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Power Systems Design EUROPE

Power Control Intelligent Motion
June 2005

Appliance Motor Controls

Power Line
Power Player
Marketwatch
Thermal Path Optimization
Programmable Power Manager

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Power Systems Design EUROPE

Viewpoint

Industry News

PSDE PowerLine

PSDE Power Player

Marketwatch

Cover Story

Features

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Volume 2, Issue 5

Picking Strawberries in the Blue Ridge Mountains

Dear Power Friends,

Summertime is almost here and everyone will be taking a break in order to recharge their batteries. One of my favorite pastimes in early summer is strawberry picking. I spent many a summer day in Mountaintop Pennsylvania attempting to gather a bucket full of strawberries, unsuccessfully I might add ending up with one strawberry in the bucket and the next two to be eaten. What ever your plans are for holiday we know where everyone will be in June, together at the annual PCIM Europe show in Nuremberg, and we will look for you at our booth 12-239 located directly across from the podium discussions.

Again, we bring you an interesting issue packed full of the latest technical advances in the field of power electronics. While the world is taking a closer look at the effects of products on our environment so ecological performance is becoming more important to consumers. As the cover story from IR demonstrates that motor control differentiates appliance manufacturers products in the marketplace. Ecolabels such as the EU flower symbol and national schemes such as Blue Angel in Germany and Nordic Swan in Scandinavia will force design for next generation refrigerators, washing machines, dishwashers and other appliances.

This months Power Player column is written by By Balu Balakrishnan, President and CEO of Power Integration who provides insights into the the effect of the recent California Energy Commission ruling (effective July 1, 2006) making it illegal in California to sell external power supplies that do not meet tough minimum efficiency standards. Energy Star, the European Union, China and Australia have also adopted standards. As a result, a transition en masse from linear transformers to energy-efficient switched-mode adapters and chargers now seems inevitable.

Our newest column introduction, PowerLine, is a special section devoted to an innovative new product launch. This month we review a product developed by Freescale.

Together with experts in thermal management: IXYS looks into highly integrated semiconductor modules that are increasingly used in power electronics. For an optimum cooling solution, this higher integration at higher current densities requires a holistic consideration of the thermal-mechanical behavior of power modules, including their integration to adjoining sub-systems. They explore the locally occurring high power loss densities result in thermally induced deformations of the components. This has a direct impact on the thermal contact affecting the heat dissipation. Better thermal behavior leads us to more economical products for green power.

Market pressure as well as a more energy and environment conscious society sets higher standards for power systems, which are hard to achieve without advanced control. Although power systems are highly nonlinear and belong to fast systems, real-time digital control seems to be a trend and at the same time a challenge for the power systems community.

See you at PCIM in Nuremberg. Stop by our booth 12-239.

Best regards,

Bodo Arlt
Editorial Director
The Power Systems Design Franchise

A Generation Change at PCIM

After the early years of moving around with the PCIM at different locations Nuremberg became the home of power engineers in Europe to meet up for the PCIM conference.

Originally started as a conference and show in the US by Myron Miller. PCIM was taken to Europe and organized by Gerd E. Zieroth. Not many events like this can have a summary of such good history. It was nice to see Christine together with Gerd Zieroth at the 25 anniversary fueling in the spirit of a big family day.

PCIM Europe has become a stable central point of interest for all the experts in power electronics. Not only the engineers and their managers showed up. Highly motivated top level executives have been seen all over the place in cross discussion. Three Key-Note Papers from worldwide recognized specialists opens each day with a very inspiring view of future improvements in power electronics.

The tradition to present new developments in power electronic, both active and passive devices, in power electronic circuits and applications, has continued with high level presenters from universities and industry. The conference includes control and system aspects as a link between device developers and device users.

Gerd Zieroth after more than a quarter of a century is handing over responsibility to Mesago to navigate the PCIM show for the future. We remember the good old days and look forward to the young and innovative future.

www.pcim.de

NEC Extends Distributor Network

NEC Electronics Europe announced that Eltech has joined its European distribution network. Eltech is an established distributor based in St. Petersburg with specialist knowledge of the Russian market.

The new agreement extends NEC Electronics' coverage to all countries of the Commonwealth of Independent States (CIS). Eltech is fully franchised to offer the complete range of NEC Electronics products to its Russian customers, including microcontrollers, ASICs, peripheral ICs, power MOSFETs, photocouplers, CMOS, RF and microwave devices, and LCD/TFT displays.

"The combination of NEC Electronics' system-based approach to applications in fields such as motor control and building management, together with Eltech's technical support, means that the needs of the emerging Russian market can now be satisfied," said Rob Green, president, NEC Electronics Europe.

"As one of the fastest growing markets in the world, the Russian electronics industry, with high levels of engineering and design resources, represents a beneficial platform for global component companies aiming to expand their operations in Russia," said Katherina Kober, executive director, Eltech. "We are proud to become a member of the distribution community of NEC Electronics – a worldwide leader in semiconductor manufacturing. We believe NEC Electronics' product portfolio and technology leadership combined with Eltech's local market knowledge, engineering and distribution expertise is the perfect base for our successful business partnership".

www.eu.necel.com

www.eltech.spb.ru

White LED Patent to Strategic Partners

Cree announced that it has licensed its pioneering white LED patent, U.S. Patent No. 6,600,175, to several strategic chip customers, including Stanley Electric Co., Ltd., and Rohm Co., Ltd., both of Japan, and Cotco Holdings, Ltd., a Hong Kong company. The licenses provide rights to manufacture and sell white LEDs that incorporate Cree's high performance LED chips. The company is currently in discussions with other potential partners to license this patent with a goal of announcing further licensing arrangements over the next several quarters.

These licenses are a result of Crees ongoing IP awareness activities.

www.cree.com

Fairchild Design Centre to Include Motion Control

Fairchild Semiconductor announced that its Global Power Resource power design and application lab in Europe is expanding to provide complete system power solutions for motion and motor control. Fairchild will invest in new equipment as well as motion and motor control engineers at its Fuerstenfeldbruck, Germany site. The centre has already completed more than 50 successful system power designs in its first eighteen months, reducing part count requirements and increasing efficiency in customer applications.

"Customers value the total power system designs we are able to give them and are seeking the same level of solutions in other areas such as two- and three-phase motor control, and motion control," said Ole-Petter Brusdal, Fairchild's vice president of Sales and Marketing, Europe. "These address industrial and consumer white goods applications – areas that are growing quickly in Europe. As The Power Franchise, our strategy is to constantly upgrade and extend the Global Power Resource design and application labs to meet the needs of our customers".

To support the additional applications, Fairchild will significantly invest to increase staff levels by 15% and add new test instrumentation like additional three phase programmable power sources, power analyzer and electronic loads to support higher current levels and three-phase applications, including inverter drives. The expanded team will offer customers specific design experience in the motion and motor control domain.

www.fairchildsemi.com

Texas Instruments Celebrates 75th Anniversary

Among many major milestones in the history of Texas Instruments, the company passed another one on May 16th by marking its 75th anniversary. Yet even as the company paused to commemorate its past, the people of TI continue to deliver technology innovations that have a profound and positive effect on people around the world.

"A common characteristic among the people of Texas Instruments is an impatient eagerness to buck the odds and do something different," said TI chairman Tom Engibous. "TIers just don't seem to know what cannot be done. So, this company has consistently achieved what others thought was impossible."

Revolutionary developments from TI include the use of a new technology to explore for oil worldwide during the Great Depression, the world's first commercial silicon transistors in 1952 and the invention of the integrated circuit in 1958. More recently, TI has become the acknowledged leader in real-time signal processing, which is the primary enabling technology behind communications and electronics products such as cell phones, HDTVs, portable media players, high-speed networking, digital cameras and other advances in digital technology.

TI is the world's leading supplier of both DSP and analog semiconductors, the principal technologies for real-time signal processing. More than half of all cell phones shipped worldwide rely on TI's wireless solutions. The company is also the world's top supplier for DSL modems, Voice over Internet Protocol (VoIP) solutions and mobile wireless LAN products.

www.ti.com

Power Events

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

EPE 2005 in Dresden 11-14 September

Dresden is the location of this years EPE, the capital of the state of Saxony, is on the one side, a very historical place mixed with high tech industry. The city itself is celebrating its 800 years anniversary in 2006 – the university was founded in 1830 – and within the last 15 years totally renovated keeping its original face. The city as well as the surrounding offer many sight seeing highlights and the local industries are producing high quality goods.

EPE 2005, Dresden offers comprehensive and promising technical programs which complete with high level of social events.

The tutorial program has been set up by a special committee to offer a broad range of high quality seminars. Tutorials will take place on Sunday 11 September. The program includes 9 tutorials.

The EPE conference provides excellent opportunity for companies to announce their latest research.

Along the years, there is an increasing trend of exhibition participants , proving that growing focus for power electronic industry. Experts use this platform for knowledge exchange and the young engineers get themselves update with the technologies. The Exhibition is still open for new industry partners.

www.epe2005.com

H2Expo 2005 in Hamburg

H2 Expo is the leading showcase for hydrogen and fuel cell technologies in Europe. It is organized by Germany-based Freesen & Partner GmbH, a consulting and event management firm specialized in the energy, environmental and waste recycling markets. In 2001, the company launched H2Expo in Hamburg, the first stand-alone hydrogen and fuel cells exhibition and conference in Europe. In the United States, Freesen & Partner has teamed with the National Hydrogen Association (NHA) and puts together the Hydrogen Expo USA alongside the prestigious NHA Annual Conference.

