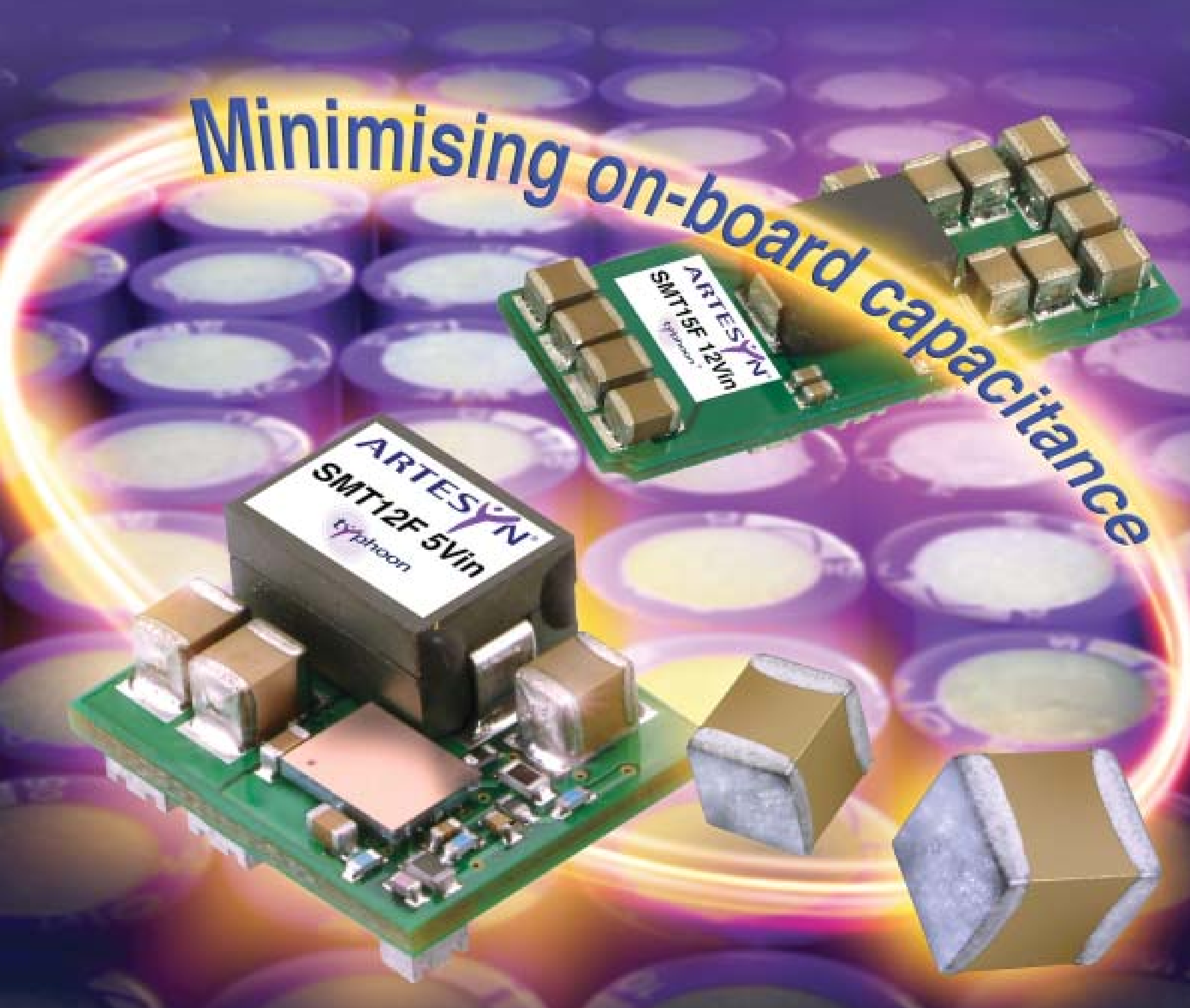
ZKZ 64717
7/8-04

Power Systems Design EUROPE

Power Control Intelligent Motion July/August 2004



Automotive Electronics: Part I

Power Player - page 10

Minimising AC Adapter

Dynamic POL Converter

ISSN : 1613-6365

Power Systems Design EUROPE

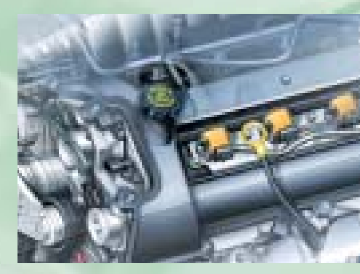
Viewpoint

Industry News

Cover Story

Power Player

Features



Automotive Electronics: Part I

NEC ELECTRONICS

New Power MOSFET family:

UMOS-4 NP-series.

Issue August 2004

Empowered by Innovation NEC

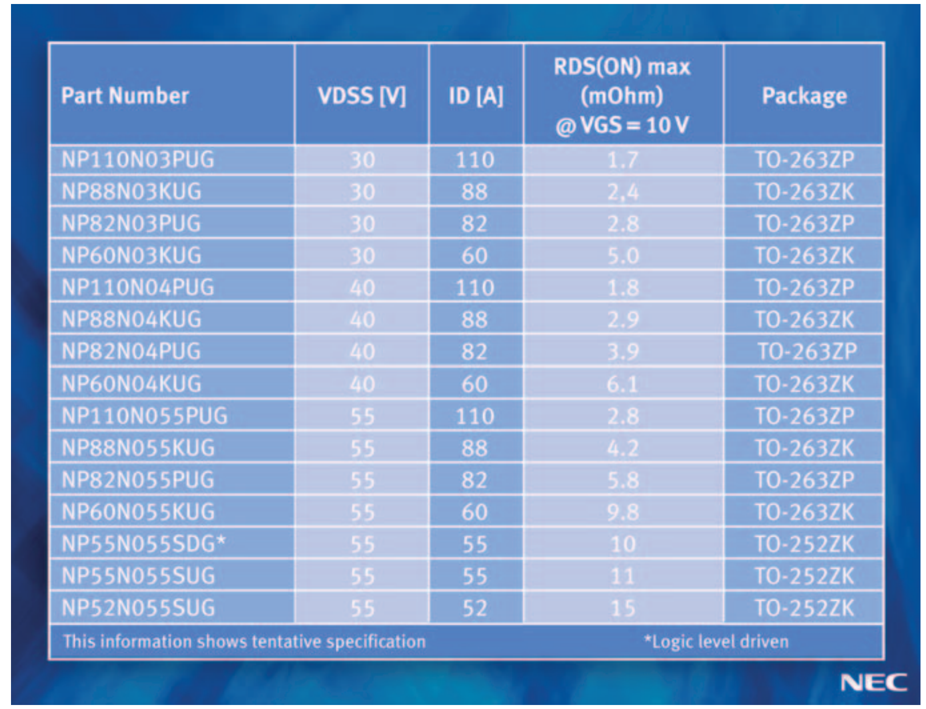
New UMOS-4 process boosts NP-series

NEC Electronics has reinforced its technology leadership with a new NP-series that exploits the company's innovative trench technology and combines it with an advanced package solution.

UMOS-4 is a new generation of NEC's leading UMOS process technology. With an ultra-fine design rule of 0.25 µm, this process achieves a cell density of well over 180 Mcells/inch².

At the same time, NEC has developed advanced TO-263 (TO-263ZP) and TO-252 packages that increase the number of the bonding wires to 4 and 2 respectively. This is in response to increasing demand for current in high-power automotive applications like Integrated Starter Generators (ISG) and Electrical Power Steering (EPS). The new NP-series is also ideal for applications like DC-DC converters or motor control.

Product overview

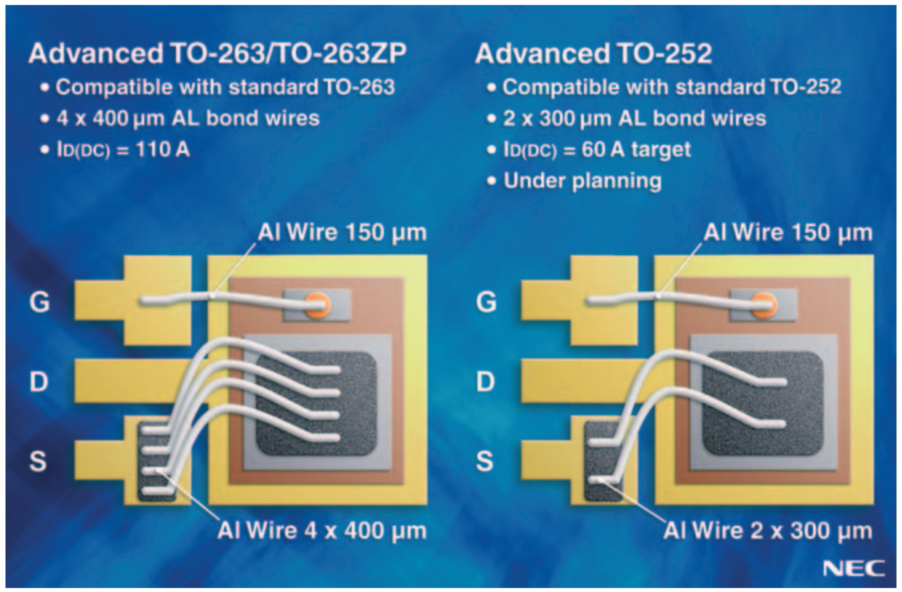


Part Number	VDSS [V]	ID [A]	RDS(ON) max (mOhm) @VGS = 10 V	Package
NP110N03PUG	30	110	1.7	TO-263ZP
NP88N03KUG	30	88	2,4	TO-263ZK
NP82N03PUG	30	82	2.8	TO-263ZP
NP60N03KUG	30	60	5.0	TO-263ZK
NP110N04PUG	40	110	1.8	TO-263ZP
NP88N04KUG	40	88	2.9	TO-263ZK
NP82N04PUG	40	82	3.9	TO-263ZP
NP60N04KUG	40	60	6.1	TO-263ZK
NP110N055PUG	55	110	2.8	TO-263ZP
NP88N055KUG	55	88	4.2	TO-263ZK
NP82N055PUG	55	82	5.8	TO-263ZP
NP60N055KUG	55	60	9.8	TO-263ZK
NP55N055SDG*	55	55	10	TO-252ZK
NP55N055SUG	55	55	11	TO-252ZK
NP52N055SUG	55	52	15	TO-252ZK

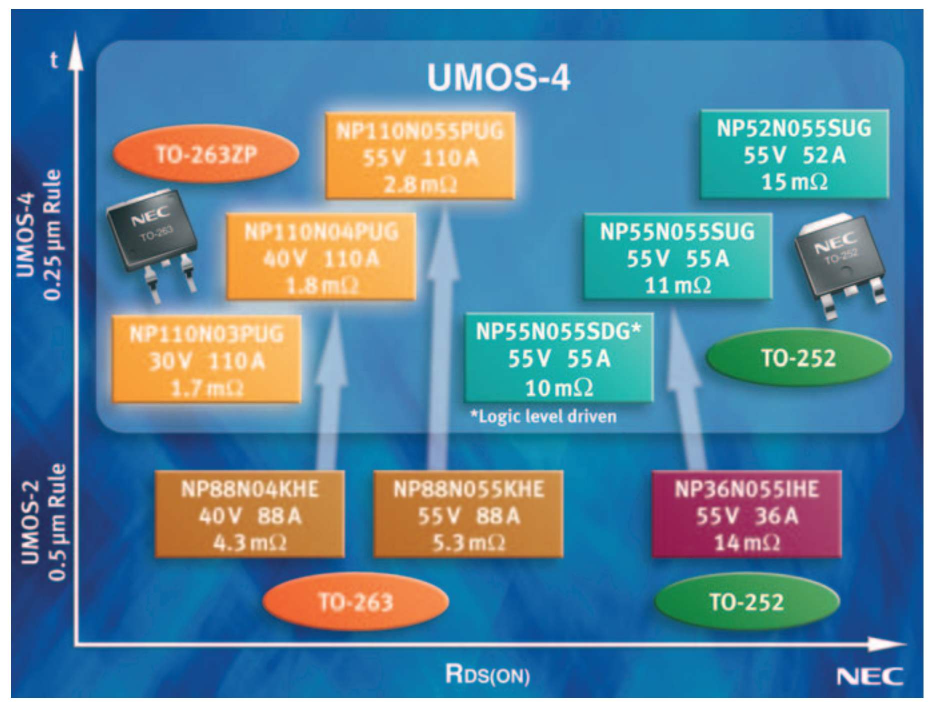
This information shows tentative specification *Logic level driven

NEC

New approach improves package capability



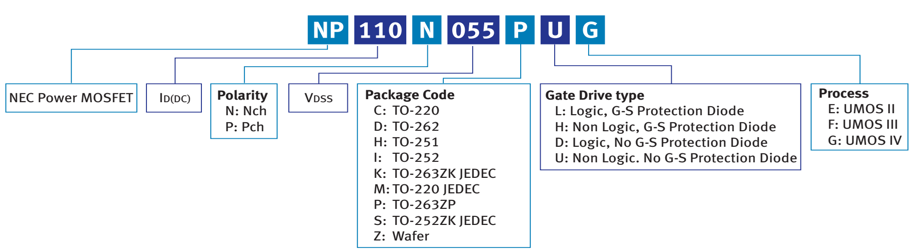
High cell density and enhanced ultra-fine process result in lowest on-resistance



Key features

- High current performance, eg, 110 A (TO-263ZP)
- Super-low RDS(on), eg, 1.8 mΩ max. (40 V, TO-263ZP)
- Compliance with AEC-Q101
- Tjmax = 175°C
- Popular TO-252 and TO-263 compliant packages

Part numbering



NEC Electronics (Europe) GmbH
Arcadiastr. 10
40472 Düsseldorf, Germany
Tel. (02 11) 65 030
Fax (02 11) 65 03-1327

- Podbielskistr. 164
  30177 Hannover, Germany
  Tel. (05 11) 3 34 02-0
  Fax (05 11) 3 34 02-34

- Arabellastr. 17
  81925 München, Germany
  Tel. (0 89) 92 10 03-0
  Fax (0 89) 92 10 03-15

- Industriestr. 3
  70565 Stuttgart, Germany
  Tel. (07 11) 9 90 10-0
  Fax (07 11) 9 90 10-19

NEC Electronics (Europe) GmbH
Sucursal en España
Juan Esplandiu, 15
28007 Madrid, Spain
Tel. (091) 504 27 87
Fax (091) 504 28 60

NEC Electronics (Europe) GmbH
Succursale Française
9 rue Paul Dautier
B.P. 52
78142 Vélizy-Villacoublay Cédex, France
Tél. (01) 30 67 58 00
Fax (01) 30 67 58 99

NEC Electronics (Europe) GmbH
Filiale Italiana
Via Fabio Filzi, 25A
20124 Milano, Italy
Tel. (02) 66 75 41
Fax (02) 66 75 42 99

NEC Electronics (Europe) GmbH
Branch The Netherlands
Boschdijk 187a
5612 HB Eindhoven
The Netherlands
Tel. (0 40) 2 65 40 10
Fax (0 40) 2 44 45 80

NEC Electronics (Europe) GmbH
Tyskland Filial
Täby Centrum
Entrance S (7th floor)
18322 Täby, Sweden
Tel. (08) 6 38 08 20
Fax (08) 6 38 03 88

NEC Electronics (Europe) GmbH
United Kingdom Branch
Cygnus House, Sunrise Parkway
Linford Wood
Milton Keynes
MK14 6NP, United Kingdom
Tel. (0 19 08) 69 11 33
Fax (0 19 08) 67 02 90

More contacts:
www.ee.nec.de/contact

E-mail:
mosfetinfo@ee.nec.de

Product specifications are subject to change without notice. To ensure that you have the latest product data, please contact your local NEC sales office.

© Published by
NEC Electronics (Europe) GmbH
Printed in Germany, August 2004
Document No. D16883EE2V0PF00

Power Systems Design EUROPE

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

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

Publisher
Jim Graham
Jim.Graham@powersystemsdesign.com

Associate Publisher
Julia Stocks
Julia.Stocks@powersystemsdesign.com

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

Circulation Management
circulation@powersystemsdesign.com

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

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

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

Send address changes to:
circulation@powersystemsdesign.com

Volume 1, Issue 6

Take a Brake and Charge Your Batteries

We all have achieved the first half of an exciting year with a positive outlook for the economy. Now it is a good time to refresh and take a brake. Like in electronics we need to charge our batteries. Afterwards we are ready to speed the second half of the year.

Having Power Systems Design Europe magazine out for the first half of 2004 makes us (Julia, Jim and me) proud that the industry has put full attention to our publication. As a newcomer with our talented racing team we took the right pole position and moved ahead. Automotive is one of the leading factors to push the economy and generate revenue. Most of the automotive technology has been influenced by modern electronics. This issue includes Part I of a two part series on Automotive Electronics.

We are present at most Conferences and shows driving power electronics forward. You will recognize that we put attention to events like PESC, APEC, SPS, EPE, Electronica and also smaller and focused events like H2EXPO.

I see myself as the catalytic element to provide the information that keeps the engineer informed on new technologies. As the budget for travel is not given to all engineers my job is to turn it to the ones that need it at their workplace. I will continue to focus into areas of high interest. These will be added to the given features we have already listed in our editorial calendar.

We chose automotive and got an absolute strong feedback out of industry. Automotive electronics serves a wide field in modern vehicles. Electronics allows the way to more efficient cars for the future. Whether we talk about combustion, electric or hybrid cars. The electronic components makes it happen that new designs become reality.

The little boys can say sometimes auto before mama or papa. Sorry, girls as well. Let us enjoy the automotive articles and continue to fuel the kids with imagination that enough of them choose to become an engineer. We need them to study and any qualified support from industry and our side will be helpful. Just to play with the Xbox, cellaur (photo) phones and watch the screen on TV is not enough. Challenge for the kids in technology gives them a good feeling on what they can achieve. That charges their batteries for imagination. The automobile industry moves ahead to optimize any design they can and automobiles will go hybrid to reduce consumption by regenerative braking.

We are the Engineers that learned once how to keep the progress going. That is our fuel that makes us as grown up kids running for the next design challenge.

In closing, I want to welcome our newest contributor to Power Systems Design Europe, a familiar face to many of you, Derek Lidow, CEO and President of iSuppli Corporation. His article leads off our Automotive series which begins on page 24.

Will take a look to see you at one of the next shows.

Best regards

Bodo Arlt

Bodo Arlt
Bodo.Arlt@powersystemsdesign.com

PCIM 2005 Call for Papers

The 26th International PCIM Conference for Power Electronics, Intelligent Motion, Power Quality and Energy Management will take place again in the Congress Centre of the Nürnberg Messe, Germany from June 7 – 9, 2005. PCIM tutorials will run on June 5 and 6, 2005.

Experts from industry and academia are kindly invited to present their latest developments and expectations for future trends at our PCIM 2005 conference.

Power Electronics is the common denominator for all fields covered at this conference, from energy management to mechatronics and the quality of electrical power.

The abstract is the basis for our International Advisory Board, evaluating your proposal for acceptance for the next PCIM Europe Conference. Deadline for Abstracts is October 30, 2004.

Send by e-mail to:
pcimeurope2005@zm-com.com

Notification of acceptance and author's kit mailed by ZM: January 14, 2005.

Your final paper: March 11, 2005.

www.pcim.de

Ansoft and Synopsys Join to Provide IC/Package Co-Design & Analysis

Ansoft announced a collaboration with Synopsys, which will provide streamlined IC and package co-design and analysis design flow solutions to address the substantial challenges of developing products based on 90 nanometer and SoC (System-on-Chip) technologies.

For package designers, the ability to lay out the package and then seamlessly analyze the package interconnect structure for power and signal integrity issues is a major step forward in productivity and reliability of the end package design. The combined solution offers a winning combination of Synopsys' package design tool, Encore, and Ansoft's signal integrity analysis products, TPA and SIwave.

With the combined tool solution offered by Synopsys and Ansoft, designers of I/O buffers, ICs and packages can now work concurrently from the same spec-sheet, utilizing a common design flow, thereby streamlining the design process, saving both time and money.

www.ansoft.com

4th dSPACE User Conference

Experts on developing software for electronic control units (ECUs) will meet up at the Liederhalle Cultural and Congress Center in Stuttgart on October 21-22, 2004.

The Center provides the ideal setting for users of dSPACE systems to present their projects. The papers will include contributions from major OEMs and suppliers like Audi, BMW, DaimlerChrysler, Hella Hueck, MB-technology and Volkswagen. This year, presentations by European system users are also on the program like Elasis, Ford Motor Company and Renault. The conference language is German. Simultaneous interpreters will interpret the German papers into English for the international audience.

The 4th dSPACE User Conference will present trends and product innovations, and is an ideal opportunity to compare notes and discuss issues with other experts in the field.

Registering to attend the Conference is easy, by visiting the dSPACE Web site at www.dspace.de/goto?uc_stuttgart, which also provides all the latest information on the event.

www.dspace.de

Infineon Introduces Automotive Electronic Sensors

Infineon announced three new sensor products for automotive safety applications. The new sensor products expand Infineon's portfolio of solutions for these automotive safety segments: Tire Pressure Monitoring Systems (TPMS), Rollover sensing, and Anti-Lock Brake Systems (ABS).

Market researchers at Strategy Analytics forecast that automotive safety applications for semiconductors will achieve a compound growth rate greater than ten percent through 2008, and grow to a market size of nearly US dollar 6.8 billion in that year. Infineon holds a strong market share position in many safety application segments, for example, by its own estimates, it is the number one supplier of Hall Effect wheel speed sensors for ABS, pressure-based side airbag sensors, and sensor devices for the emerging TPMS segment. On average, every new car contains two Infineon sensors.

