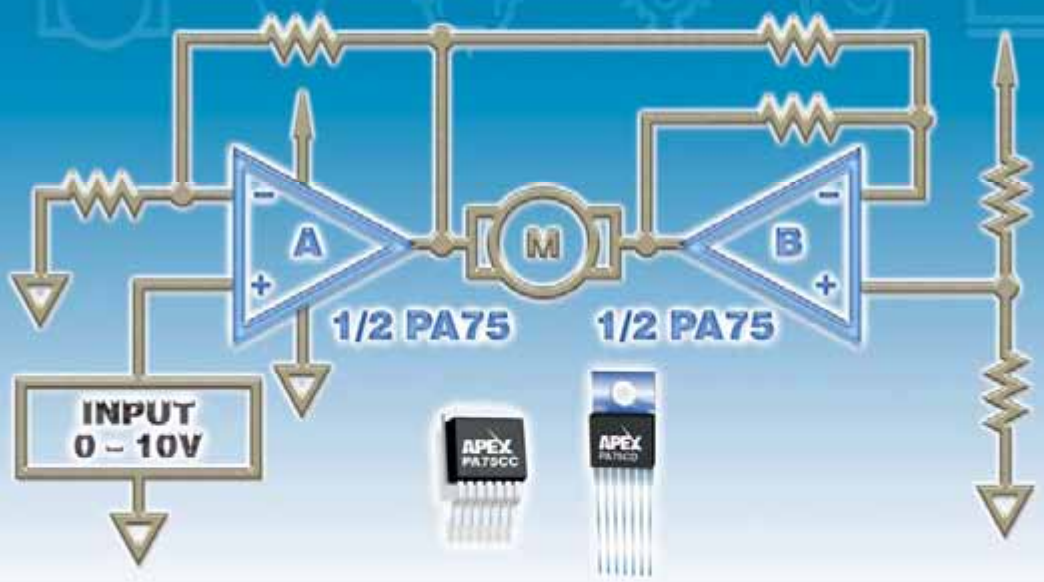

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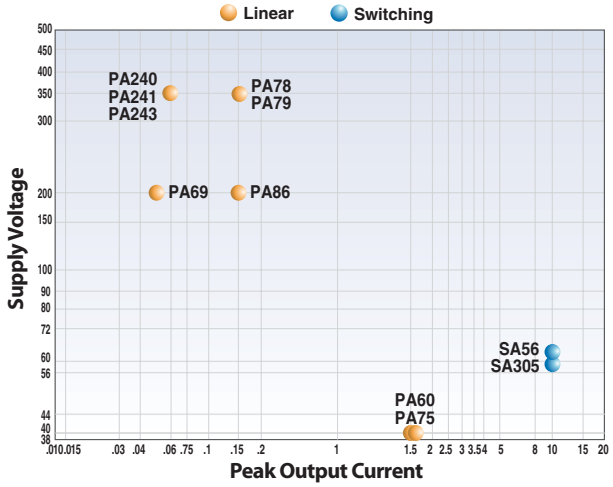

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Performance considerations

Micro-structure heat exchanger — should be optimally designed to accommodate the high heat flux of a high-performance microprocessor. Figure 2 shows the relationship of heat transfer efficiency and pressure drop on channel width. High performance is achievable with fine channel dimensions; however, to reduce the resultant high pressure drop, the fluid-delivery mechanisms must be able to provide very low thermal resistance and high flow rates.

Heat sink attachment — conventional heatsinks mated to the processor package by clips or screws can harm thermal performance due to resulting variations in thermal interface material (TIM) thickness, which requires a novel attachment to achieve device-wide uniformity and optimal performance.

Radiator design — liquid flow rate, fin surface area and tube attributes impact radiator performance. Radiator designs must be optimized through sophisticated thermal tests and various numerical simulation techniques and analytical models that are also used to validate design parameters.

Working fluid — most liquid cooling systems use a 30 percent propylene glycol and water mixture. Other systems use a proprietary water-based fluid that provides much higher thermal conductivity and almost half the viscosity of water-glycol mixtures, resulting in markedly better thermal performance versus anti-freeze type coolants.