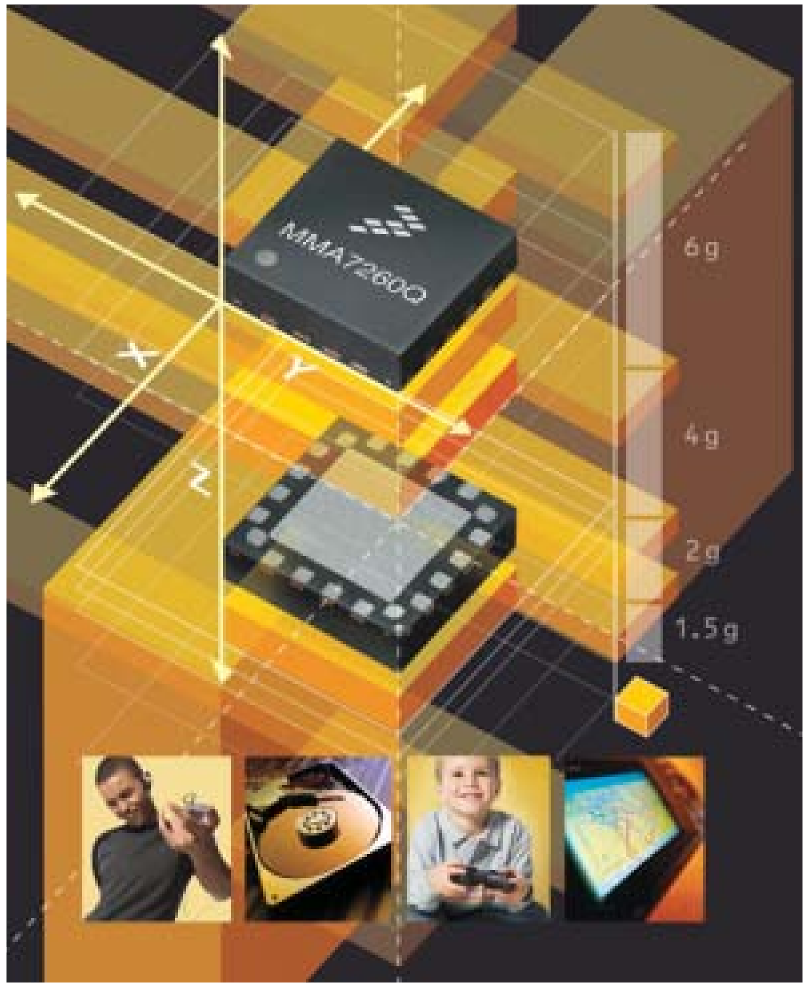
www.hydrogenexpo.com

www.h2expo.de

Industry-First G-Selectable Accelerometer Measures in Three Dimensions, Boasts Quick Power-Up and Cost-Saving Component Count

As portable electronics increase in functionality and fuel the demand for data drive storage, designers are seeking improved protection systems that use less board space. The MMA7260Q sensor now available from Freescale Semiconductor helps meet that need.

Freescale developed the three-axis, low-gravity (low-g), microelectro-mechanical systems (MEMS)-based MMA7260Q specifically for portable consumer electronics - a market that will require more than $48 billion of semiconductors in 2005, according to Gartner Dataquest estimates. The sensor is small, competitively priced and ideal for electronics that require low power consumption, high sensitivity and shock survivability.



An Industry First

The MMA7260Q includes a g-select feature that ranges from 1.5 to 6g. This gives designers the flexibility to select the g-force detection level a specific application needs. The addition of the g-select feature reduces component count, which helps improve heat dissipation and overall production costs.

The MMA7260Q is a single-chip device that detects in three dimensions, allowing portable devices to intelligently respond to changes in position, orientation and movement. The small package size requires less board space, and the quick turn-on and sleep modes make the MMA7260Q ideal for battery-powered electronics such as PDAs, cell phones, 3D games and digital cameras.

The MMA7260Q measures small forces resulting from fall, tilt, motion, positioning, shock or vibration to provide protection for shock-sensitive components. It detects acceleration or deceleration, such as when a device is dropped, helping prevent damage to the device and minimizing the risk of data loss.

The availability of low-cost, robust and highly functional three-axis accelerometers will contribute to an explosion of application opportunities in the price-sensitive automotive, industrial and consumer markets. They will enable new products and improved functionality for existing products. Manufacturers are always seeking features that will create a competitive advantage, and the adoption of three-axis accelerometers certainly will satisfy this need.

MMA7260Q features

- XYZ: three axes of sensitivity in one device
- g-select: in a single device, the sensitivity can be selected at any of these values - 1.5g, 2g, 4g or 6g
- Low current consumption: 500 micro amps
- Sleep mode: three micro amps, ideal for handheld battery-powered electronics
- Low voltage operation: 2.2V - 3.6V
- Fast turn-on time: 1ms
- Low noise: achieve higher resolution, more accuracy
- Package: 16-lead 6mm x 6mm x 1.45mm quad flat no-lead (QFN)
- Reference design (RD3112MMA7260Q) available now
- Evaluation board (KIT3109MMA7260Q) available now

Reference design enables multiple detection situations

To help demonstrate the many applications possible with the innovative three-axis sensor, Freescale offers the RD3112MMA7260Q sensing triple-axis reference design (STAR). The board includes the three-axis MMA7260Q accelerometer, the MC68HC908KX8 microcontroller (MCU), a serial port connection, EEPROM and a piezohorn. Software is also included to show the six sensing functions in various graphical user interface (GUI) modules.

www.freescale.com

Safety First

By Balu Balakrishnan, President and CEO, Power Integrations

We are all familiar with the old-fashioned AC adapters known as linear transformers, and sometimes by more disparaging nicknames (e.g., "bricks," "wall warts" and "energy vampires"). Thanks to their simplicity, low cost and reliability, these ubiquitous devices have long been the preferred power-supply technology for low-power products such as cordless phones, rechargeable tools, modems, toys, and many others. So entrenched are linear adapters, in fact, that some manufacturers continue to ship them even with portable products such as cell phones and MP3 players, despite their considerable size and weight disadvantages relative to switched-mode power supplies.

However, linear transformers are notorious wasters of electricity, and now, due to a recent spate of regulations, their days appear numbered. In December, the California Energy Commission adopted rules (effective July 1, 2006) making it illegal in California to sell external power supplies that do not meet tough minimum efficiency standards. Other U.S. states are now following suit, while Energy Star, the European Union, China and Australia have also adopted standards. As a result, a transition en masse from linear transformers to energy-efficient switched-mode adapters and chargers now seems inevitable.

Over the years, linear transformers have built a solid record of safety and reliability. Suppliers of switched-mode power supplies must now assure consumer-products manufacturers that this record will not be compromised in the transition. The most critical safety feature provided by linear transformers and therefore expected by consumer-products manufacturers is thermal shutdown. Thermal shutdown is essential for protection in overload conditions, or in abnormally high temperatures such as

when a power supply is covered by a piece of clothing or exposed to direct sunlight. Under these conditions temperatures can greatly exceed normal worst-case operating specifications. Thermal shutdown is therefore the only way for manufacturers to provide assurance that individual components are operating within specified limits.

Fortunately, thermal shutdown can easily be implemented in switching adapters with the use of integrated circuits. In fact, integrated control circuitry can actually improve upon the mechanical thermal fuses used in linear transformers. Mechanical thermal fuses cannot be reset; thus, once the fuse has done its job, the adapter must be replaced. Switchers, however, can feature hysteretic thermal shutdown, which automatically restarts the power supply when the temperature returns to a safe level. Hysteretic shutdown can therefore reduce consumer returns, an obvious benefit to manufacturers.

Switching power supplies without integrated controllers (e.g., self-oscillating switchers) may feature latching thermal shutdown, which can be reset by unplugging the adapter from the outlet. This approach presents problems for manufacturers since most consumers are unaware of this feature and simply return the power supply for replacement. Furthermore, latching circuits tend to be susceptible to noise and accidental triggering, which was never a concern with the mechanical fuses used in linear transformers.

Switching adapters provide other enhanced features such as the ability to operate across the global input voltage range (typically 85-265 VAC), allowing them to be used anywhere in the world. Many manufacturers are now demanding safe operation over an even wider range to allow for abnormal input conditions (i.e., below 85 VAC and above 265 VAC). The most robust switching power supplies employ control chips that offer under-voltage lockout, ensuring reliable operation at abnormally low input voltages (as required by standards such as IEC61000-4-11 and EN61000-4-11). The use of 700 V MOSFET technology provides additional margin at high input voltages compared to traditional 600 V switches.

Consumer-products manufacturers being forced to transition from linear transformers to switching power supplies can rest assured that today's integrated circuits actually improve upon the safety and reliability features provided by linear transformers for many years. The consumer, in turn, benefits from the energy savings and enhanced portability enabled by the transition to switching power supplies.

www.powerint.com

The Market Drivers in Power Are Changing

By Chris Ambarian, Senior Analyst, iSuppli Corporation

Every component that is supplied into multiple industries or applications has certain applications that really drive the development of that component, both technically and commercially.

In power management, the two single largest categories of devices are voltage regulation and referencing, and power transistors.

If we take a look at the top 5 applications that drive demand for voltage regulation (mobile handsets, home audio, medical electronics, desktop PCs, and laptop PCs), we see that from 2002 to 2009 there are some slight shifts up and down, but these 5 remain the top 5 market drivers even while the market size more than triples from $3.7Bn to $11.5Bn.

However, if we look at the power transistor market, we see some significant changes in the applications that drive that portion of the market.