Two of the new products are Micro-Electro-Mechanical Systems (MEMS) based on the technology of SensoNor, a leading provider of tire pressure and inertia sensors that Infineon acquired in 2003. They are the SP30, a second-generation tire pressure sensing device with three sensing functions; and the SAR10 Rollover Sensor with an angular rate sensor. The third new sensor is the TLE4941-1C, part of Infineon's third-generation Hall Effect sensor family optimized for ABS applications. The SAR10 Rollover sensor contains a silicon micromachined angular rate sensor that detects when a vehicle is beginning to roll over and enables the firing of side airbags and pre-tensioning seat-belts. The side, or curtain air bag, is an increasingly popular passenger vehicle feature. Additional information on Infineon's sensor products is available at: www.infineon.com/sensors and at www.sensonor.no

www.infineon.com/sensors

www.sensonor.no

Fairchild Receives Automotive ISO/TS16949 Certification

Fairchild announced that all of its manufacturing facilities worldwide producing automotive products have achieved the challenging automotive standard ISO/TS16949 certification. TS16949:2002 is a comprehensive quality management standard developed by the International Automotive Task Force (IATF) and Japan Automobile Manufacturers' Association, Inc. (JAMA) and specifies quality system requirements for the design, development, production, installation and servicing of automotive related products.

TS16949 members, including GM, Ford, Daimler Chrysler, Peugeot-Citroen, Renault, VW, BMW, Mitsubishi and national automotive trade associations from the US, Germany, UK, Italy, Japan and France, define the specifications and mandate suppliers meet the certification requirement in order to participate in the automotive market.

Fairchild is the Power Franchise(r), supplying components to minimize power requirements while managing, distributing and converting power in a wide variety of automotive applications including ignition control and management, ABS systems, navigation, safety, body electronics and entertainment systems. Fairchild supplies IGBTs, MOSFETs and logic products to leading automotive manufacturers such as Bosch, Siemens and Delphi.

www.fairchildsemi.com

IR to Acquire ATMI's Epitaxial Services Operation

International Rectifier announced that it has entered into a definitive agreement to acquire the speciality silicon epitaxial services business of ATMI subject to customary closing conditions and certain third-party approvals.

International Rectifier (IR) has been a major, long-term customer of ATMI's specialty epitaxial services business, located in Mesa, Arizona. IR CEO Alex Lidow said, "This group has provided excellent service to us over the years, and we are excited to have these employees join the IR team. They will bring innovative knowledge and expertise in specialty silicon and silicon germanium epitaxy, as well as key intellectual property for improving epitaxy deposition throughput and lowering production costs."

Under the terms of the agreement, IR will pay ATMI up to $41 million in cash for the operations and assets of the group, including related intellectual property, fixed assets, and inventory. Approximately 90 employees will join IR as part of the agreement. The transaction is expected to close in the September quarter, and IR expects the acquisition to be accretive within the first 12 months.

www.irf.com

SEMI Expo CIS 2004, Moscow, 27 – 30 September

SEMI Expo CIS is the annual communication platform and exhibition for the semiconductor community to meet and exchange their views with their counterparts in the CIS (Commonwealth of Independent States).

Gathering executives, analysts and academia from the whole microelectronic supply chain in and out the CIS into one single communication platform such as SEMI Expo CIS appears to be vital for the semiconductor/equipment industry at a time when investments in the whole microelectronic segment are taking off in the CIS. Major global companies such as Intel or Motorola have now launched private educational programs within local companies, hired local high-level skills through outsourcing contracts and developed a stronger cooperation with universities.

SEMI Expo CIS 2004 is scheduled to take place from 27 September until 2 October and will include an Industry Strategy Symposium (ISS), a "Semiconductor Executive Roundtable", a Market Conference targeted on "How to do business in Russia", a two-days exposition, an international reception and a business tour in the St-Petersburg region.

http://wps2a.semi.org

EPCOS Extends Agreement with Anglia

EPCOS has strengthened its UK distribution network by signing a new franchise distribution agreement with Anglia. The agreement complements Anglia's current passive portofolio which already includes a broad range of EPCOS' Inductors, Chokes, Varistors, Thermistors, GDT's along with Film standard and suppression products.

Commenting on the new franchise, Keith Rogers, UK Distribution manager at EPCOS, said: "The appointment of Anglia will be a major benefit to our customers, especially in the challenging supply situation that is developing. The considerable depth of stock that Anglia holds on EPCOS' extensive range of lead free through hole and surface mount products is backed by in-depth quality engineering that ensure that products are readily accepted by customers. Anglia's product and supply-chain team work constantly to enhance both our relationship and sales".

www.epcos.com

Power Events

- ***Power Supply Design Workshop**, August 16-19 2004, Atlanta USA, http://www.ridleyengineering.com/workshop.htm*
- ***EPE-PEMC 2004**, September 2-4, Riga, Litvia; www.rtu.lv/epe-pemc2004*
- ***H2Expo 2004**, September 15-17, Hamburg, www.h2expo0.de*
- ***Semi Expo 2004CIS**, September 27-30, Moscow, http://wps2a.semi.org*
- ***Automotive EMC 2004**, October12, York Racecourse UK, www.AutoEMC.net*
- ***dSPACE User Conference**, October 21-22, Stuttgart, www.dspace.de/goto?uc_stuttgart*
- ***Electronica 2004**, November 9-12, Munich, www.global-electronics.net*
- ***Surface Mount 2004**, November 16-18, Brighton UK, www.smartgroup.org*
- ***SPS/IPC/DRIVES 2004**, November 23-25, Nuremberg, www.mesago.de*

Automotive is the Locomotive for Innovation

Electronic applications are the modern steam

Electric cars, hybrid electric cars and combustion cars, they all need optimized electronics in conversion and motion.The elements range from MOSFETs and IGBTs to passives like batteries, super-capacitors, coils and their magnetics.

By Bodo Arlt, Power Systems Design Europe
Editor-in-Chief

The modern vehicle most popularly known as the automobile has influenced our daily life. After we enjoyed the fun factor of early days, we are now looking to the economic and environmental aspects. Still SUVs, the trucks of the current lifestyle have a high popularity for people in the new world. Only the price for gasoline has become a discussion worldwide. Europe has about two to three times higher prices for fuel than the US customers have to pay and need to be innovative for efficient design to keep consumption under control.

The combustion motor in the car will continue to be present for a longer period. There are no alternative solutions except the mass-transportation. Fuel consumption is the critical point of disputes. The main influence that effects the economic behavior of the combustion engine is given by the starter alternator concept. Regenerative breaking and additive peak pulse performance can save energy.

Energy storage is a crucial design task. Advanced batteries and supercapacitor are helping develop and improve the future designs. All the electronics has made the engine run cleaner and allows people to become lazier as all the mechanical functions for seats

Bodo's toy.

windows and sunroofs are operated by electric motors. All that is demanding extra electric power. That amount of power needs to be managed and distributed. Still the copper wiring is the distribution for power in the vehicle. Electric currents rise to such a level in 12Volt battery systems that copper-wiring diameter creates a problem of cable tree size and weight.

Having three times higher bus voltage the law of Mr. Ohm cuts the current by three and as well the active square diameter area of the wire. This is the driving factor to higher bus voltages in automobiles.

Remembering the time when my dad had his first Volkswagen beetle in the early sixties six Volt was the battery voltage and the only problem I remember from these days are the step down supply to keep the old radio running in the next new car with 12 Volt bus. In these days we moved the radio from one car to the next car and needed adoption to the previous voltage. Today we may laugh about this, in 40 Years we may laugh about the way we are trying to get the established 14 Volt equipment running in the 42Volt future. Automobiles have become very luxurious including improvements for safety. Electrical motor drives are focused to three phase solutions where IGBTs are the most economic switches. In that situation the IGBTs are performing best at bus voltages higher than 200 volt.

For electrical motor drives in automobiles we can expect a voltage range of 200 to 400 volt for the DC bus. That does not mean that all electronics will go to that voltage level. Isolation for that voltage range together with vibration in automobiles will limit the general usage of higher DC bus voltages. Safety may keep that voltage in a range that will be below the critical value that it hurts humans. The human body and the current that can flow by the body resistance define all that. The regulations defined something in the 50-volt range. Alternative concepts of electric vehicles may be nice but still have to overcome the battery weakness in the concept and the fuel cells are not yet seen in volumes in automobiles. Looking back that does not change since the first automobiles had been seen with electric drives prior to combustion engines about a century ago. Concentrating back to today's problems that 12Volt equipment will be combined with 36 Volt in one automobile. The consequences are conversion between the systems to feed the total need. The limitation of weight predicts that none of the system can be designed to carry the full backup for peak power demands. DCDC converter has to do the job.

Centralized DCDC conversion can have the problem of more wiring and extract the heat efficient. So there are also decentralized versions to be looked at and converters have their point of optimum that need also to be taken in consideration.

I have seen people talking about 2KW of total conversion done in the car. To do conversion right high efficiency is requested. There is a long experience at companies in telecom applications with high efficient converters. 90 percent is a good benchmark to look at with the consequences of 10 percent loss. That means that several 100 Watts can be generated as loss mainly heat. Heat is only good in the wintertime. Hopeful they are not in permanent use, but than their weight will be carried on extra and magnetics and heat thinks are not free of weight. Getting passive components smaller need higher frequency to operate.

Running at higher frequency needs more careful look into the electro-mechanical compatibility. As cars are made more and more out of plastics to reduce weight, magnetic shielding may become necessary and that puts on again extra weight. Consequently the cross over time for vehicles with both systems must be shortened that the benefits of the 42Volt are not eaten up by conversion elements and higher complexity, with the risk of higher failure rates.

The introduction of cars with 42 Volt Systems was projected to start with pilot series and very small volume in 2002. All these kind of vehicles must have a 14V and 42V bus. Back and forth conversation of energy is requested. Efficient power management is the secret to make it happen. The comfort equipment will continue for a while before fulfilling the 42V standards worldwide.

By the year 2010 cars with only 42V bus should be in production. That was the forecast from the market research people. The today's outlook may delay it for a few more years. I do not believe that by 2010 all cars will go for 42V. The worldwide fact is there are a number of economies that are starting in individual automobile usage. These countries are not starting with our standards of luxury and sophisticated cars.

But back to our European focus here. The consequences for semiconductor manufacture are to have driver ICs and MOSFETs to serve DC/DC conversion during the crossover time frame. All these projects have high volume and will be focused to hybrid or modules. Standardization will be helping to get progress to module design. Illumination is another big area in the car the bulbs have to be 42V types. All what we had seen for specs driving lamps at 14V will come up with 42V at a different level. Cold and hot resistance of the bulb needs to be solved at 42V and in addition the discharge lamp systems will be powered. The discharge is a power supply by itself so that will come easy for 42Volt.

Motor management has a key interest. The combination of alternator and generator will open more technical advantage than only reducing the mechanical parts in the car to one element. This combination can be seen as a step to an electric hybrid car with regenerative energy management and better peak power performance. Any of the solutions here does not fit direct into discrete package range of MOSFETs. Here the module is the only accepted solution. We have the inputs from Industry in this magazine what is on the way to serve the next generation of vehicles. Europeans have strong involvement in design processes at automakers all over the world. Japanese products are seen in Japanese cars like the Prius from Toyota.

The MOSFETs in the 75V to 100V range with minimum on resistance at given max economic die size and excellent avalanche capability is the switch to get these applications running. To respond to the several hundred amps in the starter generator combination, the module is the only practical solution to parallel MOSFET die.

In conclusion leading edge MOS-technology including IGBTs is a must combined with advanced packages in modules. Semiconductor manufactures have silicon on hand or under development to achieve these goals. Hybrid and module manufactures have experience from industrial areas. There has been no limit to tool up fast and efficient in Europe. We have seen a number of approaches at the PCIM Europe Conference in Nuremberg in May. Not only the silicon is important for automotive also the passive components are the spice to make a practical design efficiently working.

Advanced batteries and super-capacitors are the energy storage in electric- and in hybrid-vehicles. The practical usage of fuel cells can be seen later at the H2Expo in Hamburg September 15th to 17th. A good number of serious companies have developed prototypes for these technologies. First of these vehicles are in the field test for harvesting results in handling practical day to day use. So we can conclude that conversion and motion handles electrical and electronically innovation to support automobiles including drive by wire developments that will allow much more design flexibility for the body layout of future vehicles. The simulation and design software tools have improved cycle time and safety for new developments. We do a lot virtually, but finally we want to sit down and drive the car. We need to have a little fun factor to enjoy life.

Power Becomes "Cool"!

By Arunjai Mittal, VP and GM, Discretes and Power Management business unit, Automotive and Industrial business group, Infineon Technologies AG

Looking at semiconductor processes, Computers and consumer applications such as Plasma TVs, LCD TVs, DVD players/recorders, digital cameras continue to fuel the growth of the power supply market! This is predicted to continue at a constant growth rate of 10 to 15 percent within the next years ([1]). This growth is demanding power at a steadily increasing rate. At the same time, energy available is limited, which results in the requirement of more efficient energy converters.

The US government estimates that the total amount of electricity flowing through external and internal power supplies in the States only is more than 207 billion kwh/year, or about 5.5 percent of the national electric consumption, and that more efficient designs could save an estimated 15 to 20 percent of the energy lost in power conversion ([2]).

In Germany alone, electronic equipment with power supplies make up more than 7 percent of total power consumption and in addition, stand-by power consumption has become a major issue: The power consumption for computers, tele-communi-cation and other consumer applications of private households in Germany sums up to 20 billion kWh/year, out of which more than 40% is lost during stand by operation ([3]).

Legal requirements, in addition to increasing power consumption, make it necessary for semiconductor suppliers to develop technologies offering solutions that enable the highest power densities. Infineon's CoolMOS, thinQ!, CoolSET are among other technologies which contribute to the decrease of energy losses and thus enable use of electricity with highest efficiencies.

For example, stand-by power can be reduced substantially by Infineon's CoolSET F3 product family, a combination of a PWM driver IC with the CoolMOS transistor in one single package. The stand-by power consumption of this product is the lowest currently available, by far exceeding the specifications of regulation standards such as Energy Star and the German Blue Angel Eco Norm. In a typical 30W DVD recorder the stand-by power consumption can be brought down to less than 100 mW, enabled by CoolSET F3, where as under the Energy Star standard and European Energy Commission the requirement is 500 mW ([4]).

The Internet web continues to expand. Current forecasts indicate approximately 5.8 million PC server shipments in 2004 ([5]). With an average power consumption of 1 to 1.2 kWatts of power, increasing efficiencies by just 1 percent in these power supplies would mean significant reduction of electric power losses. This gain in efficiency for server power supplies potentially would save another "small" nuclear power plant of 360 MW. Not only can the highest power density level in the power supplies for 1U and 2U rack mounted servers be achieved using the latest high voltage CoolMOS transistors, thinQ! (Silicon Carbide Schottky Diodes) and low-voltage OptiMOS 2 transistors from Infineon, also efficiencies of up to 97 percent are possible.

According to the latest report of market research company IMS, as the leading supplier of power semiconductors ([6]), Infineon Technologies continues to expand its technology leadership and develops products shaping tomorrows power supply solutions.

([1]) iSuppli Power Management Market Tracker Q1 2004, WSTS FC BB_Oct. 2003
([2]) http://www.energystar.gov/ia/partners/downloads/energy_star_report_aug_2003.pdf
([3]) http://www.isi.fhg.de/e/publikation/iuk/Fraunhofer-IuK-Abschlussbericht.pdf
([4]) www.blauer-engel.de
([5]) Gartner, ML TechStrat
([6]) IMS Research, The global Market for Power Semiconductors, 2004 edition; published June 2004

www.infineon.com

Optimising the Dynamic Performance of POL Converter Modules

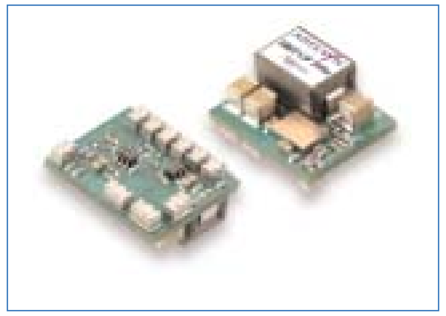
The effect of remote sense on loop stability

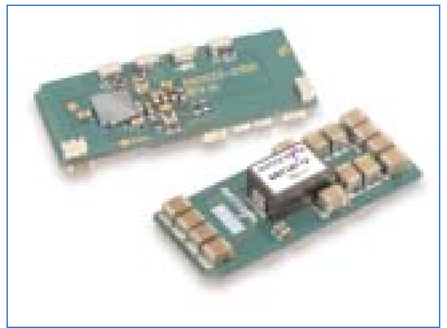
High load currents and fast transients are becoming increasingly important silicon supply issues. POL converter modules that are specifically designed to operate with remote sense and minimal external capacitance offer a cost-effective design solution. But the choice of module and remote sense implementation need to be carefully considered in order not to impact loop stability.

By Shane Callanan and Peter Bardos, Artesyn Technologies

For applications involving high load currents and requiring fast transient response capabilities, the optimum solution is to place the point-of-load (POL) converter 'on top' of the device it is powering. Invariably, board designers do not have this luxury and are forced to place the converter some distance from the load, which may affect system performance. Compensating for this situation must be addressed during the design phase.

Local decoupling capacitors can handle high frequency current transients, and remote sensing can to a large degree compensate for low frequency voltage drops on tracks. However, remote sensing can pose stability problems, because the compensation loop must be stable under large load variations and with different track impedance. This article looks at some methods of implementing remote sense, and the impact each will have when the module is integrated into an application.





Option 1: Local sense

Many basic POL converters implement this form of sensing, which regulates the voltage appearing on their output pins and offers no compensation for voltage drops on the board. The voltage drop between the converter and the load will increase with track length and impedance, and there will be a general degradation in performance between output and load. Pin and track parasitics (L and C) will degrade transient response, and their effect will be amplified as the output load current and the slew rate of the load step increases.

Option 2: Partial remote sense

One improvement on this is to incorporate a positive sense pin. Local ground is used on the converter module, and a positive sense pin allows the board designer to sense on the positive node of the load. This compensates for voltage drops between the module and load, and reduces the impact of parasitics—but on the positive line only. In order to improve transient response, extra capacitance will be needed at the load, reducing the phase margin of the design and possibly causing instability.

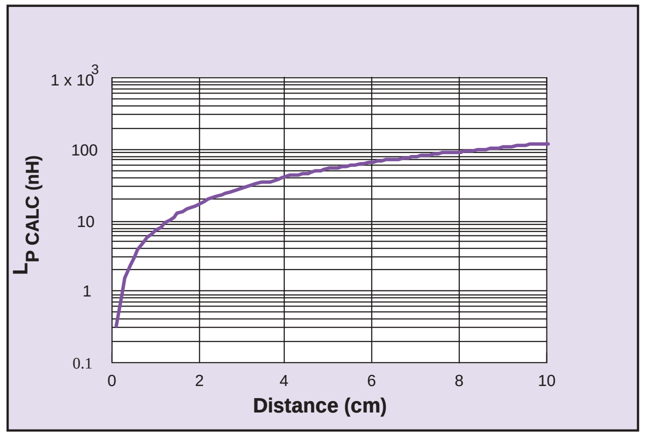


Figure 1. Theoretical calculation of parasitic inductance vs. distance.

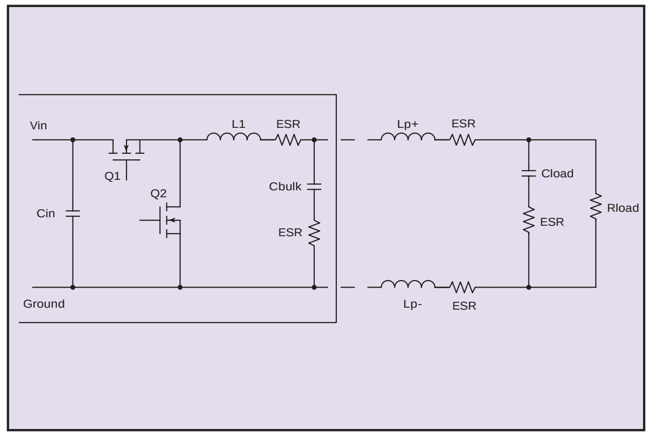


Figure 2. Circuit for analysis.

Option 3: Full remote sense, bulk capacitance on converter

This involves sensing from both the positive node and the ground of the load. However, the result is that you have now created an LC in series with an LC, which is a fourth order filter on the output. All parasitics are part of the control loop and must be taken into consideration when stabilising the loop. It is relatively easy to eliminate parasitic issues under static load conditions, but the dynamic response will be impacted by this approach.

Option 4: Full remote sense, bulk capacitance at load

By using the set-up described above, but with all output capacitors placed at the load, it is possible to restore a second-order filter characteristic, while at the same time improving transient response and retaining static load performance. However, moving all output capacitance to the load increases ripple current loops, and the module will need to incorporate some high frequency decoupling capacitors to reduce EMI.

Figure 1 shows the theoretical parasitic inductance that could be inadvertently introduced into the control loop by the board track between the converter output and the load. The y-axis shows the parasitic inductance in nH, while the x-axis shows the distance from the load in cm. This now means that the role of the module designer and board designer overlap. In the past, power supply designers would have designed a stable system and published, say, maximum capacitive load capabilities. Fast transient POL converters typically use much higher switching frequencies than earlier-generation converters, and employ a much smaller value inductor. So now the parasitic track inductance between output and load forms an integral part of the control loop—and could realistically be over 50nH (a calculated inductance figure with the load 5cm from the module output is in the region of 52nH). If, for example, the output inductor is 100nH, we have now unwittingly increased the inductor by a factor of 50%.

Mathematical analysis of each approach

Each of the four approaches to remote sense can be quantified by frequency domain analysis of the circuit outlined in Figure 2.

Closed loop analysis of each set-up quickly shows how each approach can affect the stability of the design.

Figure 3 shows the gain vs. frequency of each of the four sense methods; LoopGain 1 relates to option 1 referred to earlier in this article, LoopGain 2 to option 2, et seq. The compensation network on each design has been set constant, to illustrate how each approach effects the overall system. For the basis of this calculation the output choke is set at 200nH, onboard capacitance is 22uF, load capacitance 110uF, and all capacitors are assumed to be ceramic. A parasitic inductance of 50nH is used.

The corresponding phase margin can change from a very stable 90° down to a barely acceptable 45°, depending on the chosen remote sense method. If this potential change is not accounted for during design, it may lead to instability when the POL converter is integrated into the application. Subsequent changes in parasitic components could also affect stability.