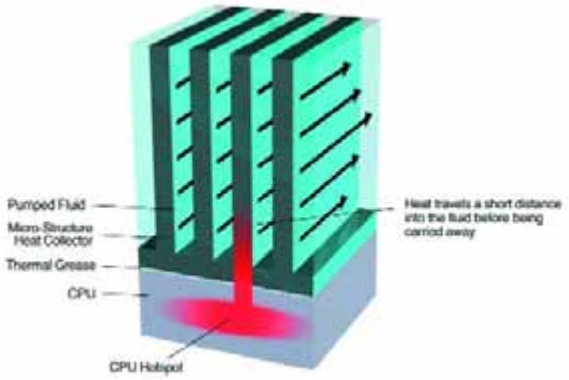

Figure 2a. Close up of micro-structure heat collector attachment to CPU.

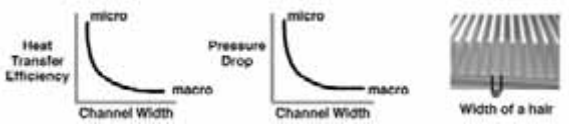

Figure 2b.: Charts show dependence of thermal performance and pressure drop on channel width.

Mechanical pump — recent advances in compact mechanical pumps have resulted in high reliability and greater flow rates than earlier pump systems that were reliable but produced inadequate flow pressure and rate for the latest high heat flux processors.

Low-noise acoustics — liquid cooling systems allow system fans to run much slower, and therefore more reliably, while producing equivalent heat rejection at given performance levels. In multi-processor systems with high heat loads, the multiple fans typically required by conventional cooling solutions can be reduced considerably by using an LCS.

Reliability design issues

Particle control — plays a crucial role in ensuring the reliable long-term performance of the LCS. The material/fluid combination must be optimized by careful analysis, testing and characterization. Material selection, along with refined assembly processes during manufacturing, significantly impact the reliability of the finished system.

Water loss control — closed-loop cooling systems completely eliminate fluid loss by means of robust, completely sealed tubing joints that prevent leaks during shipping, storage and use.

Freeze-protection — especially important during shipping and storage, the system's cooling loop should include adequate freeze-management techniques that allow the system's water-based working fluid to expand without damaging the system or harming thermal performance.

Material science control —extensive performance and reliability characterizations must be performed in the selection of all materials used in the fabrication of the cooling system in order to eliminate corrosion and optimize the service life of major system components.

Cost — one of the main hurdles facing adoption of the liquid cooling system is higher cost versus conventional air-cooled solutions. One solution now in practice has been to collaborate with strategic manufacturing partners in Asia.

Application

One real-world example required cooling a high-performance workstation to remove heat from a bare die with high heat flux, while keeping the junction temperature below 85C. The average heat flux was approximately 150W/cm², total power was nearly 220W, and available system airflow was in the range of 30-35cfm. To solve this problem, detailed simulations of the CPU power map were performed to optimize the design of the micro-structure heat exchanger and radiator. Table 1 shows the general operating specifications of the high-performance liquid cooling system developed for this application.

Thermal Performance		Mechanical Characteristics	
RS-a, ºC/W	0.1	Radiator Volume	90 x 140 x 40mm
Airflow	32-35 cfm	MCP Size	35 x 25 x 20mm
Average Heat Flux	150W/cm²	Pump Size	60 x 60 x 80mm
Power	235W	Storage	-40 to +50C
Peak Heat Flux	250W/cm²	Acoustics	< 45dB at 1m
Ambient Temperature	25C	Reliability	5 years
Junction Temp (Tj) Max	< 85C		

* *Sink-to-ambient resistance*

Table 1: Thermal Performance / Mechanical Characteristics.

Bottom line

Recent technical advances are driving the commercial acceptance and use of liquid cooling systems for high heat flux processors in computers and workstations, and new applications like high power LEDs for projectors and displays are also emerging. System designers are encouraged to explore liquid cooling for their own designs, being mindful of the trade-offs that define the optimized liquid cooling solution in terms of performance, reliability and cost versus conventional technologies.

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Wireless Gets Tough On Power Management, Cost

New modulation enables high output power

As integration and features add complexity and reduce battery lifetime, the need to add wireless connectivity to a product has also grown. Since the introduction of short range radios (SRD), a wide range of applications has added wireless connectivity creating increased demand for cheaper and more integrated solutions.

By Staale Pettersen, Product Marketing Manager, Micrel, Inc.

Today's wireless ICs require only a handful of external components and have become an inconsequential percentage of the total solution cost. Looking into the very near future and considering what existing wireless applications currently have to offer, the need for additional features and performance has placed considerable limitations on battery life. This has driven the need for more advanced power management solutions. In today's applications, the battery and power management cost is close to 50 percent of the total bill of material. To address these new challenges, companies like Micrel, Inc., have begun rolling out solutions such as the MICRF405, a 290-980MHz transmitter including a new type of modulation called Spread Spectrum ASK/OOK. This new modulation enables high output power via its spread spectrum technology with just 50 percent of the power consumption. This article will focus on how solutions like the MICRF405 radically reduce both current consumption and cost.