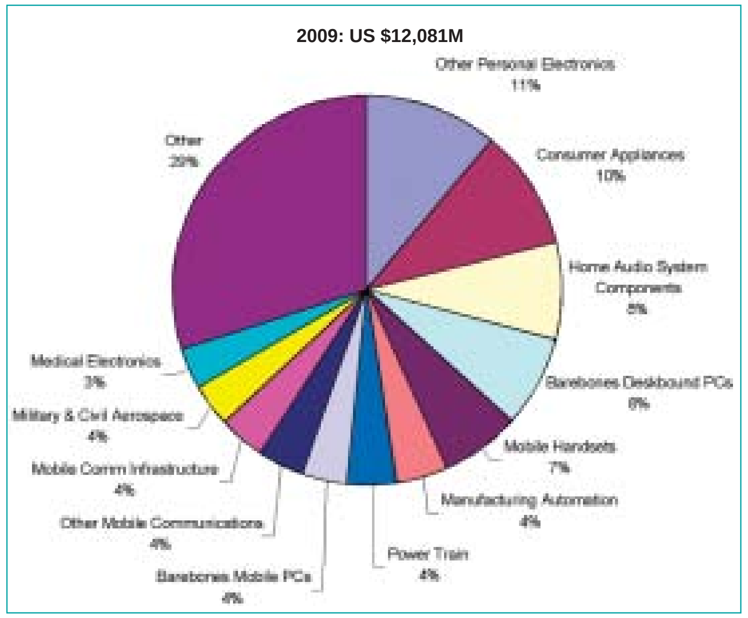


Figure 1. Market-Driving Applications for Power Transistors in 2009

By 2009, the market driver categories for power transistors become personal electronics, consumer appliances, home audio, desktop PCs, and mobile handsets.

The big news here, of course, is the emergence of personal electronics and consumer appliances as market drivers. During the period of 2002 to 2009, the size of the "personal electronics" sector – which includes items such as MP3 players, portable stereos, cameras, camcorders, and essentially anything you carry around easily that isn't a cell phone—quadruples, jumping from #3 to #1 in market impact. (See Figure 1.) This gain in market impact mirrors the increasing impact of personal electronics in the semiconductor market in general during this period.

During the same time horizon, the consumer appliances category jumps from #7 to #2 market impact, as electronic controls make greater inroads into traditionally electromechanical applications such as washing machines, air conditioners, refrigerators, and the like.

Unlike the personal electronics category which impacts the entire semiconductor industry in a more balanced way (including memory, logic, processors, analog and power), the consumer appliances category primarily impacts the power management device category. These are predominantly offline applications, heavy in power conversion content.

Additionally, the end-equipment forecasts done by iSuppli to make the appliance power device projections above also don't count upon any "discontinuity" market events, such as legislation that suddenly requires PFC or certain efficiency performance. These would represent even greater upside potential for the category.

Notably knocked out of the top-5 market drivers is manufacturing automation – a very traditional driver for the power transistor market. These projections are consistent with the broadening awareness that consumer demand is surpassing that of industry. This has large implications for suppliers; since industrial demand actually continues to grow, that means that consumer demand is growing even faster so the excitement and growth opportunity for competitive advantage are in consumer applications, so this is where the supply focuses the attention.competitive advantage are in consumer applications, so this is where the supply base focuses the bulk of its attention.

www.iSuppli.com

Ecolabels Drive Platform Approach to Appliance Motor Controls

Streamline development of home appliance applications

Achieving one, or more, of the new ecological labels (ecolabels) is becoming essential as ecological performance is becoming more important to consumers, as well as being one of the few remaining opportunities for appliance manufacturers to differentiate their products in the marketplace.

By Toshio Takahashi, International Rectifier,
Director of Engineering, System Architecture R & D group

Motor control strategies will be key to creating next generation refrigerators, washing machines, dishwashers and other appliances that qualify for ecolabels such as the EU flower symbol and national schemes such as Blue Angel in Germany and Nordic Swan in Scandinavia.

Motor Control is the Key

Traditional "on-off" motor controls present a great barrier to meeting the requirements for most ecolabels. For example, a refrigerator motor capable of switching only between rest and maximum speed results in sub-optimal performance in terms of the energy efficiency and operational effectiveness of the appliance.

This approach also demands a larger compressor than is really necessary, because it must repeatedly drive the temperature below the desired set point. Reducing the temperature below this point also results in greater heat loss from the enclosure. Finally the timed de-frost cycle, which is typically designed for worst-case conditions, causes higher than necessary energy usage.

Tools and modules that will enable cost-effective and rapid design of variable speed motor systems for appliances will help designers reach the standards set out by the various eco-labelling schemes. As well as lower energy consumption, electrical noise, acoustic noise and vibration will also be reduced. Variable speed motor technology will enable next generation refrigerators to respond dynamically to temperature sensing data, and thereby optimise energy usage as well as sizing of components such as the compressor

Maintaining the enclosure temperature within closer limits also reduces heat loss, enabling higher energy efficiency. De-frost energy is minimized since the de-frost cycle is only initiated when needed.

Accelerating Variable Speed Design

First-generation variable speed motor controls for appliances have made these advantages real for consumers but require design skills crossing many disciplines, as well as a great deal of design effort, to perfect. In particular, developing the DSP algorithms to implement Field Orientation Control (FOC), which is essential for controlling three-phase AC motors is complex and usually also requires special techniques to ensure adequate performance. FOC establishes linear control of torque by transforming three-phase AC current and voltage into two variables: torque current and field current. As a result, closed loop current control actually contains separate current control loops for torque current and field current.

Each loop is identical and consists of several control elements such as vector rotator, Clark transformation, proportional plus integral, PWM, and current sensing. Extensive knowledge of real-time control is a pre-requisite, since each of these high priority tasks must be executed sequentially. These tasks, often driven by specific hardware events or interrupts, require precise control of execution times. This demands sequencing of instruction coding to manipulate hardware at a specific time in order to control the motor.

The timing constraints usually dictate the use of assembly language for the FOC for servo application and sensor-

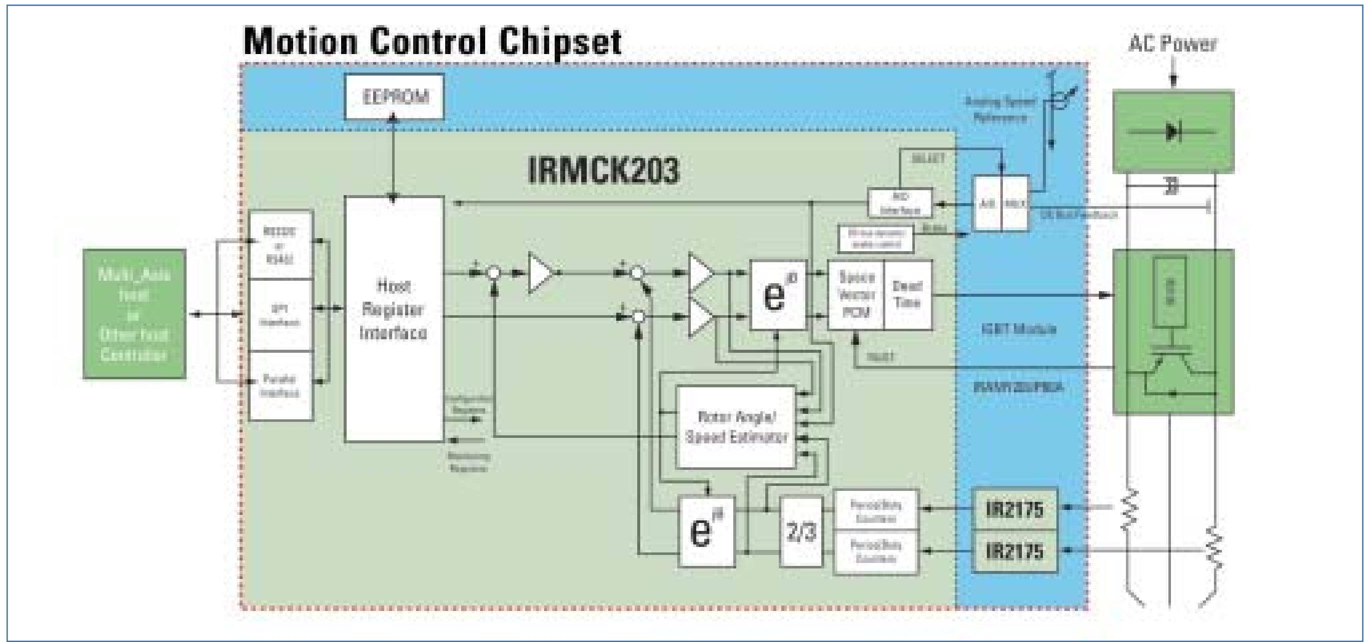


Figure 1. The Motion Control Engine Implements Motor Control IP in Hardware, Including the FOC algorithm.

less control, rather than a high level language, in order to maximise computation and update rates. Even with the speed-up thus achieved, special coding techniques—for example to accelerate multiply or divide functions—may still be necessary.

Regardless of the characteristics of the language or the chosen processor architecture, implementing FOC in software requires thousands of lines of instructions. This source code must then be compiled and linked together with any existing software modules that are being re-used to create the executable object code containing closed loop control, user interface sequencing, network communication, and all other applicable functions. Any errors or mistakes must be discovered and fixed at source code level, and recompiled and linked again to produce the revised version of the executable object code. Several iterations are usually required to reach the final product.

Code maintenance cost is another factor, the true extent of which is not typically apparent until later in development.

Hardware Integration Effort

Subsequent integration of the control and power electronic components of the drive is another challenge that requires power electronic design and hardware integration skills, as well as advanced control algorithm development, flexible user interface development, network communications, and other disciplines.