Application-optimised solutions

In practical terms, POL converter designers always face a trade-off between optimising their design and achieving the best performance at the load. The most elegant solution is invariably a combination of the two full remote sense methods, with as little capacitance as possible on the converter module, and as much as possible close to the load. The objective is to retain a second order filter on the output, whilst minimising the size of the ripple current loops. The optimum POL converter can be achieved by getting this balance right—but of course, POL converter designers also need to satisfy other criteria. A conflicting requirement is that board designers often require a self-contained POL converter, and do not wish to allocate extra board space for capacitance at the load.

Board designers attempting to power highly dynamic loads with conventional

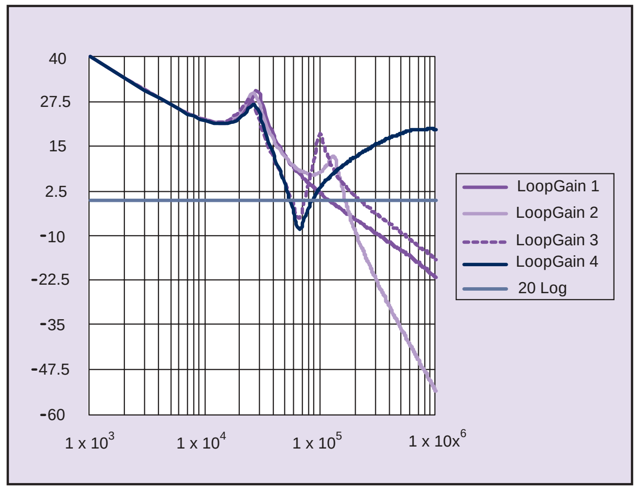


Figure 3. Gain vs. frequency of four remote sense options.

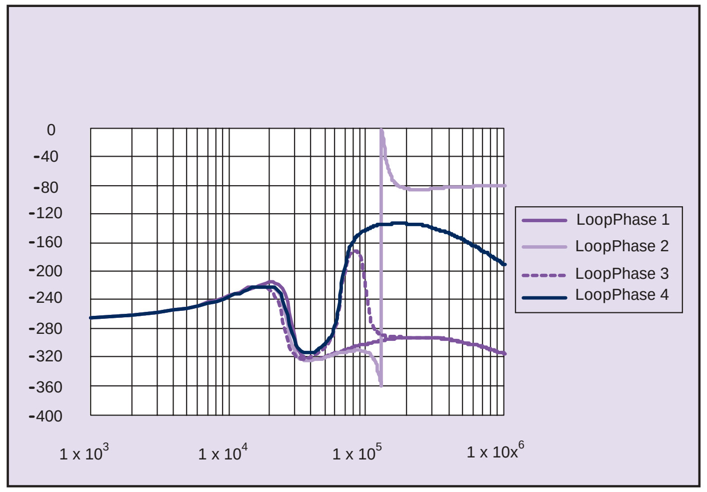


Figure 4. Phase margin of four remote sense options.

POL converters are forced to use excessive amounts of decoupling capacitors to supply the transient current; these capacitors are expensive, take up a lot of board space (often more than the POL converter module itself) and can be unreliable. Artesyn has consequently developed a family of non-isolated POL converter modules—known as F class products—which are specifically designed to maintain tight regulation in the face of very fast load transients, while minimising the amount of external capacitance that is needed. The F class family includes models that offer board designers a choice of remote sense configurations and capacitor placement schemes, enabling them to choose the most appropriate for a particular application.

The SMT12F product range is an optimised design that offers differential remote sense capabilities and minimal built-in capacitance, allowing the board designer to place the required balance of capacitors at the load. By invoking the optimum design, which is a combination of remote sense options 3 and 4 described earlier in this article, efficiency can be improved by as much as 1% at full load, as shown in Figure 5.

This needs to be tempered with the trade-offs required to achieve this maximum figure. Here we have placed minimum capacitance on the POL converter module, and defined the required capacitance at the load. This maximises conversion efficiency (95% at full 12A load for 5Vin/3.3Vout) whilst maintaining load transient capabilities of up to 300A/µs. Figure 6 shows that for a slew rate of 100A/µs, the output voltage deviates by only 1.2%, and recovers in less than 10µs to within 1% of its output set-point.

Board designers who require ‘drop-in’ fast transient POL converters that require no external on-board capacitance are catered for by Artesyn’s new SMT15F product series. These POL converters employ single-ended remote sense (option 2 in the introductory paragraphs of this article) and incorporate all necessary capacitance on the module itself. SMT15F converters have an industry-standard footprint that is slightly larger than the diminutive SMT12F, but they provide a turnkey solution that requires no external components and can handle transients of up to 300A/µs. Higher switching frequencies and integration of components have provided the foundation for this market-leading solution. The net result is that these converters have very low output impedance under all load conditions and maintain tight regulation in the presence of extremely fast load transients. This simplifies the integration task, lowers implementation costs, and significantly reduces the amount of board real estate that is needed. These converters are the latest additions to Artesyn's F class line of POL products, which are designed to power advanced silicon devices that demand high currents and switch at very fast speeds, such as network and communications processors, and high-performance ASICs, FPGAs and DSPs.

Early design decisions are vital

Remote sense compensation minimises the effect of resistance in the distribution system, facilitating accurate voltage regulation at the load. The nature in which a design invokes this, can have an impact on the performance of the module in an application. The remote sense line(s) carry very little current and hence do not require a large cross-sectional area. However, if a sense line is routed on a board, it should be located close to a ground plane in order to minimise any noise coupling that might impair control loop stability. How this impacts the module's compensation capabilities is outlined above, and the choice of remote sense should be based on how a design is required to perform in an application. Each approach has advantages and disadvantages, but in order to compensate for the latter, board designers must be aware of them in the first place. Tight load regulation, good static performance, overall efficiency and optimum transient performance can all be achieved in an application, provided informative choices are made at an early stage of design.

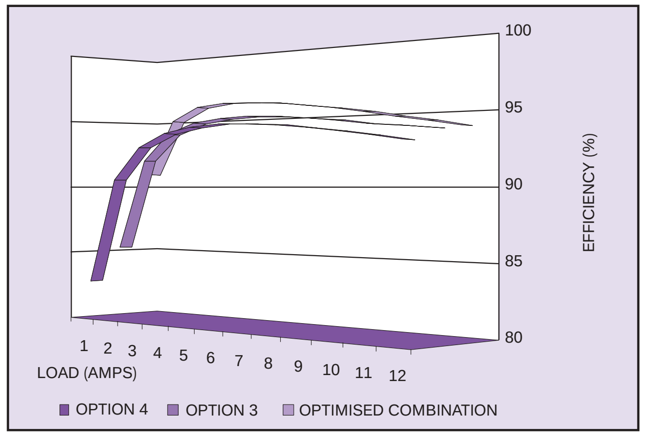


Figure 5: Efficiency plots of SMT12F-05W3V3 converter at 5Vin/3.3Vout, with various remote-sense options invoked.

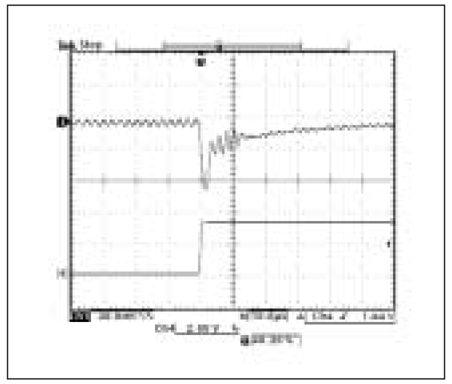


Figure 6: Transient response of SMT12F-05W3V3 converter at 5Vin/3.3Vout, to a 100A/µs 50% Iomax load step.

Company contact:
Jackie Day, Marketing Communications Manager
Artesyn Technologies, Springfield Industrial Estate, Youghal, Co. Cork, Ireland.
Tel: +353 24 25388
Fax: +353 24 25407
Email: jackie.day@artesyn.com

About the authors:
Shane Callanan is a Senior Design Engineer, and Peter Bardos is Principal Engineer, for Artesyn Technologies’ Power Group. They are based at the company’s design facilities in Youghal, Ireland, and can be contacted via email at: shane.callanan@artesyn.com, peter.bardos@artesyn.com

www.artesyn.com

Minimising Notebook AC Adapter

Optimizing rating and battery charging time

Notebooks rely on either the AC adapter, which typically provides from 15V to 20V DC output voltage depending on the manufacturers, or the Li-Ion battery packs to supply power to the notebook power system.

By Jinrong Qian, Intersil

Most consumers today prefer notebook computers to desktop computers because the notebook computer is compact in size, light in weight and its price is continuously decreasing. Notebook computers rely on either the AC adapter, which typically provides from 15V to 20V DC output voltage depending on the manufacturers, or the Li-Ion battery packs to supply power to the notebook power system. As shown in Figure 1, the AC adapter output is used not only to provide the power to the system but also to charge the Li-Ion battery.

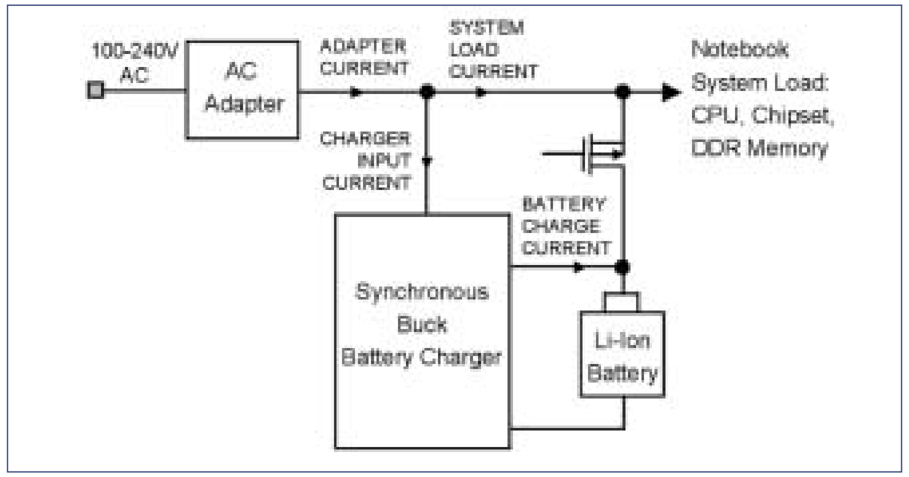


Figure 1. Notebook Power Block Diagram.

Figure 2 shows the typical current waveforms of the notebook power system. The power or current drawn by the notebook system is pulsating due to the CPU's aggressive power management modes of operation, which transitions the CPU from sleep mode to active mode and vice versa. The resulting problem is that the AC adapter must be designed for the worst case of maximum system power plus the power for charging the battery unless there is active power control of the CPU and battery charger. This significantly increases the AC adapter power rating and the adapter size, resulting in a more costly AC adapter since the pulsating power could be as much as twice the average power. So, how can we minimize the AC adapter power rating while at the same time minimize the battery charging time?

A viable solution is to reduce battery charge current when a pre-determined AC adapter current limit is reached. This method avoids overloading the AC adapter when supplying the load and the battery charger simultaneously. Figure 3 shows the current waveforms with the battery charging current regulated based on the AC adapter current limit. During t1-t2, the system load current linearly increases and the AC adapter current remains less than its current limit threshold of ILIMIT. The synchronous-buck battery charger still

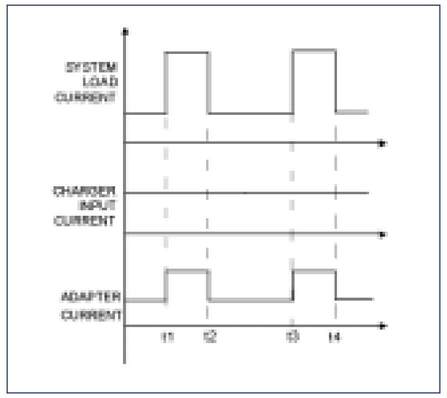


Figure 2. Current Waveforms of Figure 1.

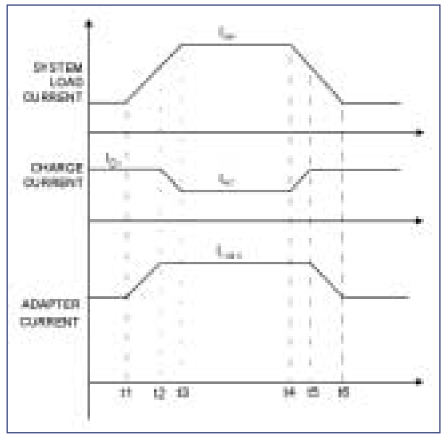


Figure 3. Current Waveforms with AC Adapter Current Regulation.

provides full-scale charging current of IB1, maximizing use of the AC adapter power while minimizing the battery charging time. At t2, the AC adapter current reaches ILIMIT, at which point the battery charge current automatically starts to reduce by adjusting the duty cycle of the buck battery charger as the system load current continues to increase. The battery charge current is reduced to IB2 to maintain the constant AC adapter current when the system load current reaches its maximum value of ISP at t3. On the other hand, if the system load current is reduced, as indicated from t4 to t6, battery charge current is automatically increased, maintaining maximum AC adapter current until such time (t5) that the system load current reaches a level that does not demand full adaptor current. In this way, we make full use of the AC adapter power, ensure maximum Notebook CPU performance, and minimize the battery charge time.

AC adapter current monitoring and limiting tolerance is also very important. Poor AC adapter current monitoring accuracy restricts the utilization of the AC adapter for battery charging. For example, a 60W AC adapter with ±10% AC adapter current limit accuracy may only have a maximum of 54W of power available for notebook use. If the notebook system draws 54W, there is no power available for battery charging.

60 W X 10% = 6 W,
60 W – 6 W = 54 W,
54 W – 54 W = 0 W
for battery charging

However, if the AC adapter current limit accuracy is ±3% when the system draws the same 54W, the AC adapter has 4.2 W available for battery charging. This definitely reduces the battery charging time.

60 W X 3% = 1.8 W,
60 W – 1.8 W = 58.2 W,
58.2 W – 54 W = 4.2 W
for battery charging

On the other hand, the AC adapter has to be designed with maximum output power of 66 W for ±10% AC adapter current limit accuracy. Assuming the AC adapter has 85% efficiency, the AC adapter input power will be 77.6 W, exceeding the 75W limit which requires the AC adapter to include power factor correction to meet the international harmonics requirements such as IEC 1000-3-2 or EN 61000-3-2. Having power factor correction typically adds 10% more to the cost of the AC adapter.

60 W X 10% = 6 W,
60 W + 6 W = 66 W,
66 W / 85% = 77.6 W

However, the maximum AC adapter input power is only 72.7W for ±3% AC adapter current limit accuracy, assuming the same 85% AC adapter efficiency. That means it is not necessary to include the power factor correction function in the AC adapter.

60 W X 3% = 1.8 W,
60 W + 1.8 W = 61.8 W,
61.8 W / 85% = 72.7 W

Table 1 shows the relationship between current limit accuracy and AC adapter power.

To deliver higher efficiency and cost savings, Intersil developed the ISL6253 notebook battery charger IC. It provides the industry's first ±3% accuracy for the AC adapter current limit to maximize the charging current and minimize the charging time under heavy system load conditions while eliminating the need for a more expensive AC adapter. Figure 4 shows the block diagram for this synchronous buck battery charger with its typical application circuit. MOSFETs Q1 and Q2 and inductor L form the synchronous buck battery charger topology to achieve high power conversion efficiency. Q4 is the power source selection MOSFET, which is turned on when the AC adapter is not available.

The current sensing resistor R2 is used to sense the AC adapter current and the voltage drop across this sensing resistor is amplified by CA1. The transconductance error amplifier gm3 is employed to regulate the AC adapter current so that it never exceeds the user-programmed limit. The current sensing resistor R1 is used to sense the battery charging current and the transconductance amplifier gm2 is used to regulate the battery charging current to ensure that the battery charging current never exceeds the limit set by the user through the voltage at CHLIM pin. Tight AC adapter current regulation and battery charging current regulation accuracies make it possible to minimize the AC adapter power rating and to shorten the battery charging time.

Figure 5 shows waveforms from Intersil evaluation board ISL6253 evaluation board. It shows that the battery charging current is reduced when the system load current is increased such that the AC adapter current reaches its current limit threshold of 5A. The AC adapter current loop has very fast step load transient response (less than 100ms), which minimizes overloading the AC adapter and prevents system bus crashes due to heavy system loads. An additional feature of the ISL6253 is that it has the world's first ±0.5% battery voltage regulation accuracy over a wide temperature range from –100C to 1000C. This accuracy is critical to improving battery capacity and increasing the battery service life.

Current Limit Accuracy	AC Adaptor Available Power	Adaptor Input Power Requirements
±10%	54W	77.6W
±3%	58.2W	72.7W

Table 1. Current limit accuracy vs AC adapter power.

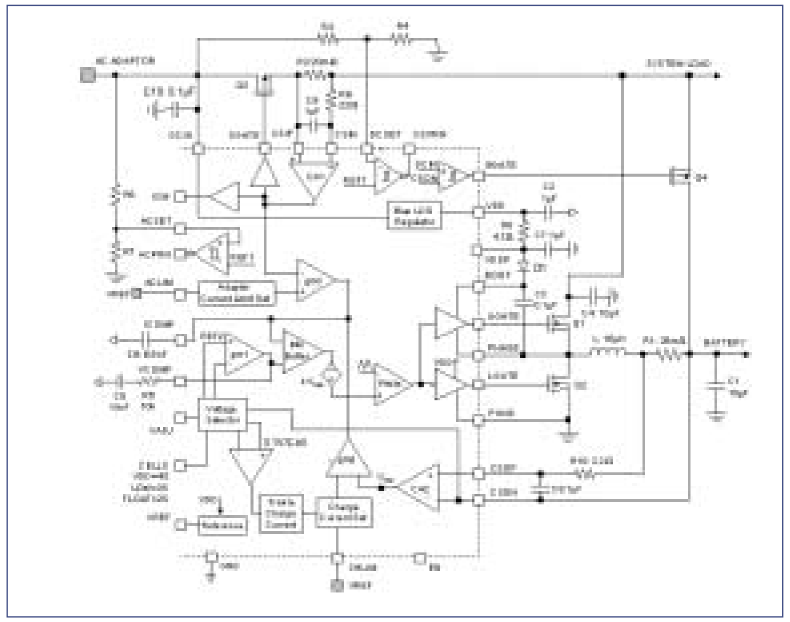


Figure 4. ISL6253 Battery Charger Schematic.

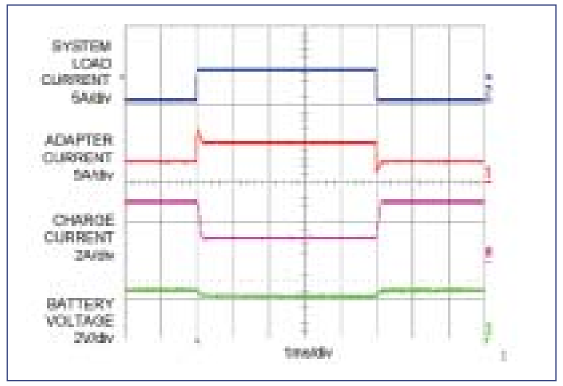


Figure 5. The experimental waveforms with AC adapter current regulation.

In summary, accurate AC adapter current regulation avoids overloading the AC adapter and reduces the AC adapter power requirements for the dynamic power system. A high AC adapter current limit accuracy reduces the AC adapter power ratings, potentially avoiding a more costly power factor correction circuit and minimizes the battery charging time with heavy system load.

Intersil's new synchronous buck battery charger control IC, the ISL6253 significantly improves the battery charging performance, potentially resulting in significantly smaller and lower cost AC adapters.

www.intersil.com

Power Systems Design EUROPE

Automotive Electronics

Driving Technology: Part I

Photos courtesy of General Motors Corporation

AUTOMOTIVE ELECTRONICS: PART I

Automotive Electronics Power Up

Fast-growing market drives rapid increase in power-management IC sales

By Derek Lidow, President and CEO, iSuppli Corporation

What's the fastest-growing electronics application market, and one of the hottest opportunities for semiconductors and power management ICs and discretes over the next five years? Here's a hint: It's not PCs, mobile phones or consumer electronics. Rather, it's automotive electronics, an often-overlooked corner of the electronics industry that nonetheless is undergoing rapid growth.

From entertainment systems, to power-train control, to safety and cockpit gadgets, each year brings an increase in the amount of electronics packed into each motor vehicle sold worldwide. Automotive is the fastest-growing segment of the major electronic equipment application markets, with global revenue expected to rise at a Compound Annual Growth Rate (CAGR) of 8.3 percent from 2002 to 2008, according to iSuppli Corp. data. This exceeds the rate of growth in all other major electronic equipment segments, including data processing and mobile communications. Automotive electronics revenue will rise to $113.4 billion in 2008, up from $70.3 billion in 2003, iSuppli predicts.

Meanwhile, worldwide shipments of semiconductors used in automotive applications will more than double over the next few years, with sales rising at a CAGR of 14.9 percent to reach $24.5 billion in 2008, up from $10.7 billion in 2002.

Figure 1 presents annual revenue growth for automotive electronics and semiconductors.

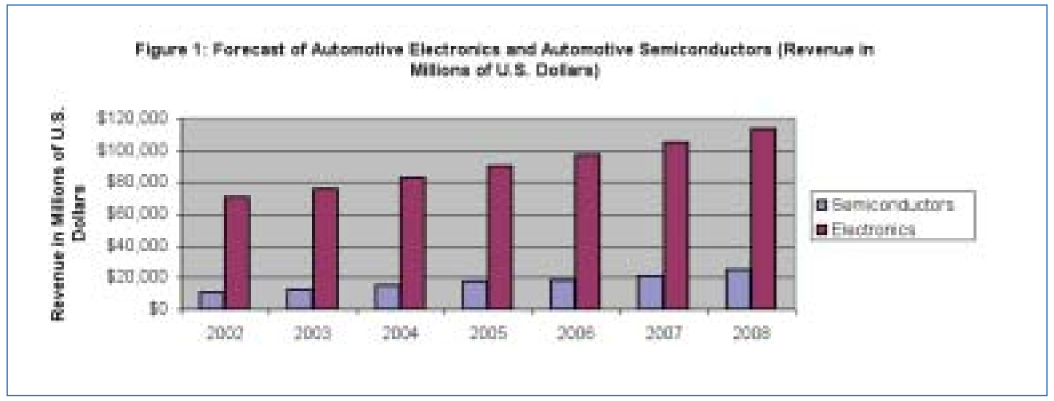
Sales of power management ICs and discretes for autos will grow even faster than the market for car-oriented semiconductors. Revenues from shipments of power management ICs for automotive uses will nearly triple from 2002 to 2008. Automotive power management ICs revenues will grow to $5.3 billion in 2008, rising at a CAGR of 18.5 percent from $1.9 billion in 2002.