The Federal Communication Commission (FCC) in North America specifies frequency bands covering 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz. Today, the frequency band is crowded with a wide range of applications ranging from RFID to WiMAX. Unfortunately, some applications, including the widely adopted in residential, building and industrial environments, have created a fairly high noise floor which makes the technology unsuitable for industrial, low power and long range applications. For these applications, the 902-928MHz frequency band is considered to be the better suited ISM band. To operate in this frequency band, some sort of frequency spread spectrum is required. Historically, there have been two types of spread spectrum; Frequency Hopping Spread Spectrum (FHSS), a method where the data signal is modulated with a narrowband carrier signal that "hops" in a random but predictable sequence from frequency to frequency, as a function of time and over a wide band of frequencies. The most significant disadvantage of frequency hopping spread spectrum transmissions is the required frequency synchronization between the transmitter and the receiver. The frequency synchronization requirement results in a slow access time and higher power consumption as the system needs to transmit on all channels to synchronize with the receiver.

The second popular form of spread spectrum transmission is referred to as digital modulation or Direct-sequence spread spectrum (DSSS). DSSS, is where a data signal at the sending station is combined with a higher data rate bit sequence, or chipping code, that divides the user data according to a spreading ratio. The issue with a DSSS radio lies in its fairly complex demodulation scheme since the signal that is received requires de-spreading and synchronization.

Spread Spectrum ASK/OOK

As more and more wireless applications on the market require ever higher output, power becomes more and more important. With Digital Modulated Systems,systems using digital modulation techniques may operate in the 902–928MHz, 2400–2483.5 MHz, and 5725–5850MHz bands, the maximum radiated output power is defined as 1W. However, a modification to this rating was made and now, maximum output power is defined as: the peak power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This modification opens up new and interesting modulation possiblities that enable long range wireless links using extremely low power. Micrel Inc., has recently patented one such new modulation solution referred to as Spread Spectrum On Off Keying (SSOOK) or Spread Spectrum Amplitude Shift Keying (SSASK).

Amplitude-shift keying (ASK) is a form of modulation that represents digital data as variations in the amplitude of a carrier wave. The advantage of ASK radio systems is the simplicity of the transmitter and receiver topology and the low current consumption. ASK/OOK is

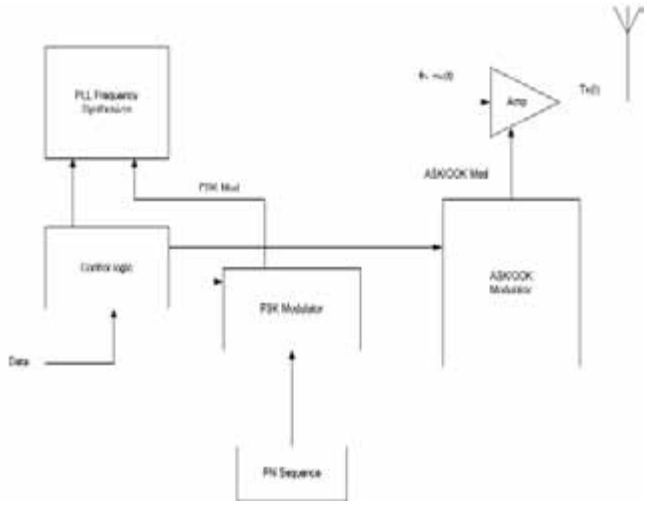

Figure 1. SSASK/OOK Block Diagram.

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a simple, yet powerful modulation scheme and is cost effective to implement both for the transmitter as well as the receiver using silicon technology. Unfortunately, an ASK/OOK modulation system occupies bandwidth less than 500 kHz or has a peak density that does not fall under "Digital Modulation Systems". This means that for an ASK/OOK modulation system, the output power of a transmitter is limited to 50mV/m or some form of FHSS technology has to be implemented to fall within the FCC part 15.247.