Motion Control Platform

There is now a new approach to motor control design, which has already successfully reduced implementation costs and design time for complex industrial motion control system. Register-configurable motion control ICs implement an entire motion control algorithm in hardware, leaving the designer to complete the design by selecting optimal parameters via a configuration tool. Compatible power components or modules for the power stage, plus analogue components including current sensing, make up a chipset that delivers a complete, configurable motor control solution in hardware.

International Rectifier (IR) has taken this approach to create the Motion Control Engine (MCE), which implements a complete FOC algorithm as well as a speed control algorithm in hardware. The MCE concept eliminates most of the complexity—including code development and maintenance—from designing variable speed motor drives.

The MCE (figure 1) includes all control elements necessary to perform closed loop controls. Motion hardware peripherals supporting space vector PWM, motor current feedback interface and encoder feedback are also implemented on-chip, as well as flow control logic for parallel multi-loop control. Hence, no multi-tasking is required. Synchronous execution mechanism of closed loop velocity control and closed loop current control is included in the logic hardware. Using a dedicated PC-based configuration tool, the designer can quickly optimise the IC to suit the parameters of selected motor and other system parameters, simply by configuring internal registers.

Hardware Chipset

Accompanying, compatible chips, also shown in figure 1, address the additional integration challenges surrounding the control and power electronic components. These include analogue gate drivers and sensors, power silicon and power modules developed together to create an integrated design platform, which eases design and integration and also reduces the number of external components required.

The analogue chips include the IR2175 high voltage linear current-sensing IC, built using IR's HVIC technology

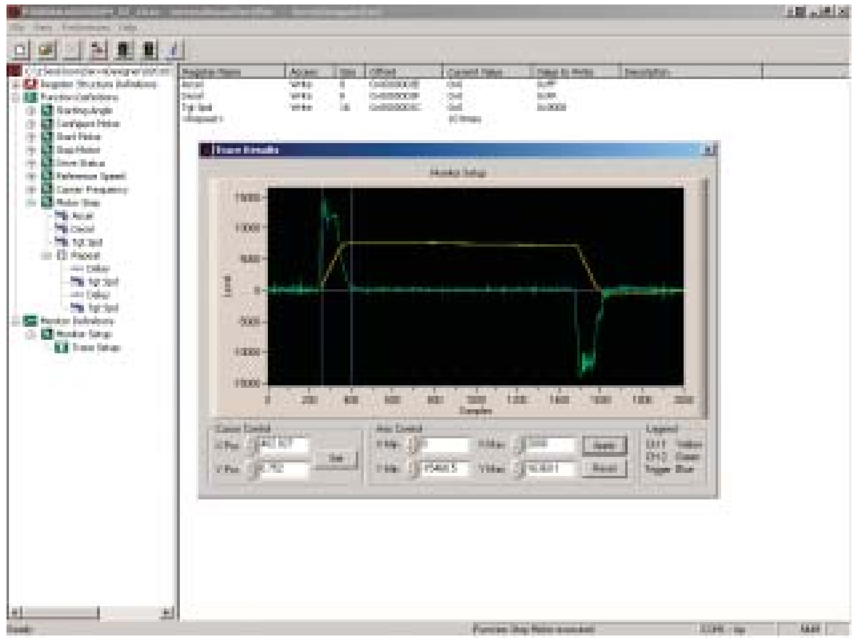


Figure 2. Servodesigner GUI.

and the IR2136 is a three-phase inverter-driver IC. These provide the essential link between the digital control IC and the power stage, as part of the integrated motion control platform.

The IR2175 senses the motor phase current through an external shunt resistor, converts from an analogue to a digital signal, and transfers the signal to the low side drivers. HVIC technology is implemented to enable high bandwidth signal processing. The IR2136 is high voltage, high-speed power MOSFET and IGBT driver with three independent high- and low-side referenced output channels. Proprietary HVIC technology enables ruggedised monolithic construction.

There are several choices for the power stage, including a family of 600V non-punch-through (NPT) IGBTs available from 6A to 20A rating in either discrete or Co-Pack with ultra-fast, soft recovery diodes. Alternatively, integrated power module (IPM) containing six NPT IGBT dice is available. The IPM also contains six commutation diode die, one three-phase monolithic IC, a gate driver chip, three bootstrap diodes with a current limiting resistor and an NTC thermistor/resistor pair for over-temperature protection.

To further streamline development of home appliance applications, IR's motion control platform also integrates dedicated peripherals to facilitate integration of variable speed motor drives into refrigerators, dishwashers, washing machines, home air conditioners, fans, and similar appliances. A kit containing all necessary hardware including heatsink, connectors and PCB—built with close reference to applicable industry standards —is also available.

Graphical Configuration Tool

Configuration of the control IC registers is achieved by writing specific values into each register from a host PC using Servodesigner, IR's Windows-based dedicated configuration tool. Via the Servodesigner GUI (figure 2), the designer can define which registers to be accessed, change the register names, customise reading and writing registers, or group registers into subgroups. Parameters can also be set during manufacture or at a customer site.

Servodesigner also allows the designer to create multiple start-and-stop speed profiles and apply acceleration/deceleration characteristics, to quickly verify that desired performance targets will be met. This feature further streamlines application development by highlighting performance deficiencies early. There are also diagnostic features, with drive and status fault conditions permanently displayed on-screen.

Configuring registers can be further simplified by using an Excel spreadsheet. Servodesigner provides a supplementary Excel spreadsheet as a template for adapting and configuring a new motor. The designer can then simply write the motor nameplate data such as motor amps, speed, encoder line count into the spreadsheet, and then import the calculated values back into the Servodesigne registers.

The tool also contains an EEPROM read/write utility so that the user can store tuned parameters and eliminate repetitive configuration. Figure 2 shows a sample screenshot of the Servodesigner graphical user interface. After configuration is completed, Servodesigner can also initiate operation of the resulting motion control solution.

Conclusion

Eco-legislation has handed designers of domestic appliances—very much a “commodity” market in modern, affluent societies—a golden opportunity to avoid price competition and once more differentiate their products in terms of performance and features. A new, hardware-based approach now overcomes the traditional barriers to designing variable speed motor controls into eco-friendly domestic appliances, by substantially reducing the design time and effort involved. This should, ultimately, allow ecolabel-compliant appliances to deliver improved performance at lower price points compared to first-generation models.

About International Rectifier

International Rectifier (NYSE:IRF) is a world leader in power management technology. IR’s analogue and mixed signal ICs, advanced circuit devices, integrated power systems and components enable high performance computing and reduce energy waste from motors, the world’s single largest consumer of electricity. Leading manufacturers of computers, energy efficient appliances, lighting, automobiles, satellites, aircraft and defence systems rely on IR’s power management benchmarks to power their next generation products.

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www.irf.com

Analysis and Optimization of the Thermal Path

Using thermal-mechanical finite element method and fluid mechanics CFD simulation

Highly integrated semiconductor modules are increasingly used in power electronics. For an optimum cooling solution, this higher integration at higher current densities requires a holistic consideration of the thermal-mechanical behavior of power modules, including their integration to adjoining sub-systems.

By Dipl.-Ing. Olaf Zschieschang, IXYS Semiconductor
By Dr. Wilhelm Pohl, Kunze Folien
By Dipl.-Ing. Michael Probst and Dipl.-Ing. Thomas Vogel, ISKO engineers
By Jürgen Schmidt, ServiceForce
By Erwin Nagy, Konstruktionsbüro

Locally occurring high power loss densities result in thermally induced deformations of the components. This has direct impact on the thermal contact affecting the heat dissipation. At contact-loss, the thermal resistance value increases markedly. The thermal contact strongly depends on the electric operating point, the module geometry and the module assembly on the heat sink as well as the materials used in the module. The power loss-induced heat flow is dissipated to the ambience through the heat sink. In order to guarantee a reliable and long-term functioning of the module components it is necessary to minimize the total thermal resistance from the heat source to the heat sink. In order to achieve this a joint project with IXYS Semiconductor GmbH, Kunze Folien GmbH, ISKO engineers AG, ServiceForce GmbH, Design Office E. Nagy as project members has been started for the IXYS Power Module GWM 120-0075P3. Below the way how this objective has been realized is described.

Taking the IXYS Power Module GWM120-0075P3 (figure (1)) as an example, the entire thermal path (figure (2)) from the power loss-induced heat sources within the module through the heat sink to the ambience as heat sink was analyzed by a consecutive finite element simulation (FE simulation) together with a fluid-mechanical simulation (CFD-simulation) and optimized based on thermal-mechanical considerations. The thermal analysis tool Flotherm 4.2 was used for CFD simulation. The thermal-mechanical FE simulation was performed using ABAQUS Standard V6.4. At the same time, a universal clip fixing was developed for the existing ISOPLUS DILTM Package with regard to the universal use, which took into consideration the simulation results and the demands on the design as well as on the assembly. Eventually, the results of the simulation were compared to the laboratory measurements.

Figure1. GWM120-0075P3 in the ISOPLUS DIL Package.