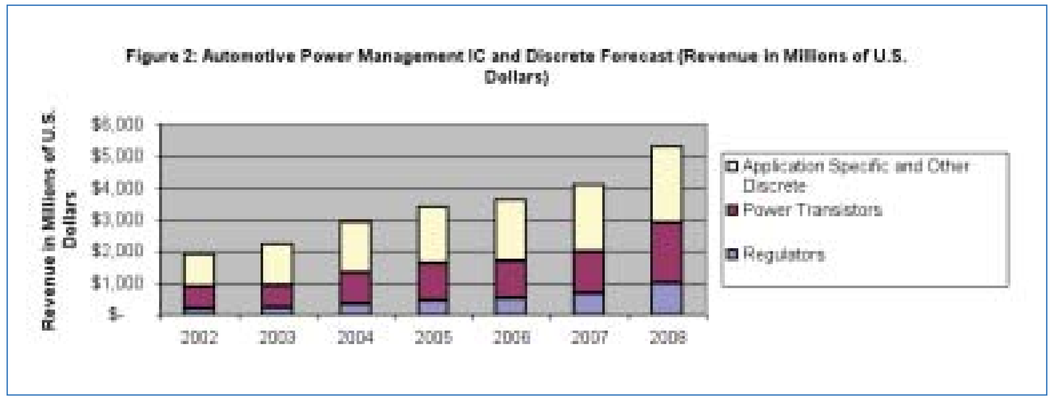
Figure 2 presents iSuppli's forecast for power management ICs for autos.

Power regulators will lead the growth, with revenue growing to $994 million in 2008, rising at a 34.1 percent CAGR from $171 million in 2002. Power transistor revenue will rise at a CAGR of 18.4 percent, growing to $1.9 billion in 2008, up from $691 million in 2002. Shipments of power application-specific and other discrete parts will grow to $2.4 billion in 2008, rising at a CAGR of 14.8 percent from $1.1 billion in 2002.

Sales of growth of power regulators and transistors to the automotive market will be fueled by the rising popularity of hybrid vehicles. Such autos use between $500 and $1,000 of power electronics in each vehicle, generating a huge opportunity for component suppliers.

A rise in average power consumption per vehicle and the delayed adoption of 42-volt electrical bus for cars will pressure auto makers to employ more sophisticated power management systems, such as Digitally-Controlled Power (DCP). iSuppli defines DCP as the integration of microcontrollers, Digital Signal Processors (DSPs) and application-specific silicon and software algorithms for system monitoring, internal and external communication, and control of power systems. DCP promises to bring flexibility and programmability to power supplies, leading to increased performance and reliability compared to the traditional





Source: iSuppli 2004

analog approach. This will reduce hardware complexity, accelerating time-to-market and ultimately lowering the cost of electronic systems.

Automotive systems will use DCP elements and will employ increased amounts of processing and power electronics. As hybrid and electric vehicles gain greater popularity, growth of this application will accelerate. iSuppli expects significant penetration of DCP in this segment in the 2008 to 2012 timeframe. In the meantime, the automotive sector will continue to be a fast-growing opportunity for power management ICs and discretes.

You can contact Derek at: dlidow@isuppli.com.

Derek founded iSuppli to provide the visibility to improve the electronic industry value chain. iSuppli accomplishes this by gathering and disseminating unique value chain data and information, and by working with its clients to use the information to make better and faster business decisions.

Prior to founding iSuppli, Derek was CEO of International Rectifier, a leading power semiconductor company. His 22-year career at IR commenced in 1977 as a production engineer. Subsequently, he served as Vice President of Operations, and in 1985 was promoted to Executive Vice President for Marketing and Administration. In 1989, he became President of IR's Power Products Division, was elected to the Board of Directors in 1994, and became CEO in March 1995. Derek earned a BSEE degree summa cum laude from Princeton and a Ph.D. in Applied Physics from Stanford as a Hertz Foundation Fellow at the age of 22. He is a member of Princeton's Engineering School Leadership Council.

About iSuppli:

iSuppli Corporation is a globally recognized provider of unique value chain services targeted to the electronics marketplace. iSuppli helps original equipment manufacturers (OEMs), electronic manufacturing services (EMS) providers, original device manufacturers (ODMs) and component suppliers improve the cost and performance of their supply chains by delivering the information, analysis, advice and tools that improve strategic and operational decision-making.

iSuppli offers services that enable clients to understand industry best practices and to implement company specific processes to achieve benchmark value chain performance. Finally, iSuppli provides high-performance, cost-effective outsourced supply chain management and decision-making. iSuppli has the largest staff of dedicated and experienced electronics supply chain experts. Our company has expertise organized by application, product types, price tracking, and supply chain management categories, including an extensive team located in China, helping clients understand and harness the worlds fastest growing market.

www.isuppli.com

AUTOMOTIVE ELECTRONICS: PART I

Hybrid Electric Car Design and Simulation

Optimize at the component level

Power electronic converters (three phase inverter and boost converter) together with the battery is simulated on detailed component level. This allows to estimate the losses, efficiency for variable voltage control and component dimensions.

By Pavol Bauer Delft University and Davor Gospodaric, Trimerics

The examination of power trains in hybrid electric car requires special techniques for the modeling of different electrical/electromagnetic components and electronics. Beside usual electronic systems, electrical drives and actuators, modern cars show highly non-linear and dynamic components such as electrical valve trains, integrated starter generators and electrical machines for hybrid and E-car applications. In addition new energy storage concepts and components as well as main and auxiliary networks have to be considered.

Examples of the "electrical take-over" already are prevalent. Steer by wire, brake by wire, electrical engine cams, temporary 4-wheel electrical drives realized as virtual and real prototypes, are examples for research and development projects in that area, whereas ABS, ASC, DSC and ABC show subsystems already running in today's cars. Many of these systems are high-power electrical drives [1] and require a significantly increased electrical power in the conventional car already. The hybrid car is the next step towards an all electric car. Simulation and variational calculations of complex systems are well known procedures to speed up problem solving and accomplish virtual prototypes.

Development Process

In combination with general purpose system simulators like Matlab/Simulink [5] for the design of a mechatronic systems or even specialized power electronic/electrical drive simulators as Caspoc[6], the whole development process including the simulation of electromechanical (EM)-components and the power train might be described by a four-step structure as shown in Figure 1.

During the first step, the theory of the component is built together with its equations and attributes. The second step contains a component simulation built on the basic technologies, such as black boxes or DLLs. These may be designed and built, far-reaching independently of the target system simulator used in the later steps. Models, designed by object oriented technologies, of all EM-components that already exist, can be reused at this stage. After that—within a vehicle system simulator - step three makes it possible to see the component acting inside the power train, i.e. the vehicle, on a basis of a virtual, but physically correct prototype. Finally, step four shows the real prototype of the component or control, usually behaving almost the same way as predicted in the simulation.

The pace of the change in the automotive industry is quickening as automobiles evolve toward a nearly "all-electric future". One of the methods and ECAD-services in the EM-field of the automotive industry, supporting this change, is TIM (Trimerics Integration Method). TIM, by its horizontal and vertical integration paths, is able to accelerate the development process of electrical machinery and electromagnetic components, hence shorten the time to market, by using simulation methods on different levels as part/component, sub-system and system (Figure 2).

Different approaches in the past showed the possibilities of integrating analytical and numerical calculation methods for the computation of electrical machinery [2]. State of the art design processes for electrical machinery use three principal calculation approaches:

- analytical methods for magnetic circuit and operational characteristics of the machine,
- numerical field calculation for 2D and 3D detail examination of the magnetic circuit at physical level,
- circuit simulation including electronics for a simulation at sub-system (drive) level

The detailed and accurate examination of power trains in modern and innovative cars, including their physical behavior, requires special techniques for the modeling of different EM-components and systems. For the simulation of different disciplines and components a combination of appropriate tools is necessary, as exemplary shown in Figure. 3.

Hybrid car system simulation

Figure 4 shows the configuration of the hybrid car system. The system controls the power distribution by splitting the engine output at the planetary gear [3]. Variable voltage system is here sim-

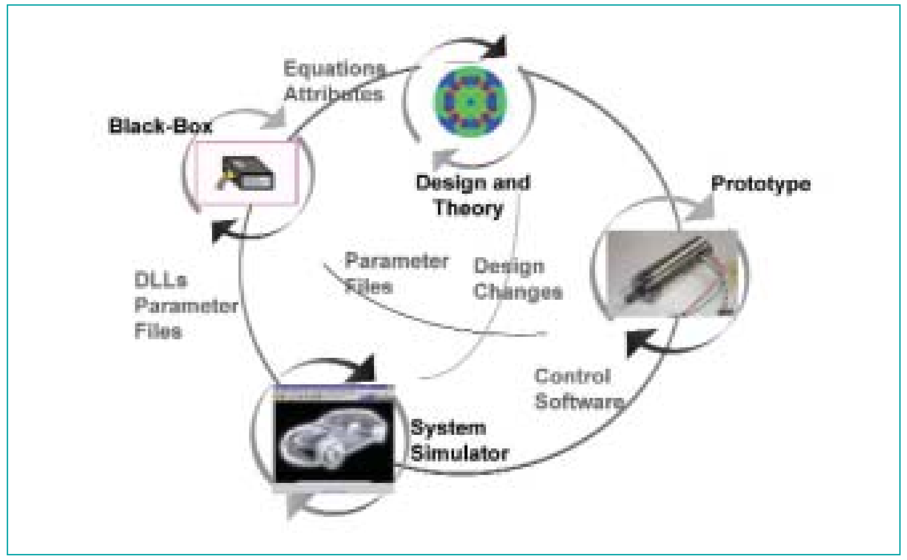


Figure 1. Development steps of power trains containing EM-components.

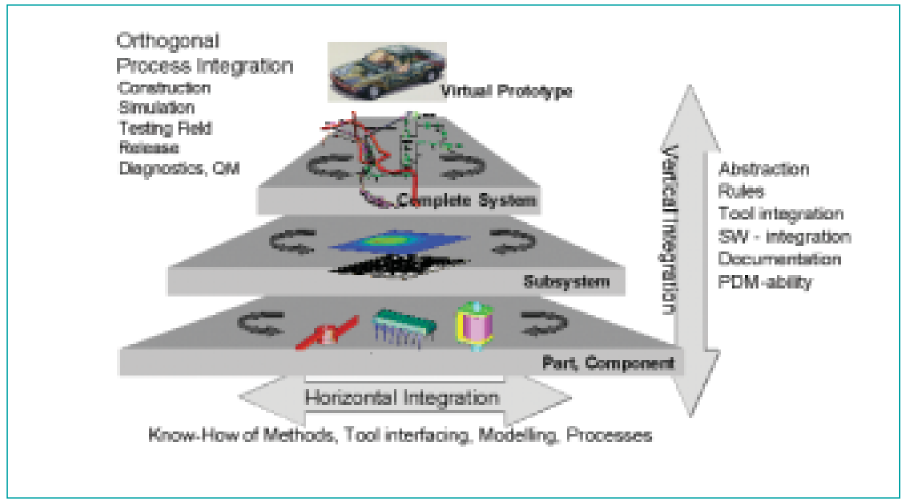


Figure 2. TIM—Trimerics Integration Method for complex EM-development processes.

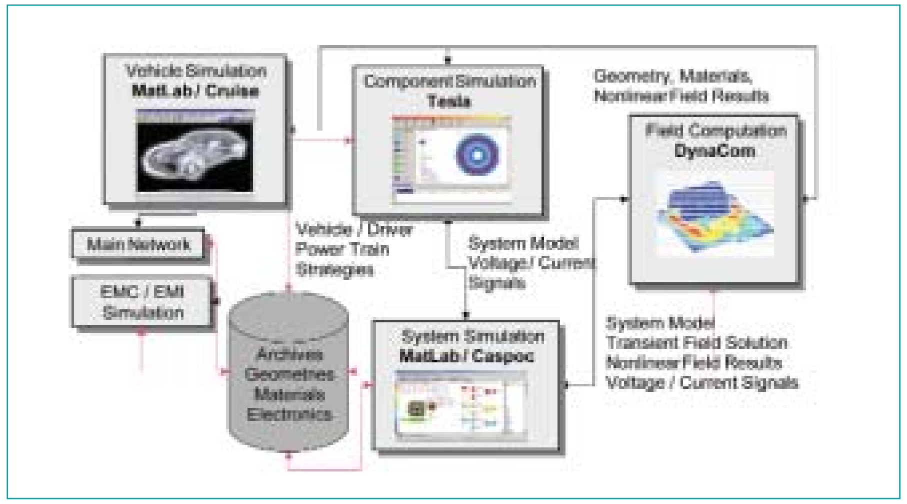


Figure 3. Integrated simulations of electrical machinery, power trains and complete vehicles.

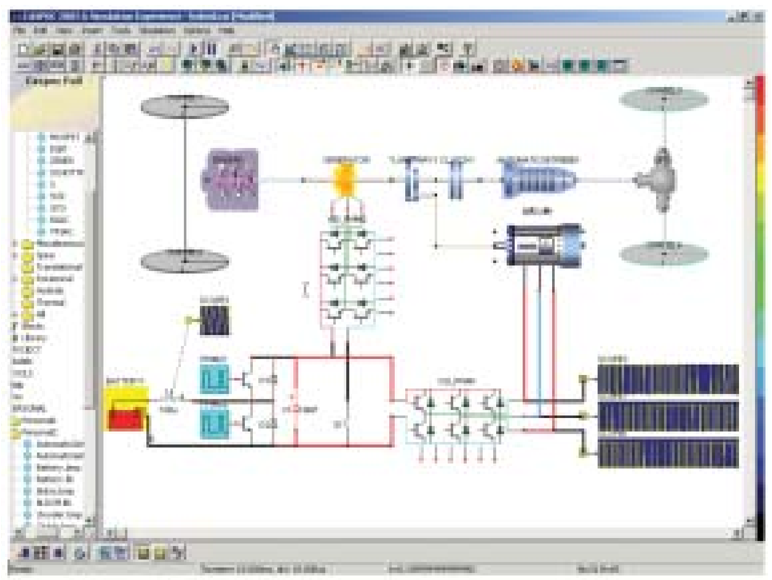


Figure 4. Simulation of a hybrid car system configuration>

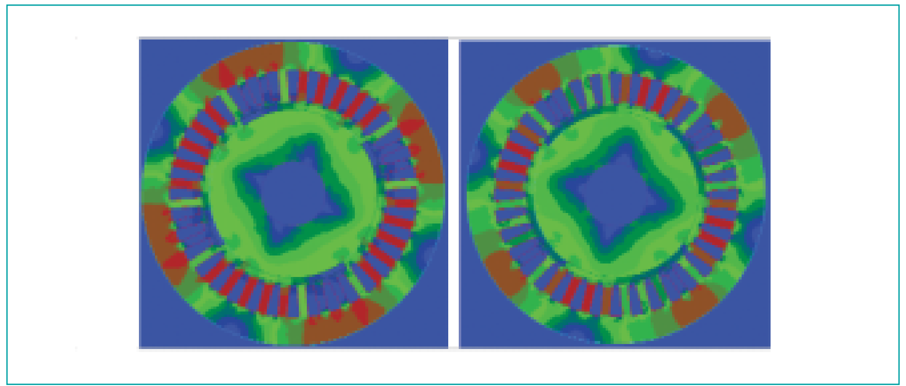


Figure 5. Field Calculation of a Starter-Generator with PM at different loads.

ulated. It allows the system voltage and battery voltage to be designed separately which prove to be cost effective [3]. System voltage design is based on the motor output and withstanding voltage of parts, whereas battery voltage design and number of cells can be altered to match required battery output and capacity. Optimum voltage can be thus acquired independently.

As already mentioned a boost converter is adopted to increase the battery voltage. The battery voltage fluctuates depending on battery operating condition. Hybrid car has a generator and a permanent magnet motor. Electric power supplied to the motor comes mainly from the generator, which makes the supply from the battery and the used boost converter relatively small. Both generator and motor are namely connected through a three phase inverter to a common DC link. Simulation of the complete system is here performed with the Caspoc [6] simulator. Scopes show the PWM voltage of a three phase inverter and operation of boost converter too. Different dynamic states, battery charging and discharging cycle during an urban ride of the hybrid car can be hereby simulated as well as inverter voltages together with the boost operation.

Simulation is performed on different levels. Power electronic converters (three phase inverter and boost converter) together with the battery is simulated on detailed component level. This allows to estimate the losses, efficiency for variable voltage control and component dimensions. At the same time different modulation and control of the converter can be tested with respect to the battery state and car performace.

Numerical field calculation

The need for axial shortness of electrical drives in hybrids and electrical cars requires the evaluation of 3D flux leakage and end winding effects by numerical field calculation (static/steady state), whereas the examination of damping effects in the power train, at the same time, assumes highly dynamic operation of the drives thus, requiring different dynamic field simulations in 2D as well as in 3D. The numerical field calculation is also a valuable help while having detailed look at the efficiency of the machine, i.e. the evaluation of the magnetic circuit and saturation effects as shown in Figure 5 for a permanent magnet machine, at different loads or different conditions in the magnetic circuit.

In hybrid applications, as well as in electrical cars, detailed examinations of the motor and generator operations/ parts by field calculation are important. The boosting functions of hybrids and the recuperation intensities in electrical cars and hybrids are a main part of the overall energy and fuel saving strategy, requiring that detailed examinations.

Conclusion

An appropriate modeling of the EM-components combined with their integration in a power train and vehicle structure of electrical cars and hybrids, gives the opportunity to optimize at the component level and at the same time to recognize and evaluate normal and exceptional situations in the vehicle system. Using the proposed methods and procedures, a wide variety of simulation tests of complete vehicles may be done quickly and accurately, giving the opportunity to virtually evaluate standard electrical values as well as interesting additional values like emission and fuel consumption.

Contacts:
P.Bauer@ewi.tudelft.nl
p.vanduijsen@caspoc.com

References:

[1] A. Krappel, B. Kraßer, Leistungsstarke elektrische Antriebe im PKW, MI-Kongreß "Fortschritt und Zukunft der Automobilelektronik", Stuttgart, November 1999

[2] D. Gospodaric, H.Gao, Parameterbestimmung von Schrittmotoren und SR-Motoren unter Zuhilfenahme der Komponenten- und Systemsimulation, VDI Berichte 1269, Innovative Kleinantriebe, S.133 ff9

[3] S.Sasaki, E.Sato,M.Okamura:The Motor Control Technologies for the Hybrid Electric Vehicle;PCIM04, Nurnberg, May 25-27, ISBN 3-928643-39-8, pp.1-10

[4] H. Iamandi, D. Gospodaric, E. Ditzer, Electrical drives work as virtual sensors in cars, FISITA World Automotive Congress, June 12-15, 2000, Seoul, Korea

[5] O. Zirn, Entwurf und Optimierung mechatronischer Systeme, Seminar “Elektrische Maschinen im Kraftfahrzeug”, Technische Akademie Esslingen, 4/2001

[6] Caspoc, Power Electronics and Electrical Drives Modelling and Simulation, Simulation Research, NL

ADVERTISEMENT

Automotive & Industrial Applications

The LT3433 is available in a 16-pin TSSOP exposed pad package which provides a small footprint and excellent thermal characteristics. When the converter input voltage is significantly higher than the output voltage, the LT3433 operates as a modified buck converter using a boosted-drive high side switch. If the converter input voltage becomes close enough to the output voltage to require a duty cycle greater than 75% in buck mode, the LT3433 automatically enables a second switch. This second switch pulls the output side of the switched inductor to ground during the "switch on" time, creating a bridged switching configuration.

During bridged switching, the LT3433 merges the elements of buck and boost DC/DC converters as shown in Figure 1. In the simplest terms, a buck DC/DC converter switches the V_{IN} side of the inductor, while a boost converter switches the V_{OUT} side of the inductor. Combining the elements of both topologies achieves both step-up and step-down functionality using a single inductor, so voltage conversion can continue when V_{IN} approaches or is less than V_{OUT}.