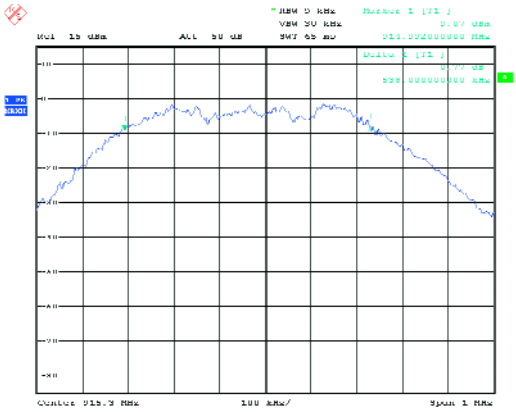

Figure 2. SSASK/OOK

Spread Spectrum Amplitude Shift Keying is a method of combining the traditional known ASK/OOK with a digital modulated signal. A typical block diagram of a transmitter, shown in Figure 1, illustrates how Micrel's MICRF405 solution operates in SSASK/OOK mode. The SSASK/OOK modulation is created by adding "user data" to an AM modulator and creating an amplitude Shift or turning "on" and "off" a Frequency Shift Keying (FSK) modulated carrier. The FSK signal is generated by adding a PN sequence to the FSK modulator that is programmed to give an occupied bandwidth >500kHz as specified by FCC. The FSK data rate and the PN sequence are selected in a ratio giving as equal peak density within the 6dB bandwidth as possible. The result is a Spread Spectrum ASK/OOK spectrum as shown in Figure 2.

The radiated spectrum and the peak density of a SSASK/OOK modulated spectrum are "equal" to a "Digital Modulated System" and therefore, are considered by FCC a "Digital Modulated System". The main benefits of this new modulation type lies in its low power consumption since it only transmits when sending a "1" and the ability to increase the output power without the need of a FHSS.

SSASK/OOK Application Circuit

In the 902-928MHz band, ASK/OOK intentional radiators is required to implement Frequency Hopping Spread Spectrum when the application requires higher output power then 50mV/m. By using Micrel's MICRF405 in Spread Spectrum ASK/OOK mode, transmission with an output power of 10dBm is achieved without the need of FHSS. The application circuit, Figure 3, consists of a matching circuit, crystal and decoupling capacitors. The maximum allowed output power allowed by FCC when using the MICRF405 as a Spread Spectrum ASK/OOK device and an external power amplifier is +20dBm. Another application circuit, shown in Figure 4, has a power consumption of 83mA when using SSOOK and 50 percent duty cycle. The maximum peak density of 8dBm/3kHz specified by the FCC limits the maximum output power.

Micrel's MICRF405, Figure 5, is a 290MHz-980MHz RF transmitter IC intended for unlicensed ISM band operations, Table 1. It is designed to work in the North American 315MHz and 915MHz bands as well as the European 433MHz and 868MHz bands. The device is fully FCC Part 15.247 and EN300-220-compliant.

The transmitter consists of a FSK/ASKS modulator, PLL frequency synthesizer and a power amplifier. The frequency synthesizer consists of a voltage-controlled oscillator (VCO), a crystal oscillator, dual modulus pre-scaler, programmable frequency dividers and a phase-detector. The loop-filter can be internal or external. The output power of the power amplifier can be programmed to eight levels. A lock detect circuit detects when the PLL is in lock. In FSK mode, the user can select between three different modulation types thereby allowing a data rate up to 200kbps. When selecting FSK modulation