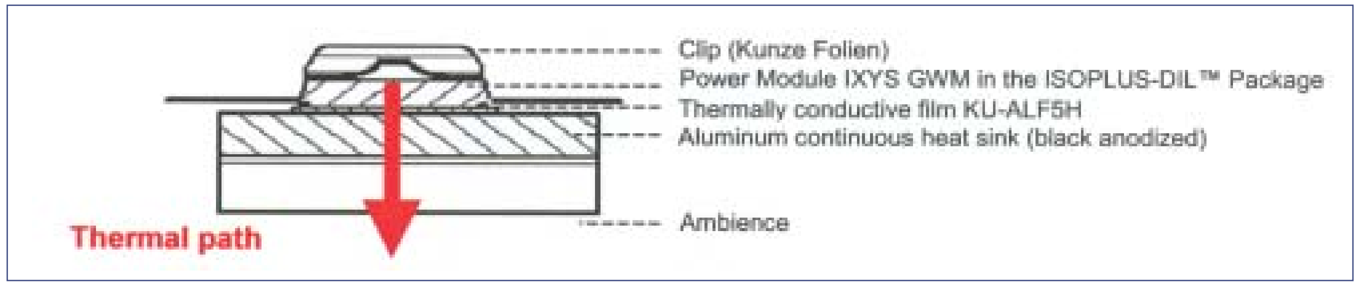

Figure 2. Total thermal path.

The analysis included the following steps:

- Generation of an FE model for the module
- Analysis of the thermal-mechanical behavior of the module together with the clip by means of FE-simulation
- Design of the clip for adjusted pressure exertion on the module
- CFD simulation of the heat flow and determination of the Rth from module base plate to ambience, giving different cooling concepts
- Comparison of results and laboratory measurements

Power Modules of the IXYS GWM series in the ISOPLUS DIL Package

The concept and design of an electrically insulating package (ISOPLUS versions) developed by IXYS for power semiconductors in standardized housings has been extended by the ISOPLUS-DIL Package. The advantage of this design with DCB substrate and semiconductors soldered to it is the flexibility to implement various circuit topologies meeting the demands of the user. The DCB with its electrical insulation capability coupled with very low thermal resistance Rth(junction-case) permits the use of advanced interface materials between the module base plate and the heat sink for which no additional insulation pads are required. In comparison with insulating films, an advantage for the thermal path can be achieved. A high integration density characterizes the component part concept. Thanks to their performance and small dimensions, these GWM modules e.g. GWM220-004P3, GWM160-0055P3, GWM120-0075P3 with V_{DSS} in a range of 40 to 75 V; I_D (T_C = 90°C) of 145 to 95 A and with $R_{DS(on)}$ from 2,0 to 3,7 mΩ are best suited for the use in automotive and industrial electronics applications such as power-assisted steering, traction drives and pump drives subjected to harsh environmental and temperature conditions. For simulation, the 3D CAD data were processed and material data of the individual components were determined. Based on the different coefficients of thermal expansion of the module's components, an optimization of the pre-curvature of the module base plate became necessary. This was based on the results of the simulation also including the thermal resistance. Both have been verified by experiment.

Process flow of the consecutively coupled simulation

The process flow chart shows the following steps (organization responsible for a given activity is marked by a distinct color) as depicted in figure (3), wherein data of fluid dynamics, thermal and mechanical simulation are exchanged.

Integrated FE simulation of the module and the clip

The production-related convex curvature of the module base plate amounts to approximately 40 µm. The thermal-mechanical behavior of the module was then simulated subject to heating up by power dissipation. Based on this, a clip for the module mounting of the ISOPLUS DIL Package was designed taking into consideration the thermal-mechanical behavior of the module. The contact pressure of the clip had to counteract the module deformation to the extent that no deformation-induced increase of the thermal resistance occurs between module and heat sink under load. In this respect, the mechanical stresses of the clip and the housing must be well below the relevant ultimate strength.

The following assumptions and restrictions have been made:

- Nominal power loss per trench MOSFET (steady state condition in nominal operation)
- Homogeneous distribution across the trench MOSFET surface
- Temperatures of the module ambience (at nominal power loss): in the area of the heat sink: 105 °C, in the remaining module housing area: 70 °C

For the sum of the thermal resistances of the thermally conductive film and the heat sink with forced cooling, a total thermal resistance of Rth = 0.13 K/W was determined to be necessary.

Thermal-mechanical behavior of the module

In a first step a thermal-mechanical analysis of the module was made. The FE model consisted of the components module, heat sink and clip. The module was designed by volume elements. Initially the heat sink and the clip were replaced by ideally rigid plates to exclude any influence of rigidities of the component part. To determine the clip force for the flatness of the module base plate, rigidity of the module is the only decisive factor.

The FE analysis included the following steps:

1. Determination of the module pre-deformation due to production by FE simulation and adjustment with the measured value for the curvature of the module base plate.
2. Exposing the module to a default thermal load in order to determine the temperature distribution and the thermally induced deformation.
3. Determination of the clip contact pressure for achieving flatness of the module during thermal load.

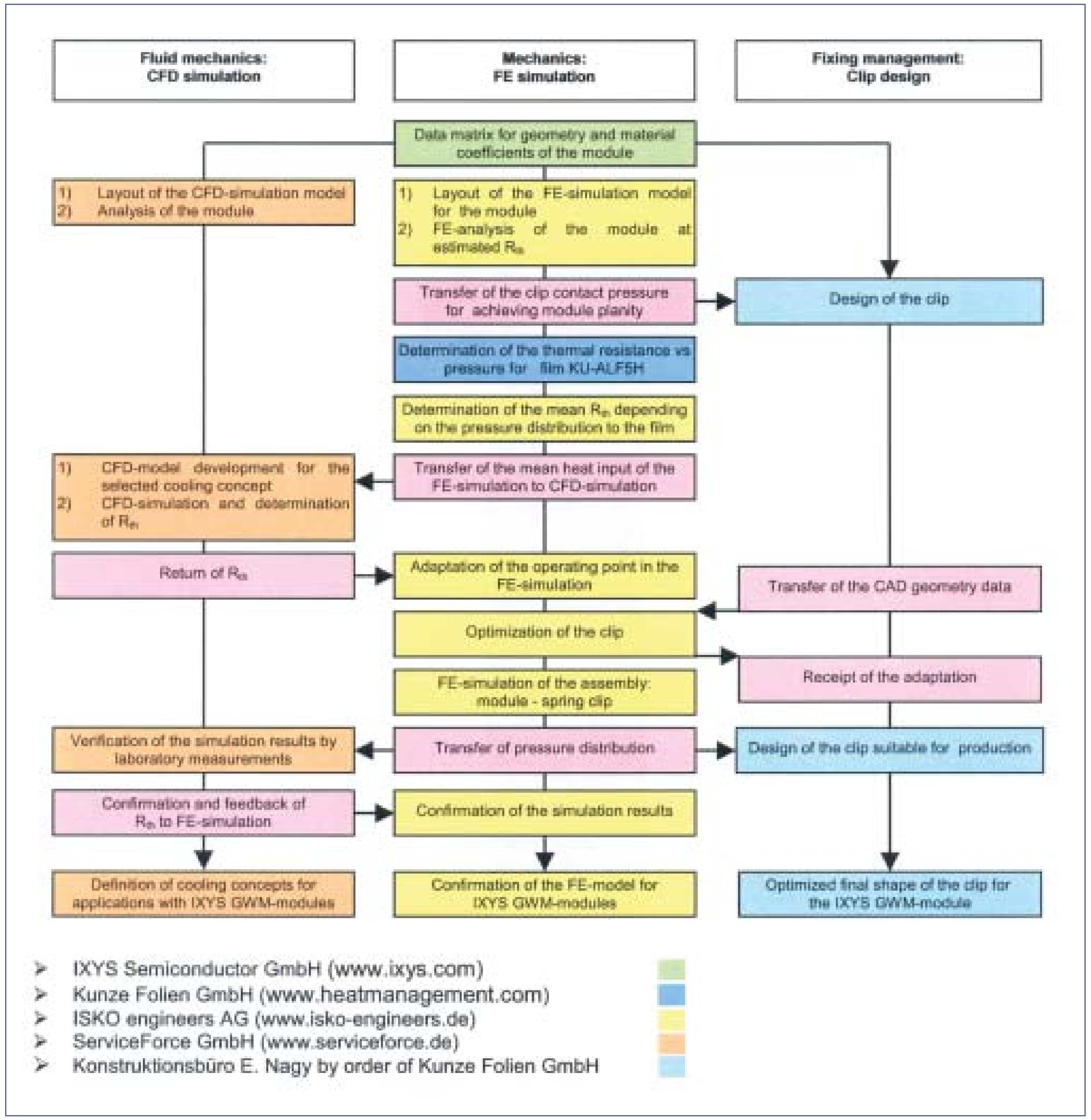

Figure 3. Process flow of the consecutively coupled simulation.

The simulation of the thermal coefficient of expansion of the housing potting showed an excellent compliance (deviation < 2%) with the measured module base plate curvature after cooling off.

The analysis of the module load with a nominal power loss confirmed the assumed maximum permissible value of 0.13 K/W for the thermal resistance Rth of the module base plate to the ambience, observing the permissible maximum temperature. The curvature of the module base plate was significantly reduced by the thermally induced deformation. For the required clip force a range between 100 N and 150 N was determined (figure 4a). This resulted in a remaining curvature of the module base plate in the range of surface roughness with mounted clip under load. Aberrations between the module and the heat sink were compensated by the selected thermally conductive film without any problems. As shown by the simulated contact pressure distribution on the top of the module housing in figure 4b, the relevant contact areas between clip and module housing are at the shorter edges of the housing.