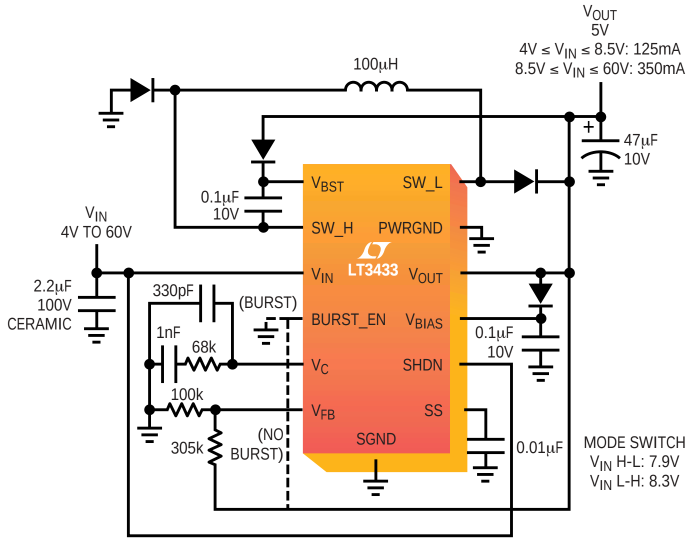


Figure 2. 4V to 60V input to 5V DC/DC Converter

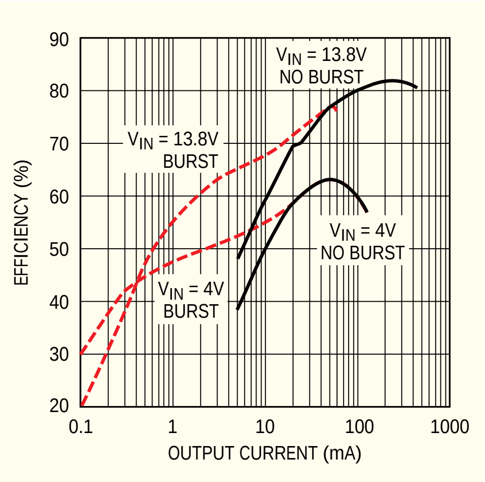


Figure 3. 4V to 60V Input to 5V Conversion Efficiency

4V to 60V Input to 5V Output DC/DC Automotive Converter

A 4V to 60V input to 5V output DC/DC converter is shown in Figure 2. This converter is well suited for 12V automotive battery applications, maintaining output voltage regulation with battery line voltages from 4V cold-crank through 60V load dump. The threshold for bridged mode operation is about 8V, so the converter will normally operate in buck mode. During buck operation, this converter can provide load currents up to 350mA with input voltages up to 60V. Operating with a nominal 13.8V input, the LT3433 accommodates loads of 400mA and produces efficiencies up to 82% (Figure 3). When the input voltage drops below 8V, the converter switches into bridged operation to maintain output voltage regulation. Because the LT3433 switch current limit is fixed, converter load capability is reduced while operating in bridged mode. With an input of 4V, the converter accommodates loads up to 125mA. Not only does the LT3433 converter operate across a large range of DC input voltages, but it also maintains tight output regulation during input transients. When subjected to a 1ms 13.8V to 4V input transition to simulate a cold-crank condition, regulation is maintained to 1% with a 125mA load.

Conclusion

The LT3433 simplifies ultrawide input range DC/DC voltage conversion, enabling simple and inexpensive solutions to a variety of design problems. Automatic transitioning between buck and bridged modes of operation provides seamless output regulation for wide input voltage ranges and input voltage transients. The use of a small footprint TSSOP package, a single inductor and few external components reduces board space requirements, increases efficiency and improves thermal performance.

www.linear.com

Dual High Efficiency White LED Drivers with Integrated Schottkys Drive Up to 20 LEDs from a 3mm x 3mm DFN

The LT3466 is a dual, full function, step-up DC/DC converter specifically designed to drive up to 20 white LEDs from a wide input voltage range. Its high efficiency, current mode and fixed frequency operation ensure uniform LED brightness, low noise and maximum battery life. On-chip schottky diodes eliminate both the added cost and space requirements of external diodes. Its two independent converters are capable of driving asymmetric LED strings (up to 10 in series per converter) from an input voltage of 2.7V to 24V, delivering efficiencies up to 81%. Its 3mm x 3mm DFN package and tiny externals provide a very compact footprint for space-constrained applications.

HIGHLIGHTS

- **Drives up to 20 white LEDs from a 3.6V Supply**
- **Up to 81% Efficiency**
- **Independent Dimming and Shutdown Control**
- **3mm x 3mm DFN-10 Package**

The LT3466 switching frequency can be set between 200kHz and 2MHz via a single resistor, enabling the designer to minimize solution footprint and maximize efficiency. Because the LT3466 utilizes a constant frequency architecture, noise is minimized, eliminating interference with any onboard RF circuitry. Its 2.7V to 24V input voltage range enables the device to operate in applications visible from Li-Ion-powered handheld devices to automotive backlighting. Also, the LT3466 acts as a constant current source. It delivers the same current to each white LED regardless of fluctuations in the LED's forward voltage drop which vary with temperature, manufacturing tolerances and age, ensuring uniform LED brightness. Although on the same chip, the independent step-up converters are capable of driving asymmetric LED strings with independent dimming and shutdown control of each string. Additional features include internal soft-start/inrush current limiting and open LED protection. The combination of the LT3466's high efficiency, versatility, low noise and extremely small "total solution" footprint make it ideal for a variety of backlighting applications that require many white LEDs in a tiny form factor.

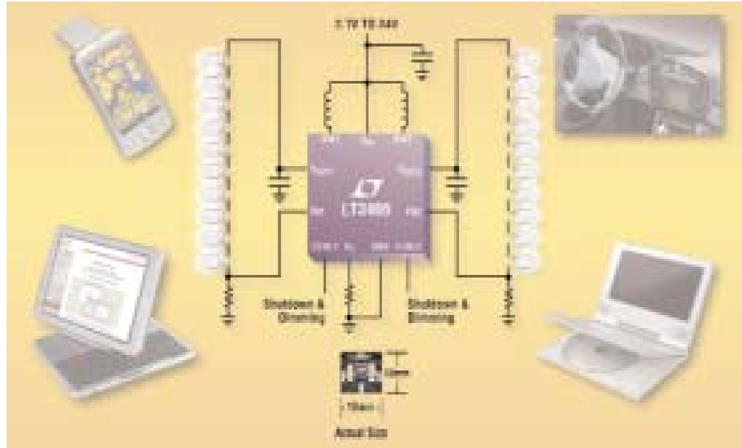


Figure 4. Dual Full Function White LED Step-Up Converter with Built-In Schottky Diodes

Low Supply Currents for "Always-On" Systems

With the adoption of new navigation, security and always-on power systems in automobiles, there is an ever-increasing demand on the battery even when the ignition is turned off. Collectively, several hundreds of milliamps of supply current required to maintain standby power to always-on processors could completely drain a battery in a matter of weeks. For example, after an extended business trip, a high-end luxury automobile would be unable to crank over the engine. Quiescent currents need to be drastically reduced in order to preserve battery life without greatly increasing the size or complexity of the electronic systems. Until recently, the requirement of high input voltage capability and low quiescent currents were mutually exclusive parameters for a DC/DC converter. A car's high voltage step-down converters require 2mA to

LINEAR TECHNOLOGY

Power Semiconductor Modules for Automotive

DCB substrate technology for increased power

The introduction of new drive and control concepts in order to reduce exhaust emission leads to further use of power semiconductors. High demands on power electronics place a great challenge on semiconductor manufacturers and the sub-supplier industry. For the ever increasing power demand in the vehicle first solutions with power semiconductor modules are available.

By Ingo Graf, eupec

The introduction of new applications in the automobile leads to a higher power demand and a concurrently increasing proportion of electronic components. Providing greater power is to be achieved with the necessity to reduce CO_2-emission at the same time. Implementation of greater power with reduced fuel consumption is the aim.

Today's 14-V power supplies with an available power of a maximum of 3.5 kW will not suffice for future applications. This has automobile manufacturers think about the step-by-step introduction of a 42-V power net in the vehicle. By increasing the system voltage the total electric power can be markedly raised whilst retaining the conductor cross section. On the way to a pure 42-V power net it is thought about an intermediate solution in the shape of a 14-V/42-V power net. Such dual supplies require suitably designed DC/DC-converters.

New powerful combinations of electric machines (asynchronous or synchronous machines) so called starter-generators (SG) are in future to replace starters and alternators used in vehicles today. The compact starter-generator enables the start of the engine in just a few hundred milliseconds. The quick starting and the Start-Stop-function reduce the fuel consumption and lower the exhaust emission at the same time. During generator operation the SG provides sufficient electric power of up to 20 kW for the power net. Solutions for 14-V and 42-V systems are possible. Beside the Start-Stop-function the starter-generators provide a boost function for extra acceleration. The additional energy for this can for example be gained by feeding back the brake energy (regenerative braking)

Further opportunities to save energy exist by the introduction of speed controlled drives for fans and pumps (power on demand) as well as by implementing electro-mechanical valve control (Electromechanical Valve Timing EVT), which realises optimised fuel consumption.

The planned introduction of alternative drive concepts such as Hybrid- (HEV), Electric- (EV) and fuel cell vehicles shows a further path to emission reduction. Even today vehicles with these new drive concepts can be found on our roads. The power supplies in these work with voltages of up to 450 V DC depending on the drive concept.

All mentioned concepts necessitate to switch a particular and appropriate current. This is to be achieved under the conditions of the required reliability, a compact size, simplicity of mounting and reduction of losses whilst minimising the system cost.

So for the starter-generator systems an AC-voltage is generated from the DC of the battery in starter mode. For this a AC/DC-inverter with six power semiconductor switches in a three phase bridge configuration can be utilised. A DC/DC converter with power semiconductor switches achieves the energy transfer between the two voltage levels.

Selecting the right technology and determination of the respective semiconductors are important steps when dimensioning the power switches. In the end these parameters will determine the lifetime of the system. Depending on the application the power switches are realised with MOSFET-chips (blocking voltages 30 V—75 V) or IGBT-chips (blocking voltages 600 V—1200 V).

During operation a heat loss is generated in the Chip which has to be dissipated by correctly dimensioned cooling. The heat generated in the Chip origi-

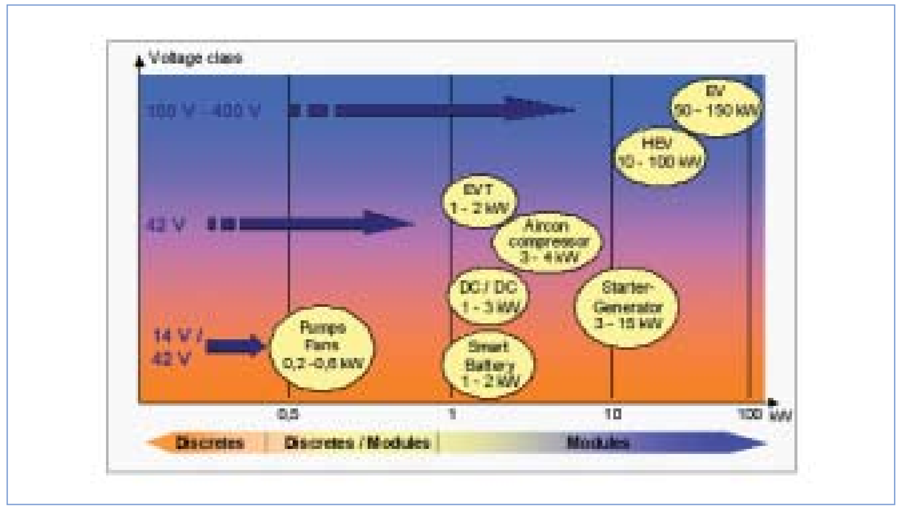


Figure 1. Automotive applications for power semiconductors.

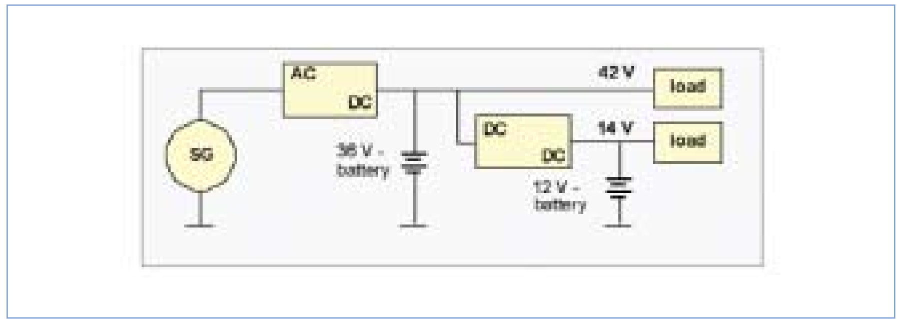


Figure 2. Typical power net structure 14V/42 V with starter-generator.

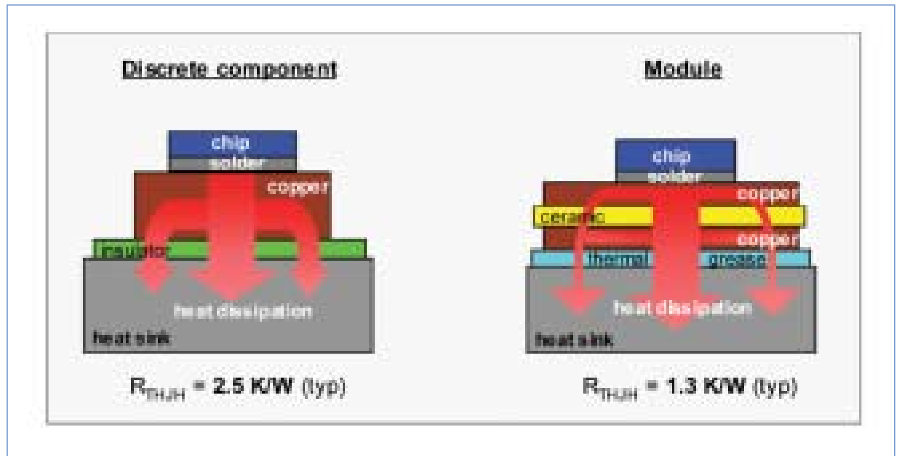


Figure 3. Comparison of thermal resistance "Discrete Component", Module.

nates from switching and conduction losses. The conduction losses are determined by the conduction resistance R_{DSon} of the MOSFET or the Collector-Emitter saturation voltage V_{CEsat} of the IGBT. R_{DSon} or V_{CEsat} should hence be as low as possible. The switching losses depend amongst others on the circuit design and the component features. High inductances in modules and construction reflect negatively here.

Mounting power semiconductors has to be simple yet electrically isolated in construction. To achieve good heat conduction and voltage isolation at the same time various technologies are applied. For so called discrete components (e.g. TO220) the silicon chip is soldered to a small copper plate, connected to the contacts and then moulded in plastic. The component is fitted to a heat sink. For this a foil is brought between the component and the heat sink which operates as an insulator. Today usually discrete components are used in vehicles.

Another technology used for cooling and isolation of the semiconductors is the so called substrate technology. This entails a multi-layered construction of various materials, differing according to the type of the substrate. One of the technologies used in industry and traction today is the DCB-technology (Direct-Copper-Bonding). The DCB-substrate consists of a ceramic layer sandwiched between a top and bottom layer of copper. The layout necessary for the required circuits are etched into the top copper layer. The silicon chip is soldered on top of the DCB-substrate, connected to the contacts and then bonded. The bottom of the substrate is soldered to a copper base plate. A housing which is filled with a gel for electrical isolation, mechanical stabilisation and dampening of vibrations of all components provides mechanical protection. The power module created in such a way can be fitted to a heat sink. For best possible thermal conduction a thin layer of compound is brought between module bottom and heat sink to equalise uneven and rough surfaces. Depending on the application the module may be constructed without a base plate.

The merits of modules with DCB-substrate are compact design, excellent heat conductivity, very high insulation capability, power density as well as current carrying capability. The low inductance construction and the high temperature stress capacity with great reliability at the same time are further features of these modules.

With the vehicle applications mentioned currents of several hundred Ampere have to be switched. For example a starter-generator may use up to

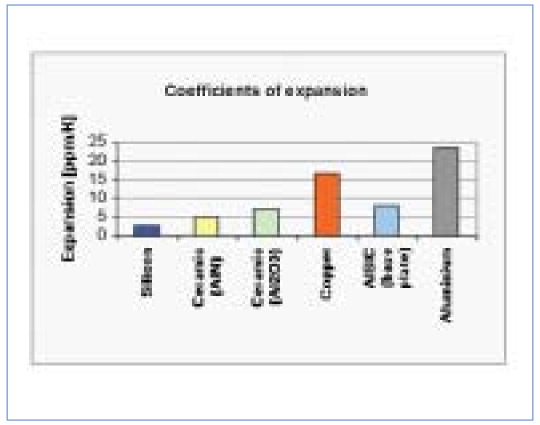


Figure 4. Coefficient of expansion for various materials in power semiconductors (discrete, module).

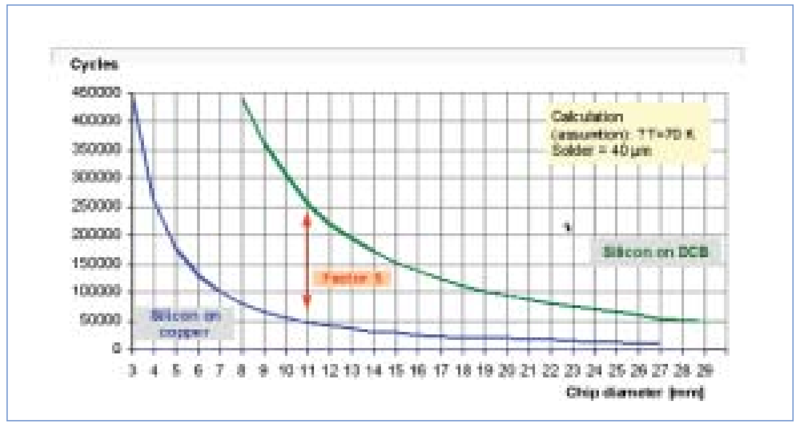


Figure 5: Calculated possible temperature cycles with silicon soldered to DCB or copper

1000 A AC short term for the starting mode and may supply up to 500 A nominal current per phase. Beside the current to be carried factors like voltage level, switching frequency of the chips, temperature level of the cooling system, output frequency of the inverter and the thermal resistance RTH between chip and heat sink will determine the required chip area. "Discrete components" will soon find their limits in future high current automotive applications. The excellent features of the DCB-modules will be utilised optimally.

Over the operational lifetime of both discrete components and DCB-modules there is recurring mechanical stress among the layers due to the permanent temperature change (Thermal Cycle). Originating from the current flow in the semiconductors and the resulting temperature increase materials such as copper, ceramics, silicon and aluminium expand with differing coefficients of expansion.

The thermal resistance between semiconductor and cooling system should be kept as low as possible. With increasing chip area this resistance decreases. Thermal bond is hence improved with the selection of larger chips. If larger silicon semiconductors are soldered to a relatively substantial copper plate, the mechanical stress resulting is enormous, due to the very different coefficients of expansion. This may result in premature solder fatigue. The consequence is delamination of the solder layer and hence an increase of the thermal resistance. Finally the component fails due to overheating.

With DCB-substrates the silicon sits on a very thin copper layer which is attached to the ceramic. The coefficient of expansion is largely determined by the ceramic. The mechanical stress to be considered with the DCB-technology occurs between the silicon and the ceramic. The coefficients of expansion for silicon and ceramic are favourably close (see Figure 4). Hence the mechanical stress can be markedly reduced by the implementation of larger silicon areas.

High demands with regard to reliability are also placed on the bond wires connections in the components. The load changes in the aluminium wire (Power Cycle) and the differing coefficients of expansion of silicon and aluminium result in micro-movements in the material. This may lead to small cracks in the connection points, the so called "Bond Wire Lift Off". In effect the component may fail. The use of materials with matching coefficients of expansion counteracts this fact in a positive way.

According to the law of Coffin and Manson one can calculate the number of possible temperature changes (Thermal Cycles). Figure 5 shows these values for silicon soldered to copper and silicon soldered to the DCB-substrate with a particular solder layer thickness. Generally with these technologies the number of possible temperature cycles reduces with increasing chip area. With the chip sizes for the above mentioned applications (chip diameter between 6 mm and 12 mm) it is evident, however, that the number of possible temperature cycles for the DCB-technology is better by a factor of five compared to soldering the silicon chip directly to a copper carrier.

In future applications power semiconductors will be exposed to temperature rises of up to 120 K. Demands are getting frequent for a reliable solder joints with a thermal cycle rate of several tens of thousands. By utilising the compact DCB-module technology the longevity of the semiconductor and wire connections in the above mentioned automotive applications may be significantly increased.

Today power semiconductor modules come in housings with a base section of up to 190 mm x 140 mm. At currents of up to 3600 A for a single DCB-module switching powers of several megawatts are obtainable. For IGBT-modules blocking voltages of up to 6.5 kV are being realised.

For 12 V and 42 V applications such as starter-generators and DC/DC-converters eupec offers a new modular concept in compact design and without a base plate. This MOSFET-half bridge module called "CarPACK" is used as a base unit to realise topologies demanded by the application. Depending on power requirement and the application a

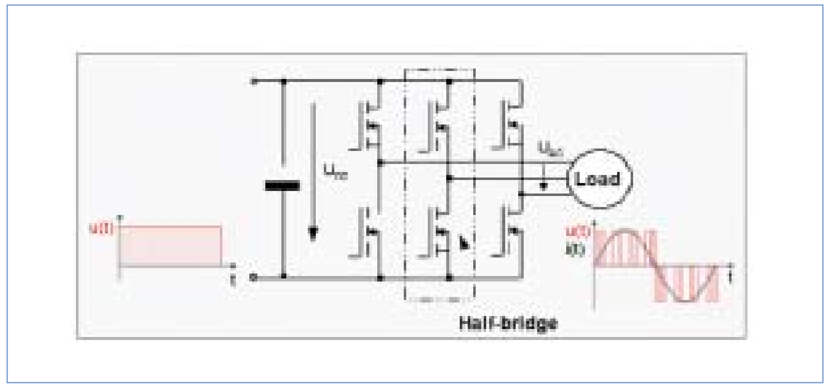


Figure 6: Circuit topology for starter-generator AC/DC-power section.

Figure 7. eupec 180 A / 75 V MOSFET half bridge module "CarPACK".

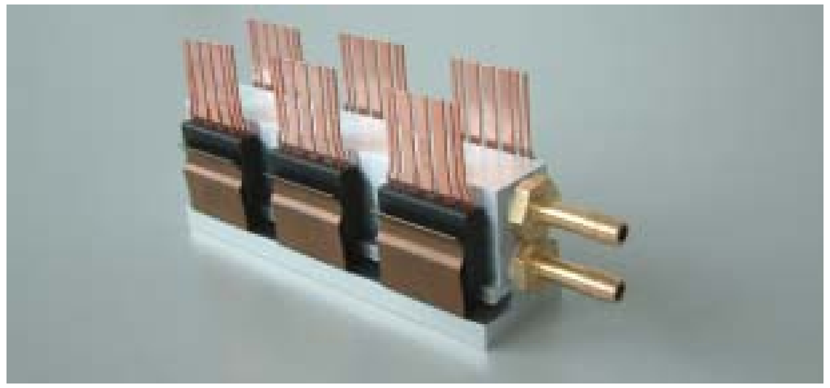


Figure 8: eupec concept for a 50 kW inverter power section with 150 A/600V IGBT modules, water cooled.

corresponding number of modules is to be combined.