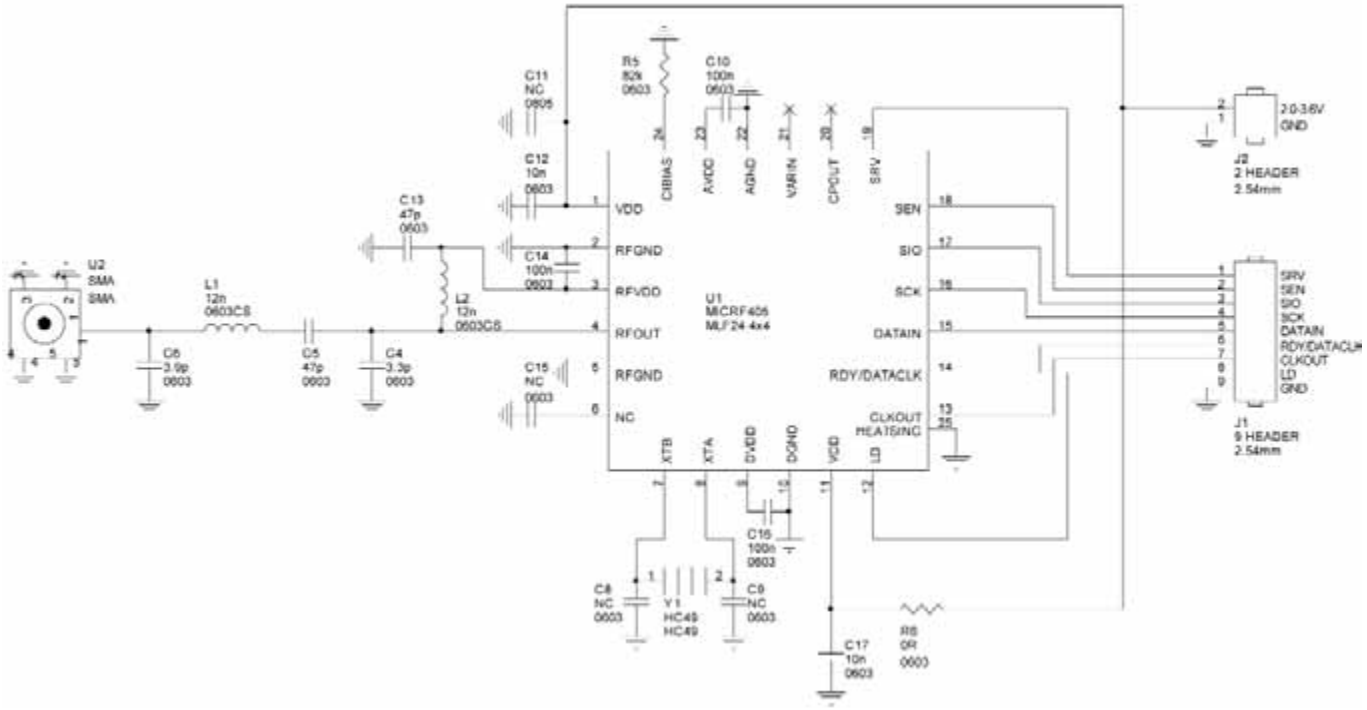

Figure 3. SSOOK Application Circuit 10dBm.

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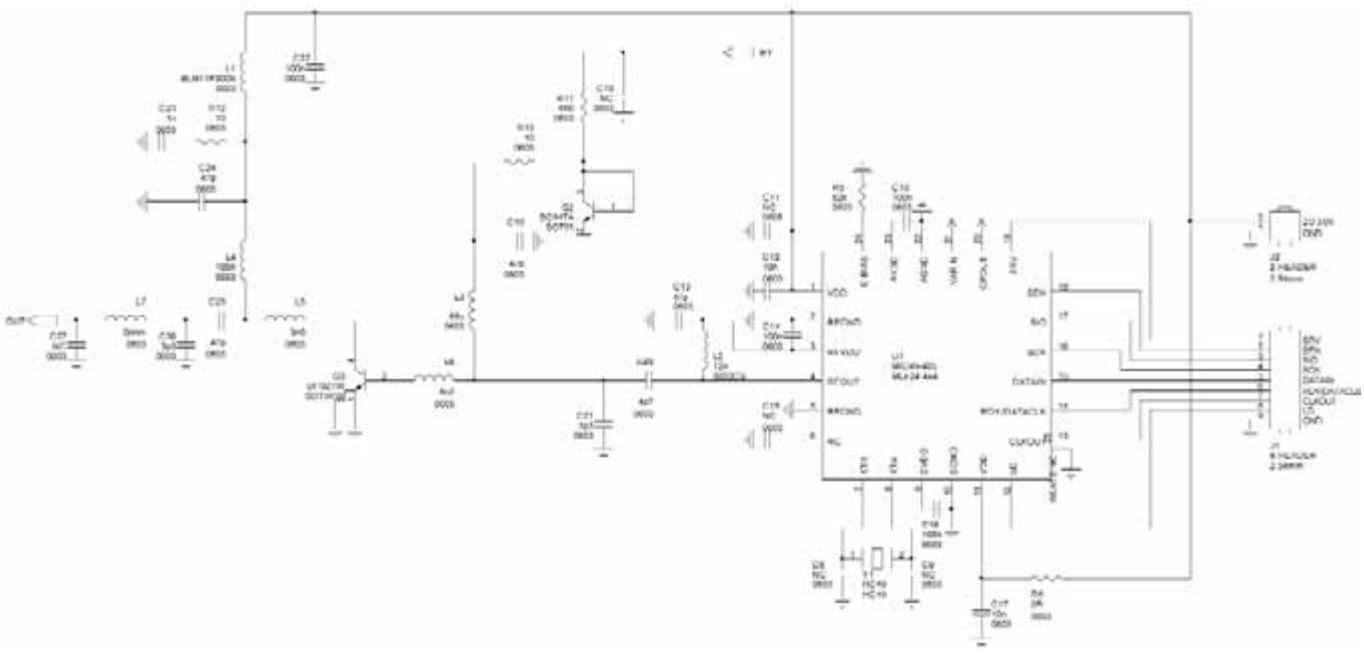

Figure 4. SSOK Application Circuit +20dBm.