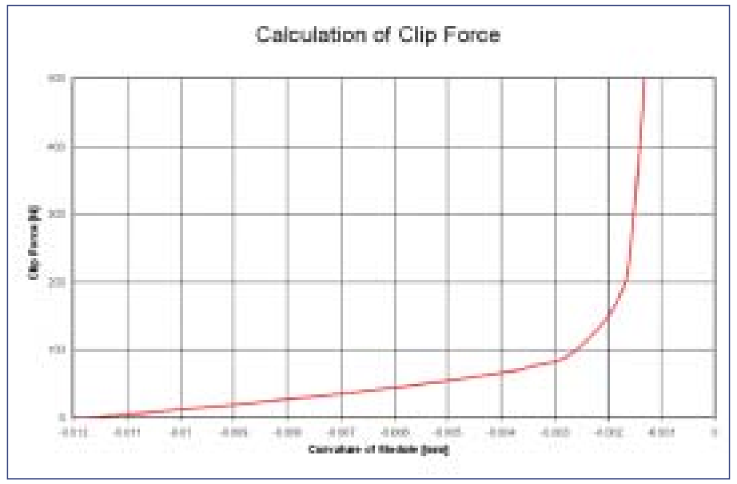

Figure 4a. Course of the clip force across the curvature of the module base plate.

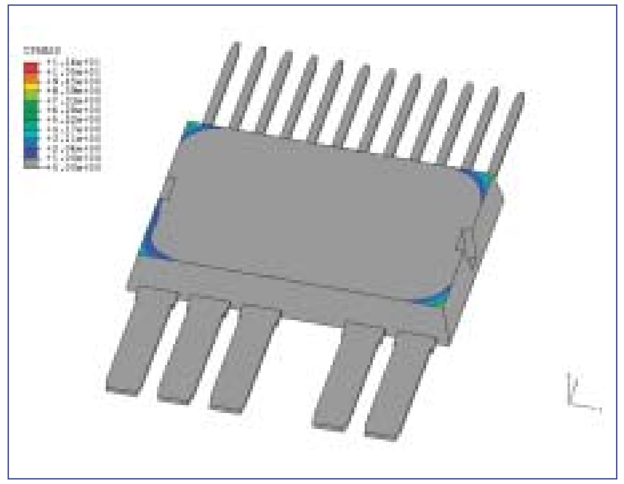

Figure 4b. Simulated pressure distribution at the top of the module housing at the required clip force.

Design of the clip in assembly with the module through FE-simulation

The clip design was made by iterative steps with FE analyses and a subsequent FE-based form optimization. The optimized final form of the clip shows a largely homogeneous stress distribution in the clip legs with stress peaks significantly below the ultimate strength. Based on the resulting final clip form, the flatness of the module base plate under the thermally induced deformations at nominal load is largely achieved (figure. 5a). The thermal interface materials compensate the remaining distance in the border area of the module base plate. The maximum value of the contact pressure exerted on the module housing by the clip (figure. 5b) is significantly below the ultimate strength of the module housing.

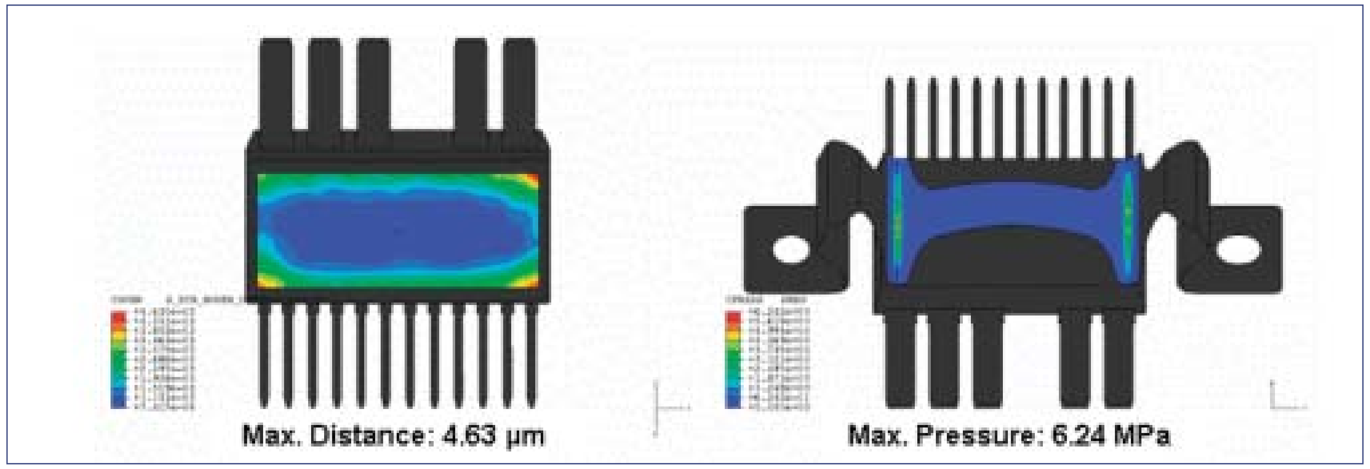

Figure 5. Distance and contact pressure after temperature rise. The sum-tolerance of all system components is compensated by the clip and its characteristic curve as a main requirement . As shown in figure (6), the peak values of the mechanical stresses in both load situations are significantly below the ultimate strength of 1,300 MPa.

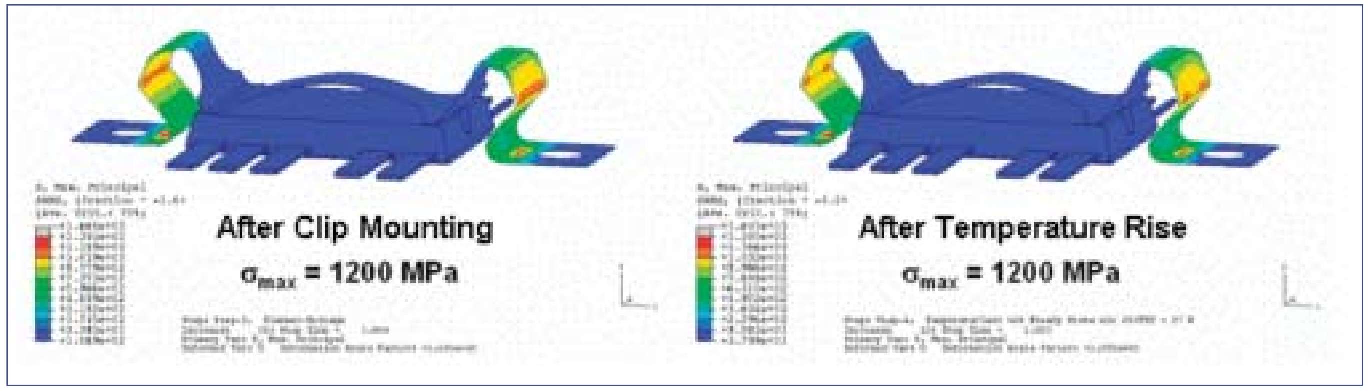

Figure 6. Main stress distributions a) after clip mounting and b) after heating up.

CFD simulation of the thermal resistance

The CAD data of the module and a black anodized aluminum heat sink were imported into the simulation software via the CAD interface and processed for thermal analysis. The thermal input of the MOSFETs at nominal power loss at steady state was defined by IXYS. In the first heating concept, a black anodized finned cooler with forced convection at different flow rate between 0 and 6 m/s was chosen. All simulations were performed at an ambient temperature of $T_{Ambient}$ = 70°C taking into consideration the thermal radiation. For the thermal resistance of the interface material, a value was assumed which occurs at nominal pressure of the clip of 110 N onto the module package. The thermal analysis of the ISOPLUS DIL™ Package showed that the thermal resistance of R_{th} = 0.13 K/W for the thermally conductive film together with the heat sink required for the FE simulation can only be achieved by additional heat dissipation measures such as forced convection cooling by fans or by fluid cooling (e.g. using water).

The actual heat dissipation of the GWM120-0075P3 was compared to the simulation results. For this purpose, the power module was operated at the test stand at room temperature of 22 °C. The temperature measurements were conducted with thermocouples installed in the heat sink at the base plate “center” and base plate “edge” (fin-side). The flow rate was measured by a thermocouple anemometer and transferred to the software. The temperature distribution was recorded with an infrared camera VARIOSCAN High Resolution 3021-ST. The module was operated in stationary operating points I = 50 (U = 1.6 V) through I = 90 (U = 1.9 V).The selected interface material was applied to thermally link the module to the heat sink. Temperature rise at forced convection at nominal power loss is shown in figure 8.

The CFD model was adapted to be able to compare the experimental results and the simulation results. $T_{Ambient}$ was changed from 70°C to 22°C and the flow rate was adjusted to 3.4 m/s. The comparison of the simulated and measured values at I = 90 A und U = 1.9 V confirms the compliance of the mathematical model and the reality (see table1):

Measurement point	Simulation	Experimental	Deviation	Parameter
Heat sink: base plate center	72.8 °C	72.4 °C	-0.5 %	Temperature
Heat sink: base plate edge top	60.3 °C	61.1 °C	+1.3 %	Temperature
Heat sink	3.4 m/s	3.4 m/s	Adjusted	Flow rate

Table 1.

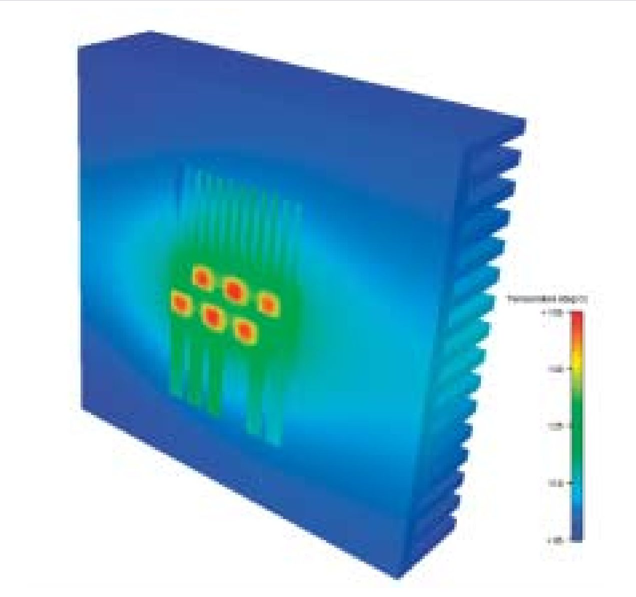

Figure 7a. Thermal analysis with forced convection (6 m/s) at $T_{Ambient}$ = 70°C.