Determining the chip blocking voltage depends on the existing system voltage and the required voltage reserve. For 42 V operation 75 V OptiMOS chips from Infineon are implemented in the module. Thermal resistance from chip to heat sink is typically around 0.95 K/W. The 75 V DCB half bridge module features a nominal current of 180 A at a temperature of 80°C at the module bottom side. The low On-resistance of the MOSFET-chips of 2.8 m_ (at 25°C) results in minimal conduction losses in the module. Switching losses are minimised due to the low inductance construction of 8 nH. Power and control terminals may be welded to a bus bar or soldered into a PCB.

The power terminals of the "CarPACK" module heat up due to the high current density carried by the module. An eupec technology called CPT-technology (Cooled Power Terminals) is patent pending. It provides for heat reduction of the terminals. Heat is transferred along the terminal lugs through the module to the heat sink. Overheating of the joint to the bus bar is thus avoided. At the same time CPT-technology assures a mechanically robust termination and hence contributes to improved reliability.

Use of MOSFET's with low blocking voltages (55 V or 30 V for 14 V applications) reduces the On-resistance of the chip correspondingly. This permits higher nominal currents per chip sectional area in a DCB-module. Other circuit configurations such as H-bridges or parallel half bridges are possible with the "CarPACK" modular concept as well.

Electric or hybrid vehicles today are operated with battery voltages of over 300 V. For the inverter with three phase bridge configuration IGBT semiconductors with 600 V blocking voltage are suitable. For this application too the described DCB modular concept may be utilised. Whilst considering the required clearance and creepage distances between the terminals as well as the attributable increase of the DCB section by 80%, a 600 V/150 A half bridge module can be realised. One example depicted in Fig. 8 is the concept of a 50 kW inverter power section. The power semiconductor modules are attached to a water cooler with a spring clip and then connected in parallel.

Power semiconductor modules based on the described DCB substrate technology will do justice to future requirements for increased power use in vehicles. Here semiconductor modules fulfil the stringent requirements for reliability, longevity and power density. Even today millions of semiconductor modules are manufactured and used in the most varying applications. In close co-operation with the semiconductor manufacturers automotive concepts for the future are developed today.

Ingo Graf
Technical Marketing
Automotive applications
eupec GmbH Warstein
An Infineon Technologies Company
E-Mail: Ingo.Graf@eupec.com

www.eupec.com

AUTOMOTIVE ELECTRONICS: PART I

Automotive "Always-On" Systems Demand Low Quiescent Currents

Small footprint solution for step down applications

Modern automobiles continue to include increasingly complex electronic systems. Furthermore, the automotive environment continues to be very harsh for any type of electronics.

By Tony Armstrong, Linear Technology

Wide operating voltage requirements coupled with large transient voltages and large temperature excursions combine to make life tough on electronic systems. What's more, the performance requirements continue to become even tougher. Multiple supply voltages are required for different portions of the system. A typical Navigation system can have six or more different supplies including 8V, 5V, 3.3V, 2.5V, 1.8V, and 1.5V. At the same time, as the number of components increases space requirements continue to shrink. Therefore, efficiency becomes more critical because of the space limitations and temperature requirements. At low output voltages and even with moderate current levels, above a few hundred milliamps, it is no longer practical to simply use a linear regulator to generate these system voltages. As a result, over the last several years, primarily due to thermal constraints, switching regulators have been replacing linear regulators. The benefits of a switcher, including the increased efficiency and smaller footprint, outweigh the additional complexity and EMI considerations.

Taking into account these constraints, for a switching regulator to be considered, it would need the following features and characteristics:

- A wide input operating range.
- Good efficiency across a wide load range.
- Low quiescent current during normal operation, standby and shutdown.
- Low thermal resistance.
- Minimal noise and EMI emissions.

Lets consider each of these essential capabilities in more detail:

Wide Input Operating Range

Any switching regulator would need to be specified to work over a wide input voltage range of 3V to 60V, and could be used in automotive systems capable of running on either 14V or 42V. The 60V rating gives a good margin for 14V systems that are usually clamped in the range of 36 to 40V. Furthermore, the 60V rating allows the device to be used in future 42V systems. This means that one design done now for a 14V system can be easily up-graded for a 42V systems without any significant re-design.

Efficiency

High efficiency power conversion across a wide load range is essential in most automotive systems. As an example, power conversion efficiency of around 85% is expected for a 5V output over a 10mA to 1.2A load range. At high currents the internal switch needs to have good saturation, typically 0.2Ω at 1A. To improve light load efficiency, drive current is reduced or is proportional to load current. Also, power for the internal control circuitry could be supplied through a Bias pin, which can be powered from the output. This takes advantage of the power conversion efficiency of a buck converter. The fact that this bias current is drawn from the output rather than the input, decreases the input supply current required for the control circuit by the ratio of the output to input voltage. For example an output current of 100uA at 3.3V only requires an average input current of 30uA at 12V. This minimizes the input current required by the control circuitry and increases light load efficiency.

Low Quiescent Current

There are many applications in automotive systems that require continuous power even when the car is parked. A key requirement for these applications is low quiescent current. The device would run in normal continuous switching mode until the output current drops below about 100mA. Below this level the switching regulator must skip pulses to maintain regulation. The regulator can go into a sleep mode between pulses where only a portion of the internal circuitry is powered. At light load currents a switching regulator needs to automatically switch to burst mode operation. In this mode, the quiescent current should drop below 100uA for a 12V to 3.3V converter. The internal reference and power good circuit will remain active in sleep mode to monitor the output voltage. Quiescent current should be less than 1uA in shutdown.

Low Thermal Resistance

Ideally, the junction to case thermal resistance should be low. If the backside of the device is exposed copper and is soldered to the surface of the PC board, then the PC board can be used conduct heat away from the device. Four layer boards with internal power planes that are commonly used today can achieve thermal resistance in the range of 40∞C/Watt. High ambient temperature applications that have good thermal conduction to a metal housing can get thermal resistance numbers approaching a typical junction to case number of 10∞C/Watt. This helps to extend the useful operating temperature range.

Noise & EMI Considerations

Although switching regulators generate more noise than linear regulators, their efficiency is far better. Noise and EMI levels have proven to be manageable in many sensitive applications as long as the switcher behaves predictably. If a switching regulator switches at a constant frequency in normal mode, and the switching edges are clean and predictable with no overshoot or high frequency ringing, then EMI isminimized. A small package size and high operating frequency can provide a small tight layout, which minimizes EMI radiation. Furthermore, if the regulator can be used with low ESR ceramic capacitors, both input and output voltage ripple can be minimized, which are additional sources of noise in the system.

The LT1976 from Linear Technology is the latest part in a growing family of 60V capable monolithic step down switching regulators. This device addresses many of the key issues required for automotive applications as outlined above. The LT1976 operates over a wide input voltage range of 3.3V to 60V.

Furthermore, the LT1976 provides high efficiency at load currents up to 1.2A. Reference accuracy is +/- 2% over all conditions of line, load and temperature. Due to its burst mode feature the quiescent current is 90uA for a 12V to 3.3V application.

The LT1976 is packaged in a small low profile TSSOP package with very low thermal resistance to allow small footprint designs. Finally it uses a current mode topology for good transient response and easy compensation, as well as patented circuitry to maintain constant peak switch current across all duty cycles. Switching frequency is a constant 200kHz and the device can be synchronized to a higher frequency. It provides tight regulation over the automotive temperature range and includes Power Good/Reset, Soft Start, and UVLO functions. The circuit provides a robust, efficient, small footprint solution for Automotive step down applications at current levels up to 1.2A. This device enables designers to implement a straightforward simple solution for tough automotive applications.

www.linear.com

Automotive Ignition IGBT Devices

Smaller and smarter is the trend

Over the last decade or so the IGBT (Insulated Gate Bipolar Transistor) has become the power switch of choice for automotive ignition applications.

By Jack Wojslawowicz and Jim Gillberg, Fairchild Semiconductor

The use of the Power Discrete transistor switch as a coil driver started off with the use of the Bipolar Darlington transistor as a single power switch in a stand alone ignition module. This module was located in the engine compartment or on the distributor which guides the spark to the appropriate cylinder. To obtain more precise timing of the spark, the distributor was removed and the Distributorless Ignition System (DIS) was created. In this system each pair of cylinders has a coil that would fire two spark plugs simultaneously, one in a cylinder on the power stroke and one in a cylinder that is in exhaust stroke.

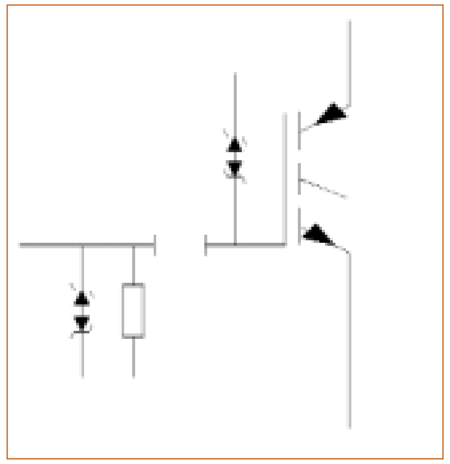


Figure 1. Schematic diagram of an Ignition IGBT.

The evolution of the current application specific Ignition IGBT is the result of the desire by the automotive systems designers to provide better spark control in their ever more complex and shrinking modules. The Ignition IGBT was developed through the combination of proven automotive qualified Power MOSFET technologies with a traditional IGBT structure. Examples of these MOSFET technologies are:

"Logic Level" gate technology so that it can be driven directly from the microprocessor in the ECU. It has built-in ESD diodes to protect it from the harsh automotive transient environment. A collector to gate clamp, employing the same diode technology as the ESD diodes, limits the ignition coil's primary voltage to prevent damage to the coil during the spark plug firing. It has an internal structure designed to sustain the reflected energy of a potential open secondary condition while still maintaining a low on-state voltage for fast coil charging under any battery condition.

The majority of ECU's today contain several Ignition IGBTs within the module representing the highest power dissipation and PCB area of any function within the module.

A developing trend is to physically locate the coil on each cylinder at the spark plug. This application known as "Coil on Plug" (COP) has the advantage of eliminating the costly high voltage ignition wires that we are all familiar with in our vehicles. These wires represent the last major high failure rate component of the ignition system. However as the ignition power switch is still located in the engine control module any current measurements/control or diagnostic functions are limited due to the cabling required to connect the power switch to the coil. This COP scheme requires an individual coil driver doubling the number of coil drivers within the module. This further consumes additional valuable board space and generates significant heat which complicates the module design.

So it is a natural migration to move the ignition power switch into the coil at the cylinder, this application is known as "Switch on Coil" (SOC). Now that the power switch is contained within the coil, the inclusion of the control electronics for direct measurement of the coil current and control of the actual spark conditions is more readily possible and this information can be communicated to the engine control module which can then optimize the fuel economy and the emissions of the vehicle. This, then, creates the "Intelligent Switch on Coil" (ISOC).

Several challenges must be overcome in moving these electronic devices into the Intelligent Switch on Coil environment: Cost, Size, Temperature and

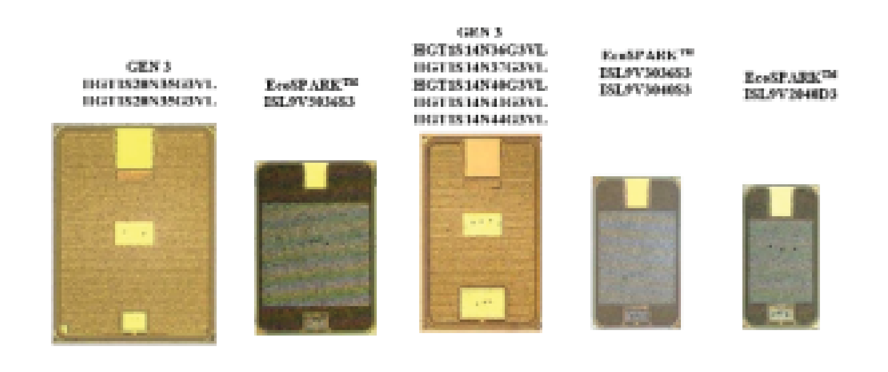


Figure 2. The progress made in the reduction of the silicon requirements of the Ignition IGBT over the last several years.

Figure 3. PQFN or Power QFN package.

Figure 4. Established Packages D2 PAK, D PAK, PQFN and SO-8.

System Intelligence

Several generations of Ignition IGBTs have been developed over the years each focused on improving the cost/performance ratio of the IGBT. The coil's open secondary energy has decreased over the years as better coil designs have emerged and has leveled off at about 300mj. As the ignition IGBT generations have evolved, the device's structure has been optimized for handling this energy.

As the silicon area has been reduced with the latest generations of ignition IGBTs this has allowed for a continued reduction in size and cost of the packaging required. The most recent and smallest package offering for an ignition IGBT handling 300 mj of open secondary energy is called the PQFN or Power QFN . The PQFN package allows for the standard power assembly techniques of solder die attach, heavy aluminum bond wires to maintain the current handing capability and thinner headers to maintain similar thermal capability of the product.

The electrical circuitry required for the Switch on Coil application must be contained within the new generation of "pencil" coils. These coils are significantly smaller then the traditional automotive coils and therefore puts further demands on the size of the electrical components.

While the components are getting smaller they are also now being enclosed within coils with little thermal cooling available and in a very high temperature environment over the engine. Depending on the power dissipation within the coil the control electronics may readily see operating temperatures of 175°C. This is not an issue for the power switch portion of the Ignition driver but as more intelligence is added to the Switch on Coil applications this higher operating temperature requirement must be dealt with.

Once the power switch is contained within the coil there is a desire to add additional circuitry to the ignition IGBT to add more functionality to improve system performance and achieve the "ISOC" concept. Some of these additional functions are:

- Input Gate Drive Control/Buffering
- Coil Current/Voltage Monitoring
- Maximum Dwell Time Limitation
- Fault Detection/Fault Reporting
- Battery Over/Under Voltage Operational Control

One approach to these requirements is to add a control IC along with the Ignition IGBT to perform these functions. Ideally, this IC should be incorporated into the packaging of the IGBT. One advantage of the PQFN package is the ability to easily offer this additional functionality by adding a 2nd paddle into the package for mounting the control die. Figure 6 is a picture of a family of PQFN devices and highlights the multiple paddles and multiple die capability of this package. The other advantage of this dual die approach is that the combination of the IGBT and control die is far less sensitive to electrical transients which can produce catastrophic failures in monolithic devices. In the case of Ignition IGBTs this collector voltage normally typically exceeds 300 volts and could rise to over 500 volts in some applications. This leads to the requirements to isolate extremely high voltages and the potential to forward bias SCR

Figure 5. Examples of Coil on Plug or Pencil Coil designs.

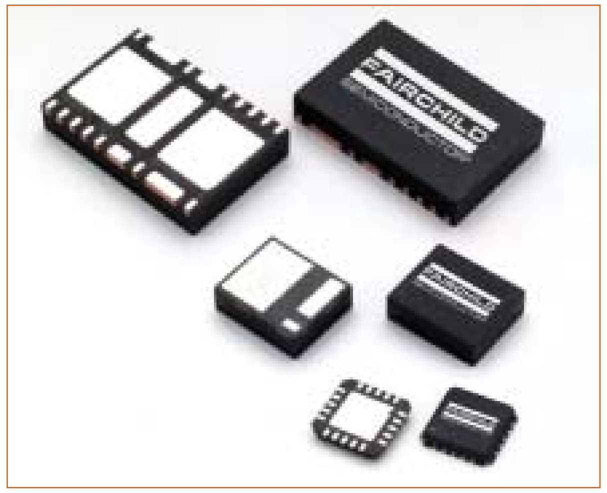


Figure 6. The family of PQFN devices.

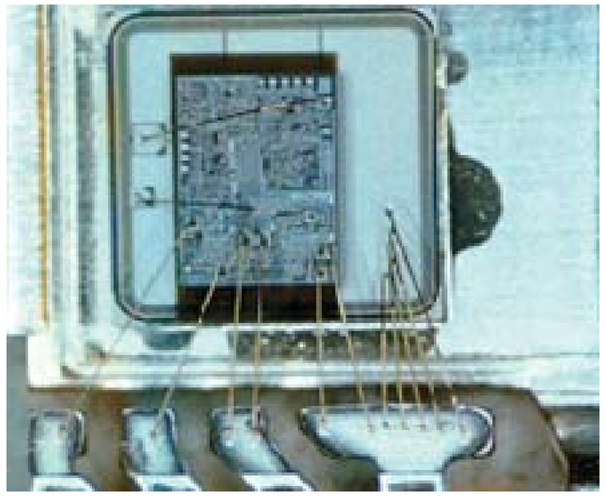


Figure 7. "chip on chip" and side by side mounting of control and power die.

like structures within a monolithic device leading to latch up issues in a harsh, noisy automotive environment.

With this appropriate packaging technology, a control die and IGBT can be co-packaged. This allows the control IC to be physically disconnected from the IGBT and no unexpected or undesired junctions are present that could lead to interaction issues between the two devices. One assembly option is to combine the control die and IGBT in a single power package utilizing an insulating die attach to offer the required electrical isolation between the dies. In this option the control die is mounted "chip on chip", where the control die is physically attached to the top surface (the emitter side) of the IGBT. Another approach is where the die are mounted side by side. The control die is isolated from the back or header of the TO-220 or TO-263 (D2-Pak) package again through the use of an insulating die attach. Both options are being employed to produce "smart" power devices within Fairchild Semiconductor.

New power silicon technologies along with new packages and new die attach materials are enabling the continued evolution of automotive ignition devices. Smaller power devices combined with simple analog/mixed signal IC technology are resulting in a new generation of Intelligent Switch on Coil (ISOC) products for the automotive market.

www.fairchaild.com

Power Management for LCD Automotive Displays

European automakers in forefront

On the drawing board, automakers are designing LCD cluster displays that will allow drivers to customize speedometers, tachometers and engine monitoring gauges in formats tailored precisely to their preferences.

By Roger Holliday, VP Microsemi

Automobile manufacturers are increasingly using LCD display technology to differentiate their product offerings, particularly at the luxury end of their product lines. This trend began with the introduction of Global Positioning System (GPS) navigation displays centered on the dashboard for viewing by both driver and passengers. Initially offered as options, these displays are now a standard feature in most luxury models. When GPS functions are not customer selected, the displays provide traditional vehicle and diagnostic data.

More recently, automakers have begun adding entertainment systems to their high-end vans and SUVs, providing full motion video for rear-seat passengers. Now some premium vehicles even offer full motion video for rear-looking CCD cameras on their GPS displays, to provide added safety while moving in reverse.

CCFL Backlighting

As with all flat panel displays, side or backlighting is the essential element in providing readable data presentation. Cold cathode florescent lamps (CCFL) are the lighting source of choice in applications, such as automotive, which must operate in a wide range of ambient light. Automotive displays also face a critical need for effective brightness control. Display brightness is a serious safety

concern, since levels required for daytime viewing can effectively blind drivers at night. Display intensity that is more than 20 percent above optimal levels can cause momentary blindness and threaten driver safety.

To address this significant liability issue, automotive—and primarily European—designers have focused on incorporating sophisticated power management functionality that provides true lamp dimming across the entire ambient condition spectrum. This approach is perfectly suited for full motion entertainment and back-view video displays, as well.

A simpler, but significantly limiting, solution reverses display contrast as ambient light decreases below preset levels. This typically involves the simultaneous change in background color from light to dark and on-screen information from dark to light. The effectiveness of this approach is limited, has questionable ergonomic characteristics, and no application for video displays. Thus, the more sophisticated true wide-range dimming solutions establish the leading edge in automotive display technology.

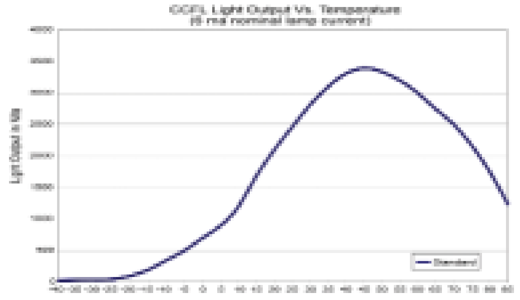
Automotive Performance

Performance requirements for automotive LCD displays differ significantly from flat panel units used in other applications. To operate in bright sunlit ambient environments, automotive display backlighting systems can be required to provide outputs in excess of 600 candelas/m2 (nits)—about four times the brightness provided in a typical laptop computer.

This is the primary reason that LEDs are not currently an acceptable alternative to CCFLs in automotive display backlighting. Current LED offerings used in PDA's and similarly-sized display products provide light output an order of magnitude below what is needed to meet dashboard readability requirements in full daylight conditions. LED development is underway with hopes of meeting this challenge in the future.

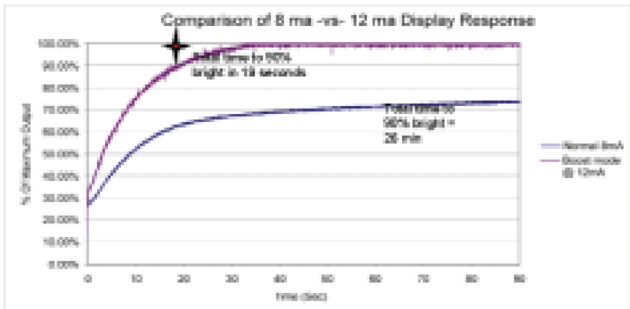
At the opposite end of the brightness scale, minimum backlight intensities to provide flicker-free readability in night-

CCFL Temperature Effects in LCD Notebook, Monitor and Television



Lamp brightness is directly related to CCFL/product temperature

CCFL – Example of Lamp Current Affect on Warm Up Time



Lamp current overdrive or "Boost Mode" can dramatically improve display brightness response

time driving conditions are as low as 3 to 5 nits. These levels cannot be achieved using traditional analog lamp current control. To provide a consistent, safe, visual environment for both driver and passengers, CCFL automotive displays must be able to handle dynamic dimming ranges of 225:1—more than ten times that typically provided in the best computer displays.