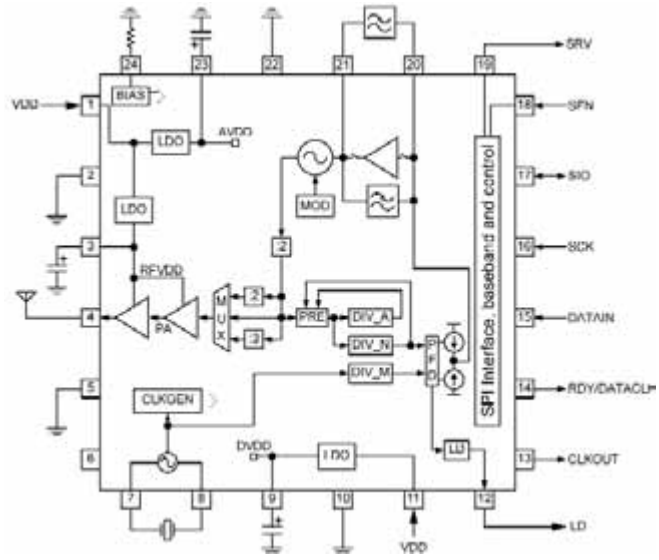

Figure 5. MICRF405 Block Diagram.

is applied with dividers, the MICRF405 then switches between two sets of register values (M0,N0,A0:"0" and M1,N1 and A1:"1"). The second modulation type is closed loop VCO modulation using the internal modulator that applies the modulated data to the VCO. The third FSK modulation type is Open loop VCO modulation. In ASK modulation, the user can select between two modulation types, with or without spreading. In both modes, the modulation depth is programmable.

Note: MFL is a registered trademark of Amkor Technology.

www.micrel.com

Reference		
Frequency	290-980	MHz
Voltage Supply	2.2-3.6	V
Temperature Range	-40 to +125	?C
Output Power	10	dBm
I_{tot}	18	mA
I_{PD}	<1	ì A

Table 1. Micrel's MICRF405 Reference.

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Speed up Buck Regulator Design

National Semiconductor announced the addition of six high-frequency buck regulators to its popular SIMPLE SWITCHER product family along with a “dial-in” performance enhancement to its WEBENCH design environment. The six new regulators feature a unique combination of high performance, flexibility and ease-of-use for DC-DC power supply designs.

National’s new buck regulators and enhanced WEBENCH suite of tools enable novice as well as seasoned power supply designers to easily “dial in” their size and efficiency requirements while also realising fast time-to-market. Design results are verified by WEBENCH online electrical and thermal simulations and created for 24-48 hour delivery using BuildIt! custom prototype power supply kits.

The new regulators operate with an input voltage range up to 75V and deliver up to 3A of continuous output current. The patented emulated –current- mode technology provides superior load transient response in low duty cycle applications that are not addressable by traditional current mode control. Operating frequency is adjustable from 50 kHz to 1 MHz, providing industry- leading dynamic range. To reduce EMI, a frequency synchronisation pin allows multiple ICs from the family to self-synchronise or to synchronise to an external clock. The new regulators guarantee robustness with cycle-by-cycle current limit, short-circuit protection and thermal shut-down.

“Combined with National’s WEBENCH suite of tools, SIMPLE SWITCHER regulators allow design engineers to make decisions about their power supply design, such as the trade-off between size and efficiency,“ said Mal Humphrey, product line director for National’s Power Management Group. “Any engineer, including seasoned power supply designers, can create, optimise and analyse their design in just one minute.

Emulated current-mode control overcomes traditional current-mode control’s noise susceptibility by emulating the buck switch current signal, which is then used for current-mode control. The emulated buck switch current signal is the sum of an emulation ramp current and the sampled diode current just before switching occurs. Avoiding direct buck switch current measurement minimises the effect of switching noise, while maintaining the benefits of the current-mode control.

http://power.national.com

PWM Controllers Integrate MOSFET Drivers

Intersil introduced the ISL6545 and ISL6545A single-output PWM (pulse width modulation) controllers. These devices integrate the boot diode and current-sensing functions, reducing the number of external components required.