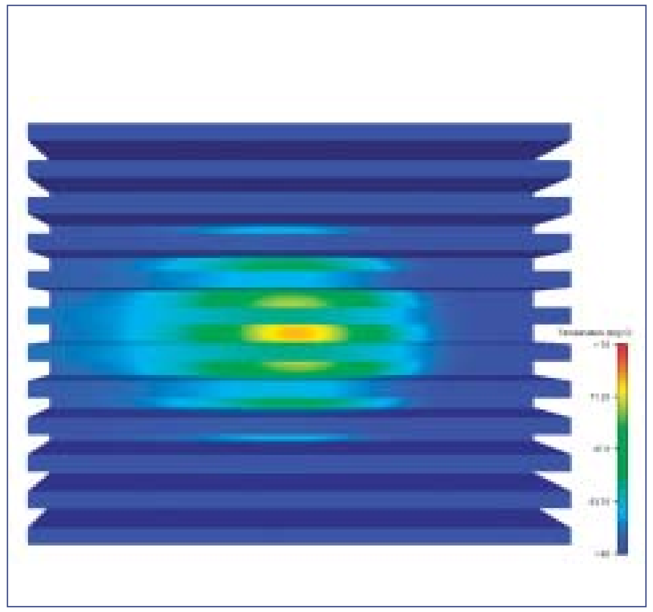

Figure 7b. Simulated temperature distribution at the heat sink (Dimensions: 128 mm x 100 mm x 30 mm, base plate: 10 mm).

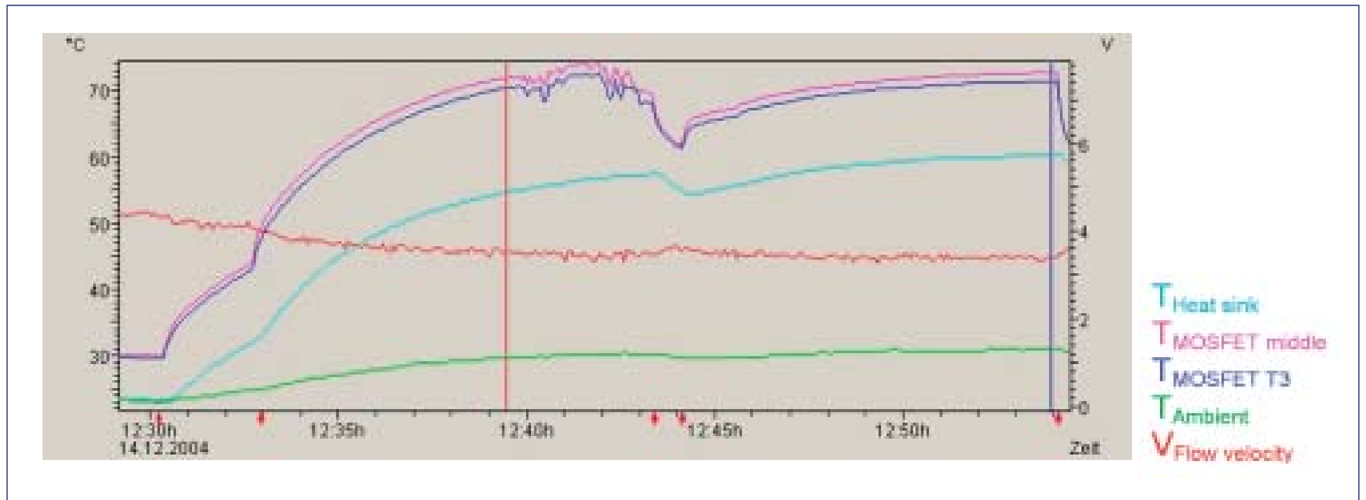

Figure 8.Temperature rise at forced convection (3.4m/s) at $T_{Ambient}$ = 22°C and at nominal power loss.

This result was confirmed by test at a second operating point I = 50 A and U = 1.6 V. The verification by experiment shows that the thermal resistance of R_{th} = 0.13 K/W at nominal power loss which the thermal-mechanical simulation was based on was accurate and is feasible in practice by the shown heat dissipation concept. The heat dissipation concept, however, largely depends on the installation and environment in the customer-specific application.

Conclusion and outlook

Within the joint project it could be proven that the results of finite element simulation and CFD simulation match the reality very well. The modeling of power modules requires exact knowledge of the input parameters. The results can be used in practice and facilitate the development of the ideal thermal solution. The method shown which consists of first simulating the module including mounting by FE simulation and optimizing in assembly provides a comprehensive solution, taking into consideration the thermal-mechanical interactions during operation. With CFD thermal analysis, the optimum heat dissipation concept for the customer-specific application is defined already before the prototype production in order to prevent later heat-induced failures. The employment of this option provides for decisive technical and economical advantages working in a competitive world, where "Time to Market" is a key issue. The system is a closed loop, which will be described further in an analysis by examining step by step the effects of the optimized cooling on the electronic circuits and the temperature-dependent characteristics of the power semiconductors.

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DESIGN & SIMULATION

Nonlinear Control in a Linear Framework

The techniques might be applied for power systems

If the operating point (scheduling parameter) is varying slowly, then biquadratic stability analysis of the control system is performed. If we switch among different operating points – most likely in the case of power converters – then quadratic stability analysis of the control system is required.

By Dr. A. Forrai, Mitsubishi Electric Corp., Japan

Day by day, market pressure as well as a more energy and environment conscious society sets higher standards for power systems, which are hard to achieve without advanced control.

Although power systems are highly nonlinear and belong to fast systems, real-time digital control seems to be a trend and in a same time a challenge for the power systems community.

The article deals with robust gain scheduling control, which is a widely used technique for controlling certain classes of nonlinear or linear time-varying systems.

To achieve high-performance over the entire operating range with a single linear time-invariant (LTI) controller it is often impossible. Therefore, the parameters values are measured or estimated in real-time and the LTI controllers are scheduled by parameter measurements.

Robust Gain-Scheduled Control Design

In the aim to treat the control design in a unified framework we have to address three important issues:

- linearization of nonlinear systems;
- robust controller design for LTI systems;
- robust gain-scheduled controller design and stability analysis.

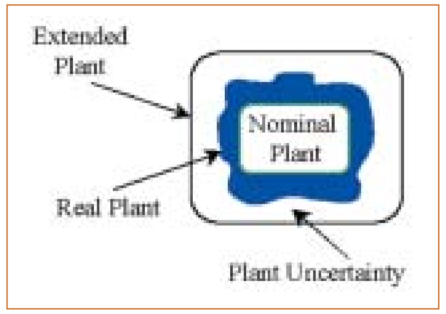

Figure 1. Models for control system design.

Linearization of nonlinear systems is a well-known procedure, for example: linearization around an operating point and feedback linearization, are frequently used in practice [1].

The first approach means that, system identification experiments are performed around different operating points, where the system is considered linear, thus LTI models are derived, which can form a linear parameter dependent model.

Feedback linearization has the main objective to find out a feedback law such that the nonlinear plant is transformed into a linear plant, which is valid in the entire operating range. Since feedback linearization exactly cancels the nonlinear terms, it is not a robust scheme. Furthermore, real-time implementation of the feedback linearization law is computationally expensive and might be numerically fragile.

Let us assume that the system is linearized around operating points, then considering a control-oriented system identification approach we can derive LTI models and an upper uncertainty bound (due to parameter uncertainty and unmodelled dynamics) as shown in Fig. 1.

A suitable model for control design is a proper balance between model fidelity and simplicity and requires not only advanced system identification techniques, but also physical insight and significant domain expertise [2].

The next step is to translate the performance specifications given in time-domain (in terms of settling time and percent of overshoot) into frequency-domain. Then, a robust controller for the LTI plant can be designed, based on specifications on the sensitivities using software tools [4]. The main difference between classical control and robust control is that in the framework of robust control plant uncertainty is taken into account during controller design, which is a more realistic approach [3].

The next issue, which we are going to discuss is, robust gain scheduling controller design and stability analysis. Gain scheduling consists in designing for each operating point a LTI controller and a switching controller when the operating conditions change.

It is known that when gain scheduling is used, the stability of the 'frozen' system ensures stability of the time-varying system for slowly varying parameters. In the case of gain-scheduled control systems, stability analysis is performed considering the variation range and variation rate of the time-varying parameter, using linear matrix inequalities (LMI) [5].

Quadratic stability means that, stability holds even when the parameters change arbitrarily fast, which can be quite conservative in many applications. Biquadratic stability means that, stability holds in a parameter box, defined by variation range and variation rate of the parameter, which leads to a less conservative test and is used in the case of slowly varying parameter dependent systems.