Dimming at these low light levels creates additional challenges, even for the advanced duty cycle drive techniques employed in today's PWM-driven inverters. For example, at the low duty cycles encountered when providing light levels below 1 percent of rated maximum, only a few lamp current cycles per burst are firing the CCFLs each second. Here any variation in the number of PWM pulses per burst would appear as unacceptable display shimmer, creating possible driver distractions. These challenges can be met when using the proper systems engineering approach.

Thermal Issues

The temperature extremes from –40 to +85 °C encountered within an automobile further complicate display ballast design. CCFLs must provide the same high outputs on February mornings in Sweden as they do on balmy summer days in Sicily to meet readability standards. Failure to do so promptly in the cold can lead a driver to believe that the display is not functioning. As a result, various forms of high pressure (also referred to as self-heating) lamps have become a virtual requirement for automotive displays.

Self-heating lamps can require strike voltages as high as 3,000 Volts, about four times the strike voltage of CCFLs used in comparably-sized standard displays. In addition to these voltage requirements, boost (current overdrive) techniques are employed to achieve driver-suitable brightness levels quickly when displays are turned on in cold weather.

Lamp current overdrive of as much as 50 percent may be used to achieve this rapid "warm up". This combination of voltage and boost power requirements needs to be managed carefully at the system level from a software and hardware standpoint. A good portion of that effort is applied to the transformers. Consequently, step-up transformers used in conventional inverter designs require significant re-engineering to operate at automotive performance levels while also meeting target cost and form factors.

Fault Protection

Bulb fault detection is particularly critical in automotive backlighting systems, since any arcing or unwanted striking due to a missing, or accidentally-damaged, CCFL lamp is simply not allowable in the possible presence of vaporized or liquid gasoline. In automotive inverter topologies, the sensing of bulb current provides fault detection—a lack of current denotes an open circuit and a failed or damaged CCFL lamp. At low brightness levels and low duty cycles, differentiating lamp current from parasitic leakage and system noise can be difficult. But clever circuit design has been demonstrated to meet this challenge in a number of automotive display products.

Consumers Driving Display Direction

Despite these many stringent technical requirements, and a demanding cost model, luxury car manufacturers—and in particular European automakers—have led the way in implementing these advanced flat panel display systems. Their past and on-going efforts are proving to be more than justified as consumer enthusiasm grows for vehicle video applications that require it.

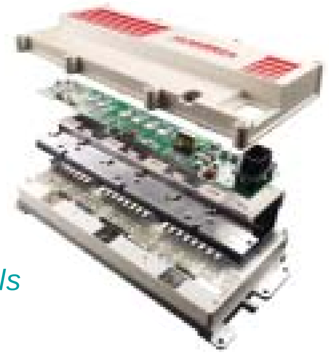
As these differentiating features progress globally downward into mid-level vehicles and below, an increasing number of consumers will benefit from the advancements in lamp construction, system engineering, and backlight power management designs pioneered for the displays in these luxury brands.

www.microsemi.com

AUTOMOTIVE ELECTRONICS: PART I

Advanced Integration of Electric Drive Systems

Pressure contact technology and mechanical integration



Automotive applications are the focal targets for these advanced drive systems which are built for DC voltages from 42 V to 900 V and power levels from 15 kW to 250 kW.

By Werner Tursky and Peter Beckedahl, Semikron

SKAI modules (Semikron Advanced Integration) are DC to 3 phase AC conversion systems and consist of all components necessary to supply a load with electrical energy in the requested quality and quantity.

The main functional blocks of the SKAI drive systems are: power semiconductor switches in three phase inverter configuration, DC link with the storage capacitors, sensors for current, temperature and voltage, gate drivers for the switches, controller hardware, bus interface, power supply for the electronics and cooling system. Due to its proven high reliability, SkiiP technology has been chosen for the mechanical construction. New solutions for the layout of bus bars and DC link are demonstrated which allow ultra low inductance. A parasitic inductance of <1nH for the MOSFET half bridge has been realized. SKAI modules are successfully employed in many automotive applications.

Integrated functions

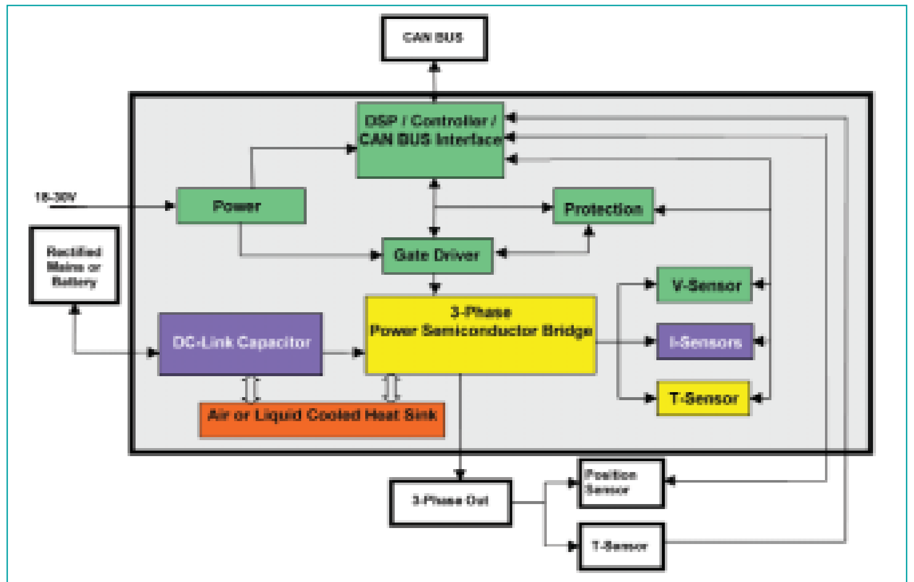


Figure 1: Block diagram of a SKAI module.

Integrated technology

All hardware functions converting electrical energy from a DC source to the current and frequency required by a variable speed 3 phase AC drive, are integrated into the SKAI advanced drive systems. Figure 1 shows the block diagram of the system.

The basis for the packaging design is SkiiP technology because of the high long term reliability. SKiiP® technology is based on pressure contacts which replace large area solder connections. Fatigue and associated degradation of solder joints are eliminated in this way. Multiple pressure contacts assure low thermal and electrical resistance.

To reduce parasitic inductance of the packaging design to a few nH a special layout of the DC link and multiple access to the DBC substrates has been chosen.

Figure 3 shows the principle of this kind of construction for a high voltage SKAI with IGBTs and freewheeling diodes (FWDs). The IGBTs and freewheeling diodes for the top and the bottom switch are positioned on one substrate and the distances between the switching elements and the freewheeling diodes are short. An additional benefit of this design is the equal current distribution between the paralleled power switches.

The lowest parasitic inductance was achieved in the low voltage SKAI: <1nH for the MOSFET half bridge and <4nH including DC link (1nH) and capacitors (2nH). High switching speeds with reduced over voltage can be achieved in this system. The voltage spikes are only 15 V, even when the full rated current is switched off.

Driver, Protection and Controller Circuits

All electrical functionality required to drive, protect and control the 3 phase inverter is integrated in the system on a single printed circuit board (PCB). The PCB contains the controller (DSP TMS320LF2406/2407), the isolated gate driver and protection circuits, and the power supply for the electronics. A serial bus (CAN bus) is the interface to the controller. This PCB is mounted in the module cover and placed above the power switches. The electrical interconnection to the substrate is made by short spring pin contacts that connect the PCB with the DBC substrate.

The SKAI has internal protection against over-current, over-temperature, DC-bus over-voltage and power supply under-voltage.

For DC link voltages from 42 V to 900 V different versions of the SKAI module have been developed.

Low voltage systems with MOSFET switches

These systems are intended for the use in battery driven or light hybrid vehicles. The load currents needed here are from 300 ARMS to 700 ARMS depending on battery voltage and cooling conditions. Depending on the battery voltage the SKAI is equipped with best of its class trench MOSFETs with 75 V, 100 V or 150 V blocking voltage. The on-resistance of the MOSFET switches including all the packaging related resistance is 0.86 m_ for the 75 V version, 1.14 m_ for the type with 100 V MOSFETs and 2.09 m_ for the 150 V SKAI, respectively.

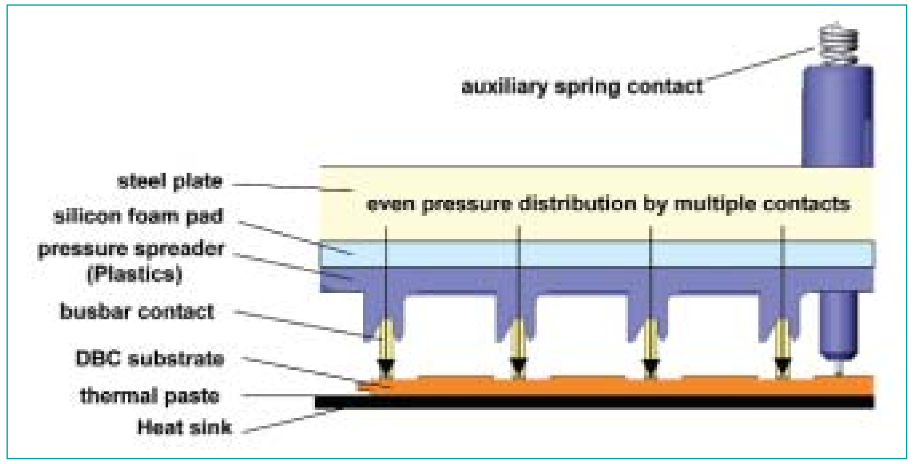


Figure 2. SkiiP technology.

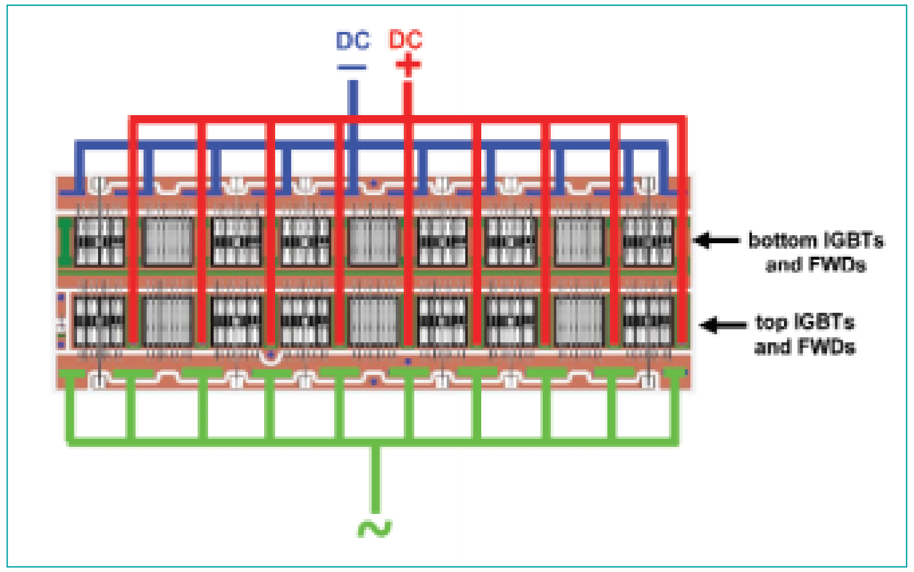


Figure 3. Principle of low inductive contacting of an isolation substrate equipped with paralleled and freewheeling diodes.

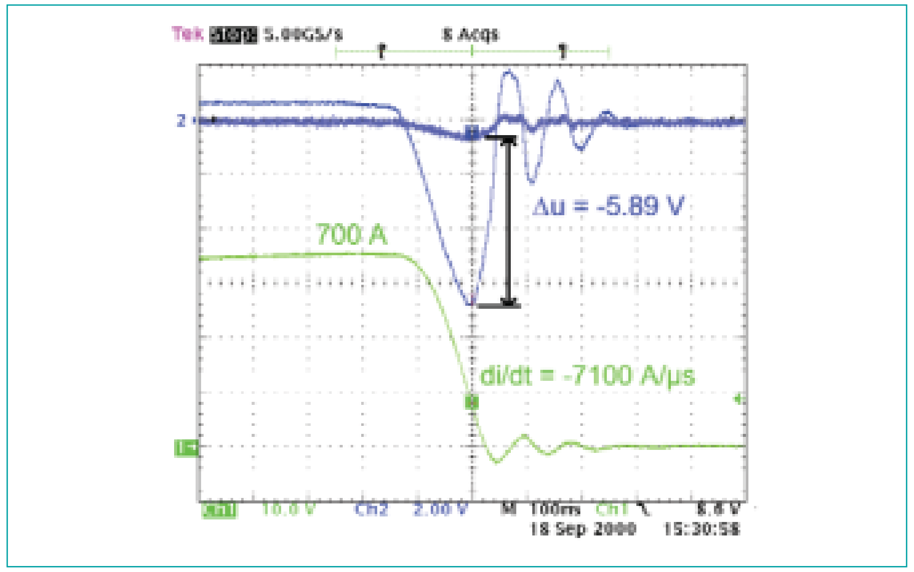


Figure 4. Switching off 700A at di/dt = -7100 A/µs.

AUTOMOTIVE ELECTRONICS: PART I

Figure 5. SKAI with MOSFET.

Figure 6. 1200 V/ 300 A SKAI.

Figure 4 shows the result of measuring the parasitic inductance of one MOSFET phase leg. A current slope of 7100 A/µs was applied by an external switch. The relation _V = L o di/dt and the measured peak voltage _V = 5.89 V give L = 0.83 nH in good agreement with the simulated value of 0.9 nH.

The standard heat sink is a water cooler (50% water, 50% glycol) with pin fins. Their oval cross section gives better thermal performance and reduces fouling tendencies.

Figure 5 shows a pilot production sample of the low voltage SKAI with MOSFET switches. The dimensions are 315 x 115 x 95 mm_, the weight is 3 kg.

Table I lists the technical data of the low voltage SKAI.

High voltage systems with IGBT switches

SKAI with 600 V and 1200 V IGBTs and freewheeling diodes in CAL technology are targeted for use in full hybrid or fuel cell vehicles or in industrial applications. Data of the 600 V and 1200 V type SKAI are listed in table II. Due to the higher ripple current capability and life time at extended temperatures, foil capacitors are used. A 1200 V SKAI can be seen in figure 6. The power of 250 kW at a volume of only 8.6 litres makes the compactness of the design obvious.

www.semikron.com

SKAI – Type (water cooled)	SKAI 75 V	SKAI 100 V	SKAI 150 V
Max. DC Link Voltage	62 V	80 V	125 V
Continuous Output Current (T_W=70°C, 10kHz, PF=0,8)	500 A_{RMS} 1)	500 A_{RMS}	400 A_{RMS}
Peak Output Current	700 A_{RMS}	600 A_{RMS}	500 A_{RMS}
Switching Frequency	0 – 20 kHz		
DC-Link Capacitance	29.7 mF	19.8 mF	9 mF
Ambient Temperature	-40°C – +105°C		
Cooling Water Temperature	-40°C – +70°C higher temperatures at reduced current		

1) limited by power terminals

Table1. Technical data of a low voltage SKAI.

SKAI – Type (water cooled)	SKAI 600 V	SKAI 1200 V
Max. DC Link Voltage	450 V	900 V
Continuous Output Current (T_W=50°C, 5kHz, PF=0,8)	400 A_{RMS}	300 A_{RMS}
Peak Output Current	500 A_{RMS}	400 A_{RMS}
Switching Frequency	0 – 20 kHz	
DC-Link Capacitance	1.5 mF	1 mF
Ambient Temperature	-40°C – +105°C	
Cooling Water Temperature	-40°C – +70°C higher temperatures at reduced current	

Table 2. Technical data of a high voltage SKAI.

Integrated Circuit for 3-Phase Controller

Serving 42V motor/generator systems in cars

The use of electronics in cars is still on the increase. Differentiation and innovation in the car industry can sometimes only be achieved through electronics. For instance, emissions-free cars are conceivable only with extensive use of electronics.

By Thomas Haller, Renesas

Even vehicles already being built today can only meet the limits imposed by legislation on pollutants and the low level of fuel consumption sought after by end users thanks to the use of numerous electronic control devices. The next step is the development of Electrical Vehicles (EV) or Hybrid Electrical Vehicles (HEV). This increased use of electronics in vehicles is leading to an ever-growing consumption of electrical power, which the vehicle's conventional onboard power supply will soon no longer be able to cope with. The decision to move to a higher voltage of 42V was made a long time ago, even though its implementation is being delayed at the moment. One thing for certain is that this change to vehicles will involve a great deal of effort from which end customers will not directly benefit. This means that the work will not be paid for. Nevertheless, all car manufacturers are focusing their attention on these types of concept study. As for semiconductor manufacturers, who have to provide the wherewithal for this type of change in the form of suitable components, they are already getting geared up for the changed requirements.

This article provides a description of the HA13730FR control module developed by Renesas Technology. This is a driver for 3 half-bridges to be used in a 42V onboard power supply for controlling 3-phase motors which are used alternately as a power unit or, when required, as generators for producing the 42V onboard power supply voltage. The power stages are externally connected to this. This ensures that the driver module is versatile and flexible to use, according to the relevant application. This module is ideally used along with HC861xP power MOSFETs with a current-carrying capacity of 500A at voltages up to 100V and a very small on-resistance, supplied by Renesas Technology. Figure 1 illustrates a possible application circuit.

Technology provides the basis for any design. In the case of the product described here, the newly developed 100V SOI (silicon on isolator) Bipolar/C-MOS/LD-MOS technology with a 0.5µm line width and 3-layer metallisation was selected. The SOI process was chosen in order to suppress parasitic components and support a high electric strength on the small chip surface. Figure 2 shows a cross-section of the layer structure of a conventional tech-

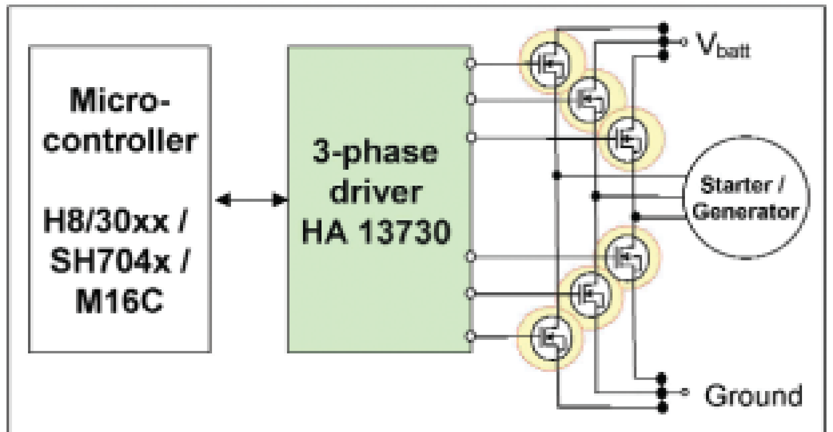


Figure 1
The control IC HA13730 allows a very simple circuit to control a 3-phase motor in as generatore or starter.

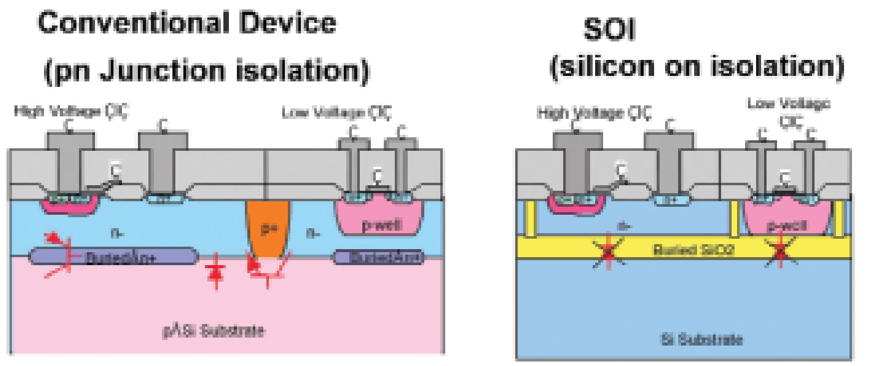


Figure 2
This figure shows the comparison of the cross section of conventional power ICs and the SOI technology. Parasitic devices, such as diodes and bipolar transistors, can be eliminated. The circuit size can be reduced dramatically.

nology where the components are insulated by pn transitions, while beside that is SOI technology with SiO2 insulation layers. It can be clearly seen that there are no parasitic transistors between well and substrate, between adjoining wells, as well as no well-substrate diode. This also provides for a considerably better packing density (Figure 2).

Control module

The HA13730FR driver module can be used to control all six MOSFETs in a 3-phase motor or inverter.

The circuit contains:
- a gate driver
- an active voltage limit circuit (active clamp) for external power MOSFETs in the 100V/500A class
- a soft gate driver circuit
- driver monitoring and protection circuits
- boost and buck transformers for the supply-side drivers and
- an input circuit.

Input circuits are arranged for each pair of earth-side and supply side drivers (high- and low- side drivers) and include protective features such as reciprocal locking, etc.

The boost transformers generate an increased gate voltage for the driver, while the buck transformer resets the high-side switch's diagnostics measurement values below the logic level.

Each driver has protective and monitoring functions to prevent:
- overcurrent
- overvoltage
- excessive temperature and
- under-voltage.

Figure 3 provides an overview of the relevant function blocks.

Gate voltage monitoring circuit

Special attention was focused on the power transistors' soft gate controller and on the active voltage limit during the development of the HA13730FR. Both these functions optimise the whole circuit's power loss and significantly reduce radiated interference.

Figure 4 shows the main circuit for the soft gate controller and the active Zener circuit.

The active voltage limit still has, similar to the usual Zener and protection diodes, a controlled ohmic path. This completely prevents, through being controlled, a sharp rise in current in the event of a Zener breakdown and therefore stops the voltage from overshooting the optimum point.

The soft gate controller limits the inrush current using a controlled resistor Roff, thereby preventing voltage peaks on power-up. Particularly in the case of very high currents of between 200 and 500A, a "hard" power-up can generate a huge amount of interference and noise. The soft gate controller reduces the radiated interference and power loss, thereby contributing to the components' greater reliability and longer service life. In the case of an active Zener circuit, the soft gate circuit has a high impedance and therefore supports the control function.