The ISL6545 and ISL6545A allow a lower BOM cost by integrating the boot diode, the overcurrent protection, and the MOSFET drivers onto a single chip. The overcurrent function protects the controllers from a shorted output by using the lower MOSFET’s on-resistance, rDS(ON), to monitor the current, enhancing the efficiency of the controllers and reducing cost by eliminating the current- sensing resistor.

The ISL6545 and ISL6545A make implementation of a complete control and protection scheme for a DC/DC step-down converter driving inexpensive N-channel MOSFETs in a synchronous buck topology simple. A fixed frequency oscillator (300kHz for ISL6545; 600KHz for ISL6545A) reduces design complexity while reducing typical application cost and increasing efficiency, allowing these devices to be used in small form factor applications.

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Graphite thermal transfer compounds of the WLPG product line are delivered in plastic syringes containing 2, 5, 10 or 20 ml; larger syringes or other packaging units are possible.

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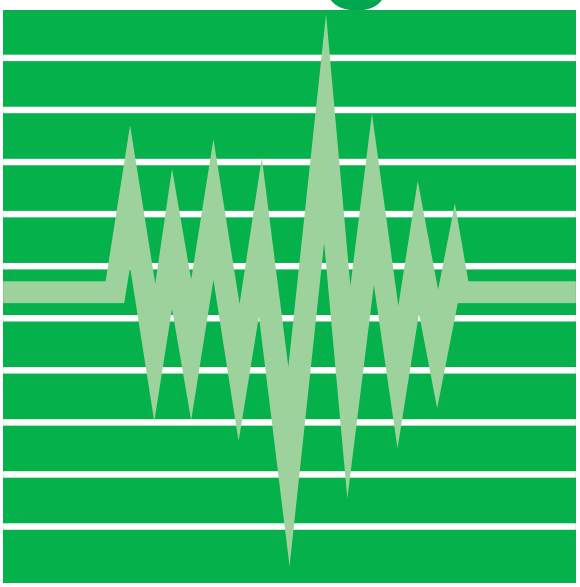

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Power Rack Platform with Digital Power Management

ROAL Electronics USA, Inc. (Los Angeles, CA) a leader in design, manufacture, and service of AC/DC and DC/DC power supplies, specialized in Digital Power Management, debuted its new high efficiency, high power density self cooled Power Rack family RHPS225 in 1U 19 inches suitable for IT, Data Storage and Communication, Networking, Telecom, Industrial applications using distributed power architecture. The rack series can be populated on demand with up to 5 units together for a maximum output power of 6000W for the 12V version RHPS225, and up to 7500W for the 48V version RHPS225A. The RHPS225 is available also as a stand alone part with Power Supplies shipped separately.

Each model accepts a continuous input standard Voltage from 90 to 264Vac, has incorporated hot swap and redundant parallel operation capabilities. The customers can fit either the RHPS224 AC/DC Front End available in rating of 1200W maximum output power for the 12Vdc version with power density of 17W/inch3 and efficiency >87%, 90% at nominal input AC Voltage, or the RHPS224A in rating of 1500W output power for 48V output version which reaches 21W/inch3,with typical efficiency > 90%, 92% at nominal input.

Both Power Supplies and Power Rack versions do not require minimum output load and provide a 12Vdc or 5Vdc stand-by output power for application system's control circuits.

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GaN Schottky Diodes for Power Applications

STMicroelectronics and Velox Semiconductor announced an agreement to jointly introduce GaN (Gallium nitride) Schottky diodes into the market, with a long term goal of establishing both companies as dual-source suppliers of the devices. GaN-based diodes will enable the design and production of Switch Mode Power Supplies (SMPS) for computers, consumer applications, and industrial products that are smaller, more efficient, and lower cost.

ST and Velox offer complementary skills that the two companies believe will accelerate the development of the critical technologies – increasing the likelihood of success, leveraging the capital costs required, and increasing the quantity and quality of product offerings available. Velox has developed 600-volt GaN Schottky diodes and the diodes are in the final stages of development before transition to production. ST will help complete the development, perform product qualification, and will market and distribute the diodes.

In the first phase of the agreement, ST intends to test and qualify all the devices, and use its worldwide distribution system to market and distribute GaN Schottky diodes under the Velox brand name. In the second phase Velox and ST expect to be full dual sources. Velox is licensing its production technology for the devices to ST to enable second-source manufacturing; both companies are working together to synchronize manufacturing and quality systems. These synchronization efforts may delay the start of the production originally planned by Velox, though the resulting delay will ensure an agile and consistent supply of GaN devices.

GaN is a wide bandgap semiconductor material, currently used typically in optoelectronic applications, and in high-power and high-frequency devices. In SMPS applications it enables the implementation of higher frequency power-factor correction circuits which offer benefits in efficiency, product size, low noise, smaller heatsink requirements, and higher yield.

www.veloxsemi.com

www.st.com

LPS3008	LPS3010	LPS3015	LPS4012	LPS4018
0.56 - 330 µH	0.47 - 330 µH	1 - 330 µH	0.33 -3300 µH	0.56 - 3300 µH
Up to 1.8 A	Up to 2.3 A	Up to 2.0 A	Up to 5.0 A	Up to 4.8 A
3 x 3 mm	3 x 3 mm	3 x 3 mm	3.9 x 3.9 mm	3.9 x 3.9 mm
0.8 mm high	0.9mm high	1.4 mm high	1.1 mm high	1.7 mm high

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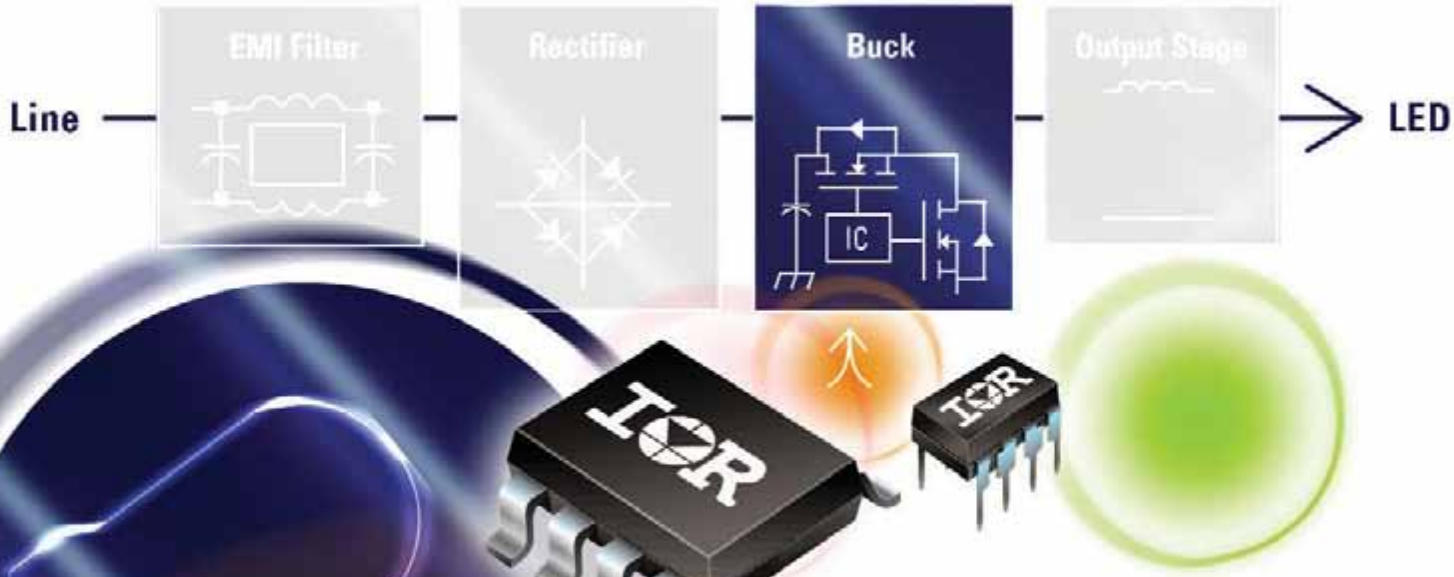

IR's high-brightness LED driver IC's, adapt and compensate to LED parameter variations to enable a highly accurate and inherently stable design.

FEATURES

- 200V or 600V control IC in compact 8-pin DIP or SO package
- Incorporates continuous mode, time-delayed hysteretic buck regulator
- External high-side bootstrap circuit delivers frequencies up to 500kHz
- Low-side driver provided for synchronous rectifier designs
- Micro-power startup of less than 500µA
- 140ns deadtime for continuous current regulation
- Auto restart, non-latched shutdown and PWM dimmable capability

Part No.	Package	Voltage	Load Current Regulation	Micro-power Start-up	Deadtime	Frequency
IRS2540PbF	DIP8, S08	200V	+/-5%	<500µA	140ns	<500kHz
IRS2541PbF	DIP8, S08	600V	+/-5%	<500µA	140ns	<500kHz

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