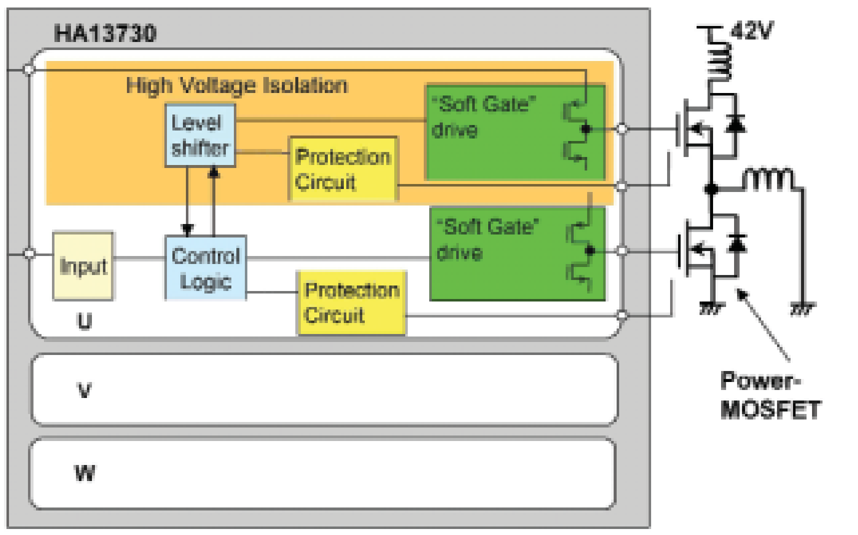


Figure 3
Block diagram of the 3-phase Gate driver.
- **Gate-driver ("Soft Gate" drive / active clamp)**
- **Protection Circuit**
- **Control Logic**
- **Level shifter**
- **Input circuit**

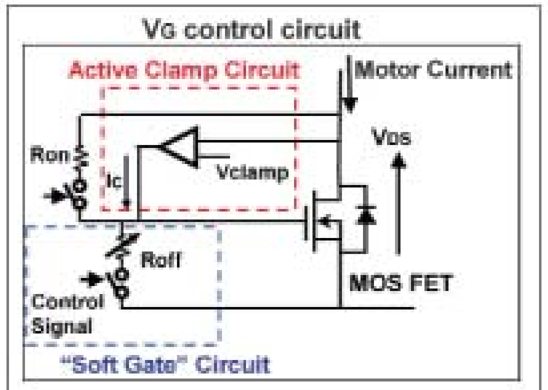


Figure 4
„Soft Gate" Circuit and active Clamping

The differences in the circuit curves between a trench MOSFET with a hard conventional gate controller and the soft gate controller with an active Zener circuit are shown in Figure 5.

With conventional controllers, switching off the power MOSFET at 500A with the 40V power supply can produce voltage overshoots of up to 100V. This is approaching the limits of the technology. On the other hand, the active Zener circuit's and soft gate controller's voltage peak is limited to 65V. The power loss in the transistor is kept to a minimum. This means that the loss in the driver module is also limited, which facilitates the integration of all six drivers.

During the power-up process, it is also possible, in the case of a conventional, unregulated power-up, to reach voltage overshoots of up to 100V. The soft gate circuit limits the dV/dT and the voltage peak to below 54V. In this case too, the reduction in power loss and radiated interference is obvious.

The HA13730FR can be used to create a beneficial, reliable and effective circuit for controlling a 3-phase motor/generator module. The new 0.5µm SOI technology along with the development of the special soft gate and active Zener circuits can help, even in the case of high output currents, to keep power losses and radiated interference to a very low level. As a result, powerful units for 42V onboard power supply can be created.

Prototypes of the HA13730 module are available and are being tested.

The next step is to develop a similar driver module for controlling a 3-phase motor with HiGTs (HiGT=High conductivity IGBTs). This will then make it possible to build efficient drives for electrical vehicles.

www.renesas.com

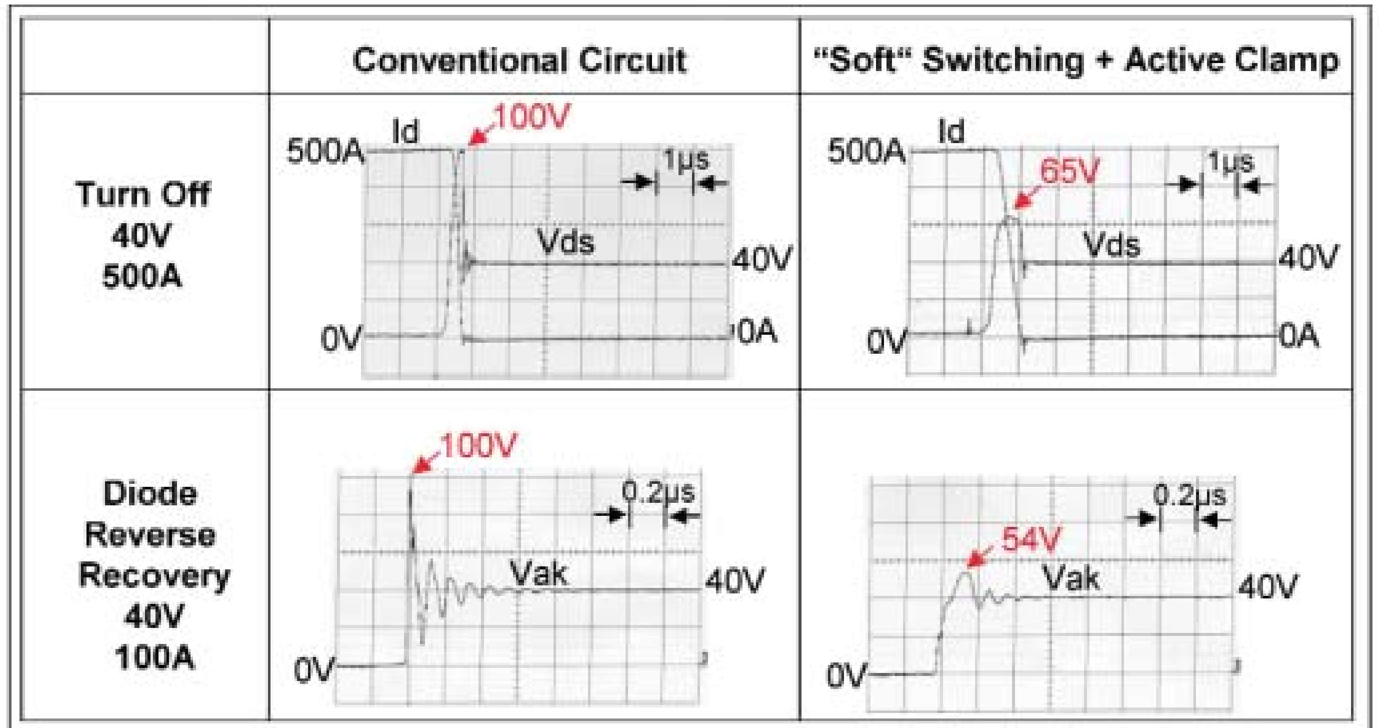


Figure 5
The figure shows the turn off waveform and the body diode reverse recovery of a conventional gate drive compared to the „soft" switching of the HA13730. EMI can be reduced very effectively.

Double feedthrough capacitor

EPCOS has added an innovative double feedthrough capacitor to its tried and tested range of feedthrough capacitors employing metalised polypropylene films. Compact dimensions and excellent attenuation properties, right up into the gigahertz range, distinguish the new double feedthrough capacitor from its competitors. Solder-free MeshContact technology ensures uniform concentric bonding of the capacitor windings and avoids the thermal stress of soldering. Even higher insertion loss and high dielectric strength are the results.

The standard double feedthrough capacitor is available with a capacitance of 0.1 µF for a rated current of 2 _ 200 A. Thanks to modular design, special types with different capacitances and for different rated currents can be supplied on request. The same applies to terminal configurations and case design. The capacitor is suitable for rated voltages up to 600 V DC or 250 V AC. The double feedthrough capacitor satisfies the requirements of EN 132400.

www.irf.com

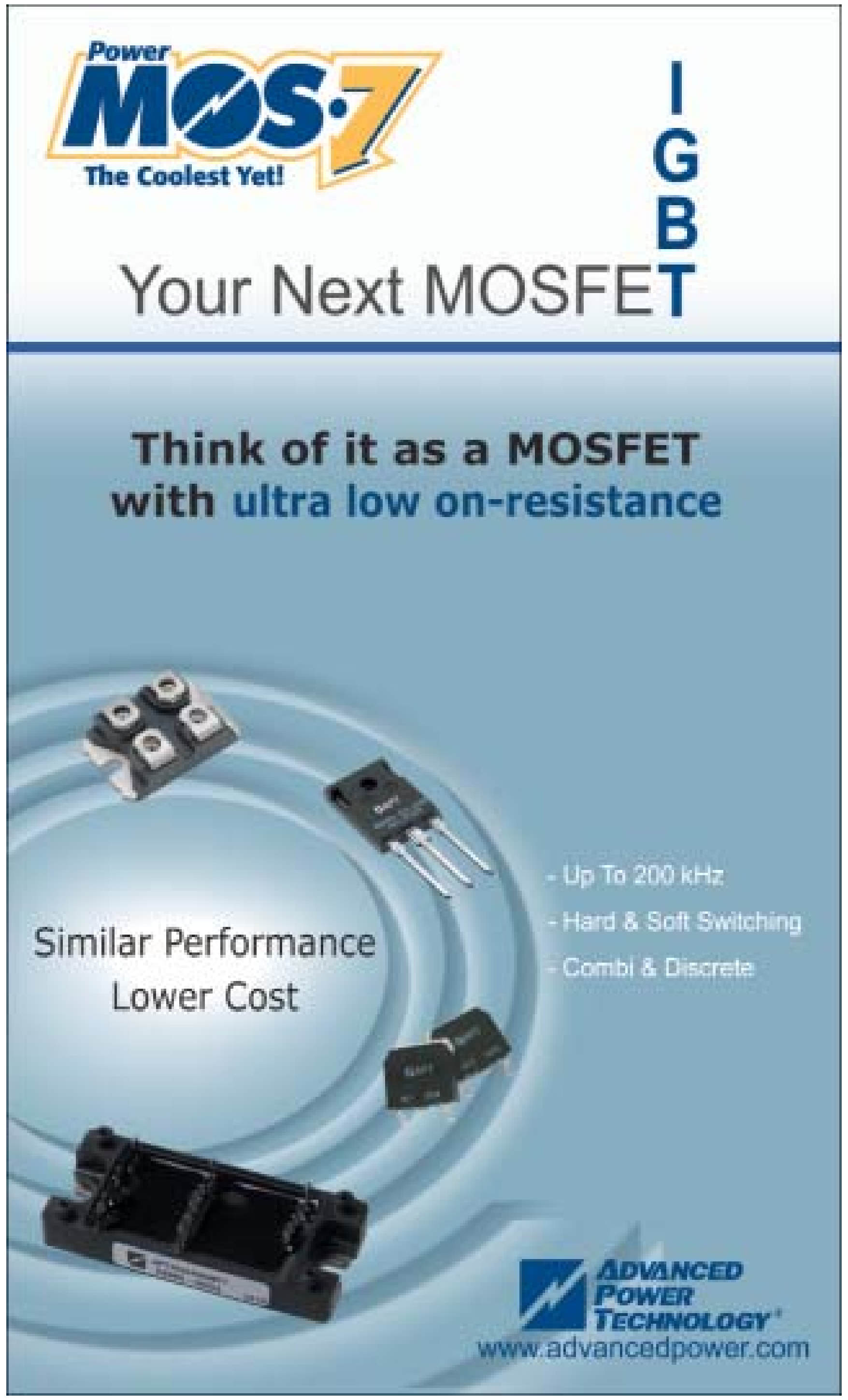
Ultra low resistance PowerMOSFET

NEC Electronics introduce a new series of PowerMOSFET in advanced UMOS-4 technology. NEC's well known NP-series has been extended by the development of 15 new products, targeting markets for low voltage devices, like the automotive sector. The products are available in popular TO-252 and TO-263 compliant packages and feature ultra-low resistance, high current performance and temperature stability up to 175 °C.

NEC Electronics is heading for technology leadership with its new PowerMOSFET NP-series. These devices make the most of the company's innovative UMOS-4 trench technology and combine it with an advanced packaging solution. UMOS-4 is a new-generation UMOS process technology. With an ultra-fine design rule of 0.25 µm, the process achieves a cell density of well over 180 Mcells/inch^2.

The main product features are ultra-low $R_{DS(ON)}$, down to 1.7 m_ max. (@ 30 V, advanced TO-263ZP), benchmark setting high-current performance up to 110A and temperature stability up to 175°C. The products cover the low voltage range (30 V, 40 V and 55 V).

www.necel.com



XL - Power Made Easy

Highest module performance based on newest packaging technologies.

Danfoss Silicon Power has introduced the next generation of power modules with screw connected power terminals for a power range from 10 to 90 kW. This generation will close the gab between the current medium power modules with soldered power terminals to the high power module solutions for line voltages up to 690V. The design is compatible to the existing high runner modules with 21mm terminal height, consequently existing heat sinks and busbars can be used as well as combinations of different module series are possible.

The product family consists of a wide range of configurations in different power classes such as single switch-from 100A to 900A and half bridge modules from 2 x 50A to 2 x 450A. Customized designs for instance with integrated over temperature and/or over current sensors can also be offered. Each single switch or half bridge can be placed in separate positions apart from each other on a common heat sink. The excellent heat spreading is performed by a 3mm Copper base plate soldered to the substrate in a lead free solder process.

The rugged design is achieved by aluminium wire bonding technology of all internal interconnections, incl. the power terminals, ensuring highest possible temperature- and power cycling capabilities.

www.danfoss.com/siliconpower

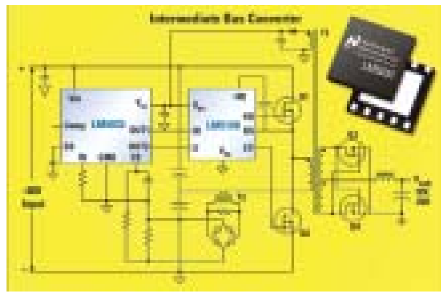
Sonic-FRD Ultrafast Recovery Diodes

IXYS announced the introduction of a new generation of ultrafast recovery diodes called Sonic-FRD (DH-series). The diodes of the Sonic-FRD family have a VRRM rating from 600 V to 1800 V with different current values. The first products with this new fast recovery design are available in TO-247 package.

This Sonic-FRD diode is ideally suited for power applications from medium to high switching frequencies and high rates of change of current (di/dt), especially hard switching, free wheeling and boost configurations, such as in Uninterruptible Power Supplies (UPS), AC-Inverters with IGBT, Switch Mode Power Supplies (SMPS), Power Factor Correction (PFC) circuits. All of these will benefit from the optimised characteristics of reduced reverse recovery current (IRR) and charge (QRR) as well as a soft recovery with short tail currents that results in reducing the losses in switching transistors, minimizing EMI noise and the need for additional snubber circuitry.

www.ixys.com

PWM Controller Using Intermediate Bus Architecture



National Semiconductor introduced the LM5033, the industry's first fully featured 100 V DC-DC PWM (pulse width modulation) controller that meets the challenging specifications of the Intermediate Bus Architecture (IBA). This recently introduced architecture controls the multiple low-voltage power supply rails in complex power systems using digital ASICs, DSPs and FPGAs that are found in telecommunications, automotive and industrial applications.

As designers continue to enhance converter performance and power density, traditional power conversion techniques are giving way to new distributed power architectures such as the IBA. The IBA consists of an isolated bus

converter powered from a higher-voltage distributed power rail that produces an "intermediate" lower voltage distribution bus, typically 8 V to 14 V, to feed multiple non-isolated regulators at the point of load. Since the IBA uses two stages of power conversion, the bus converter and point-of-load regulators must be more efficient and fit in a smaller board area to offer a compelling alternative to single-stage distributed power systems.

Designed on National's new Analog-BiCMOS-DMOS high-voltage process technology, the LM5033 operates off a wide range of input voltages from 15 V to 100 V for lower component count and higher efficiency. It also has efficient PWM and gate driver performance at frequencies up to 1MHz.More information about the products is available at www.national.com/pf/LM/LM5033.html and http://www.national.com/pf/LM/LM5100.html.

www.national.com

Protect 2-Cell Lithium-Ion Battery Packs

Seiko Instruments' S-8242 Series is the ideal solution for protecting 2-Cell Lithium-Ion Battery Packs due to its extremely small footprint design. The world's smallest package, (1.8 x 2 x 0.85 mm) has the lowest current consumption available (10µ Max. operational mode and 0.1µ Max. at power down mode) on the market today. This energy-efficient device is also well suited for Lithium-Polymer Rechargeable Battery Packs, further demonstrating its flexible design characteristics.

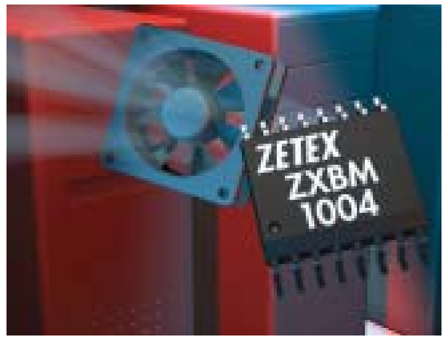
With the lowest number of external components, this battery protection IC sets the industry standard.

This high accuracy IC is available in a 6-pin SNB(B) or a SOT-23-6 surface mount package, and features overcharge detection voltage for each cell from 3.9 V to 4.4 V in 50 mV increments, overdischarge detection voltage from 2.0 V to 3.0 V in 100 mV increments , and has two levels of overcurrent protection.

Additional features include a high withstanding voltage of 28 V, a charger detection function, and a wide operating temperature range of -40°C to +85°C.

www.sii-ic.com

Variable Speed Control IC



Flexible variable speed control of single-phase brushless DC fans and blowers is provided by the ZXBM1004 pre-driver IC from Zetex. Compared to fixed speed alternatives, this integrated solution offers reductions in component count, audible noise and power consumption.

Fully compatible with NTC thermistor, voltage and PWM input signals, the QSOP16 packaged ZXBM1004 provides thermal control of single-phase motors up to 100W in PC, mainframe and other applications dependent on forced air-cooling.

The ZXBM1004's adjustable minimum speed setting prevents the fan from running too slowly or not being able to start. An external resistor protects the speed control circuit against supply voltage fluctuations, ensuring air flow is maintained at the target level. A built-in automatic restart function is set using a single capacitor.

An integral Hall amplifier enables Hall sensors to be wired directly to the controller for the detection of fan rotation and speed. Compatible with virtually any type of Hall-effect sensor, the ZXBM1004 removes the need for external signal conditioning circuitry.

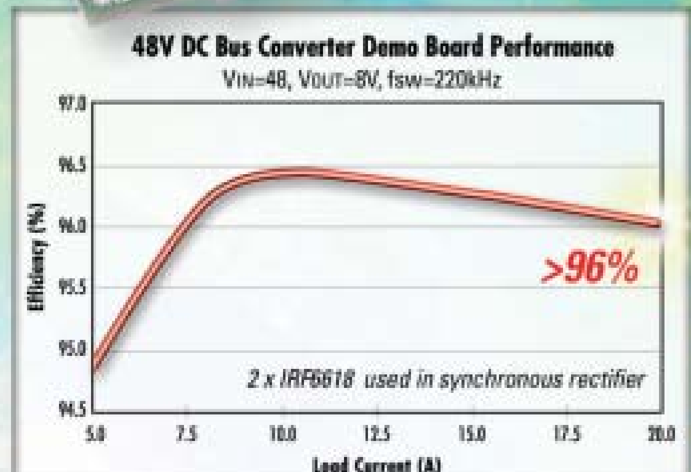
Two separate diagnostic outputs are offered by the controller—a pulsed rotor speed output and a locked rotor alarm output. In response to a locked rotor condition, the ZXBM1004 puts phase drive outputs into a safe mode that protects the transistor pair and motor windings.

www.zetex.com

Companies in this issue

DirectFET™ MOSFETS RAISE THE BAR IN CIRCUIT EFFICIENCY

DirectFET Delivers Lowest $R_{DS(on)}$ for Highest Efficiency Synchronous Rectification Circuits



Part #	Function	BVDSS	$R_{DS(on)}$ @ 10Vgs	V_{GS}	I_D @ Tcase=25°C	Q_G typ.	Q_{GD} typ.	Layout code per AN-1035
IRF6618	Sync FET	30V	2.2mΩ	±20V	150A	46nC	15nC	MT
IRF6612	Sync FET	30V	3.6mΩ	±20V	89A	28nC	8.8nC	MX

The new IRF6618 MOSFET in the DirectFET package gives circuit designers a benchmark solution for high performance synchronous rectifiers in isolated converter topologies. This revolution in packaging technology allows circuit designers the luxury of improving circuit efficiency, while reducing overall board space and removing heat in tiny spaces.

IR's benchmark DirectFET package technology incorporates our latest power MOSFET technology to achieve new levels of performance and power density.

IR Advantage

- Lowest conduction losses in synchronous rectification socket
- Compatible with or without double-sided cooling
- Two DirectFETs for up to $20A_{OUT}$ @ $8V_{OUT}$ (~160W)
- >96% efficiency at 160W
- Enables solutions in ~25% smaller than 1/8th brick, or ~53% smaller than 1/4 brick
- Lowest profile package at 0.7mm, suitable for backside PCB mounting
- Acheives 100W/in² performance in the bus converter

IRF6618 Features

- Best performance synchronous rectifier in DirectFET package
- Typical $R_{DS(ON)}$ of 1.7mΩ and maximum of 2.2mΩ
- 1°C/W junction-to-board thermal resistance, 1.4°C/W junction-to-case thermal resistance

Choose DirectFET MOSFETs to keep your most demanding applications running cool.

BUY ONLINE | REGISTER FOR EMAIL NEWS

for more information call +44(0)20 8645 8015 or visit us at

http://directfet.irf.com/dfdcz

International IOR Rectifier

THE POWER MANAGEMENT LEADER