Practical Examples

As example, let us consider a coil on a magnetic core, which saturates as the current is increasing. The transfer function of the linear parameter dependent model is given by:

$$P(i,s) = \frac{1}{sL(i) + R} \quad (1)$$

where i is the current, R = 6.8 Ohm is the coil resistance and L=L(i) is the coil inductance, which is current dependent. Measurements showed that at i = 0.2A, L = 2H and at i = 2A, L = 0.5 H. Our main objective is to control the current with high accuracy between 0.2 A and 2A. For simplicity we assume that the power converter is ideal and there is no constraint on the control signal (applied voltage). The design specifications are: settling time 0.1 seconds and percent of overshoot less than 1.5%.

System identification experiments, performed around different operating points show that the system can described by P(s) = 1/(sL+R) LTI models as well as plant uncertainty.

$$W_T(s) = 0.1\frac{s+50}{50} \quad (2)$$

The performance specifications given in time-domain are translated into frequency-domain and leads to the performance weighting function [3]:

$$W_S(s) = \frac{s^2 + 80s + 2500}{s(s+80)} \quad (3)$$

The next step is to design for each operating point a robust controller and a switching controller, when the operating conditions change. We consider two operating points around 0.2 A and 2A. Furthermore, let us note the designed robust controllers for the operating points by K1(s) and K2(s), then the robust gain-scheduled controller is given by:

$$K(\alpha,s)=\alpha K1(s)+(1-\alpha)K2(s) \quad (4)$$

where

$$\begin{matrix}\alpha=0 & when & i=0.2\,A\\ \alpha=1 & when & i=2\,A\end{matrix} \quad (5)$$

The previous equation can be written as:

$$K(i,s)=\frac{i-0.2}{1.8}K1(s)+\frac{2-i}{1.8}K2(s) \quad (6)$$

Then biquadratic analysis is performed, when the current varies between 0.2A and 2A and the absolute value of the current rate is |di/dt|<18A/sec.

The block diagram of the control system is shown in Fig. 2.

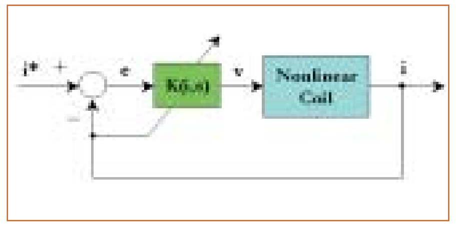

Figure. 2 Gain-scheduled control system.

Fig.3 shows the gain-scheduled system step response (green line) as well as the system step response (blue line) when LTI controllers have been used, and tests have been performed not for the designed operating point. It is obvious that using a single LTI controller, performance and robustness cannot be assured in the entire operating range.

In the considered example, the physical parameter (inductance) is dependent on the operating point (current), which can be easily measured. Therefore, high performance and robustness can be achieved with minimal cost by increasing the complexity of the controller.

There are other practical examples where robust gain-scheduled control is used such as: aircraft control (where the dynamics strongly depend on: angle of attack, speed and altitude) or car steering control, where the controller is desired to work well inside the operating domain defined by car speed and road conditions (friction coefficient), shown in Fig. 4.

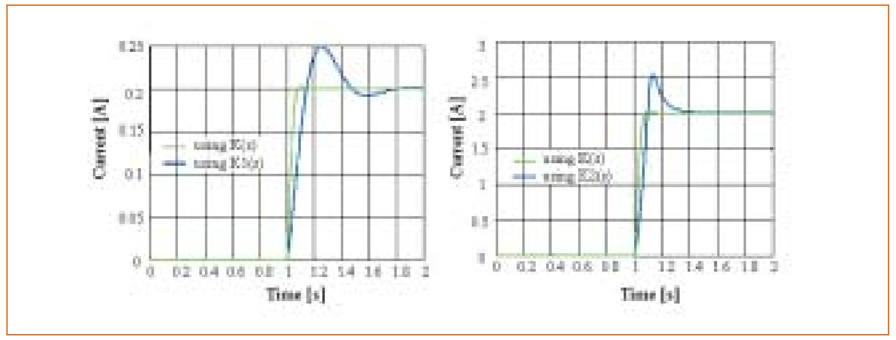

Figure. 3 Step responses – comparisons.

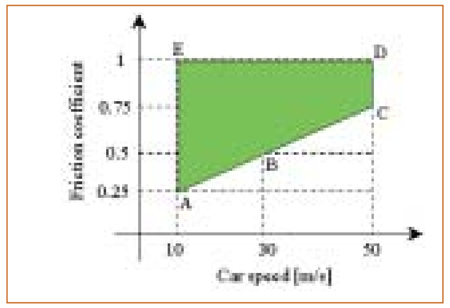

Figure. 4 The operating domain of the steering controller.

Conclusions

The article briefly reviewed powerful linear control design techniques, which are currently applied for nonlinear systems in other industries, thus might be useful for the power systems community, too.

The main features of gain scheduling can be summarized as:

- gain scheduling employs powerful linear design tools (well-understood) on difficult nonlinear problems;
- performance specifications are formulated in linear terms;
- gain scheduling enables the controller to respond rapidly to changing operating conditions.

The described techniques might be applied for power systems, too. If the operating point (scheduling parameter) is varying slowly, then biquadratic stability analysis of the control system is performed. If we switch among different operating points – most likely in the case of power converters – then quadratic stability analysis of the control system is required.

The main advantage – from the design engineer viewpoint – is: the design is performed in a well-understood linear framework with commercially available software tools.

References:

1. *Khalil, H.K.: Nonlinear Systems. 3rd edition, Prentice Hall 2002.*
2. *Ljung, L.: System Identification - Theory for the User. New York: Prentice-Hall 1987.*
3. *Doyle, J.C., Francis, B.A., Tannenbaum, A.R.: Feedback Control Theory. New York: Mcmillan 1992.*
4. *Chiang, R.Y., Safonov, M.G.: Robust Control Toolbox, User's Guide. The MathWorks, Inc. 1992.*
5. *Gahinet, P., Nemirovski, A., Laub, A.J., Chilali, M.: LMI Control Toolbox, User's Guide. The MathWorks, Inc. 1994.*

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Single-Chip Programmable Power Manager

Sequences, tracks and monitors supplies in hot-swappable cPCI circuit board

Power supply management in modern day Compact PCI (cPCI) boards involves not only the sequencing and monitoring of on-board supplies but must also provide hot-swap functionality. The hot-swap functionality is determined by the Compact PCI specification while the sequencing and monitoring of the supplies is determined by the circuit board functionality and the devices used on that board. Hence, designers resort to using multiple ICs to address the power management problem.

By Shyam Chandra, Lattice

Power Supply Challenges in a Compact PCI Circuit Board

Most off-the-shelf hot-swap ICs limit inrush current during card insertion, but they do not respond to power supply faults local to the circuit board. In order to prevent a power supply problem local to a circuit board affecting the entire system, it is desirable to isolate the faulty card from the back plane supply. In addition, designers will be required to implement multiple power supply busses to meet the supply sequencing and tracking requirements of the devices on the board such as FPGAs, CPUs and ASICs. Multiple reset generators/ supervisory chips and various logic functions will be required, in addition, to monitor all supplies. Hence, traditionally it takes multiple devices to implement complete power management on a Compact PCI circuit board, and it may still not address all the issues.

This article shows how Lattice Semiconductor's ispPAC Power Manager device implements complete power management of a cPCI card including circuit board isolation during power supply faults eliminating the complexities previously encountered.

Application Example: Power Supply Challenges in a typical cPCI Circuit board

Figure 1 shows the devices used on a typical cPCI Circuit Board along with its backplane interface and power supplies. There are 3 multi-voltage devices on this card: A PowerQUICC CPU, ORT42G5 FPGA and the Switched Back Plane ASIC. The following table (Table 1) summarizes the power supply requirement for each multi-voltage device.

The power management circuit should not only limit the inrush current on the 5V, 3.3V, +12V & -12V backplane supplies, but also generate standard cPCI handshake signals during the hot swap process.

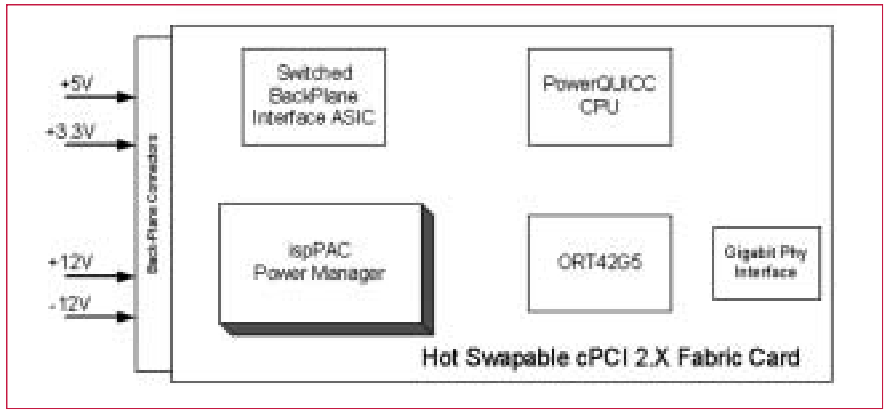

Figure 1. cPCI Circuit Board with Multi Voltage devices.

Device	Supplies Required	Sequencing & Tracking	Additional Requirements
PowerQUICC CPU	1.5V Core & 3.3V I/O	Voltage difference between core and I/O should not exceed 400 mV during power-up or down 1.5V should track 3.3V	CPU_Reset should be active for at least 50 ms after the supplies stabilize
ORT42G5 FPSC	1.5V Core, 3.3V I/O	Core voltage should be present before I/O voltages ramp. Power Supplies should ramp monotonically 1.5V 1st & 3.3V 2nd	
Switched Backplane ASIC	2.5V Core, 3.3V I/O	3.3V and 2.5V should track	

Table1. Individual device power supply requirement.

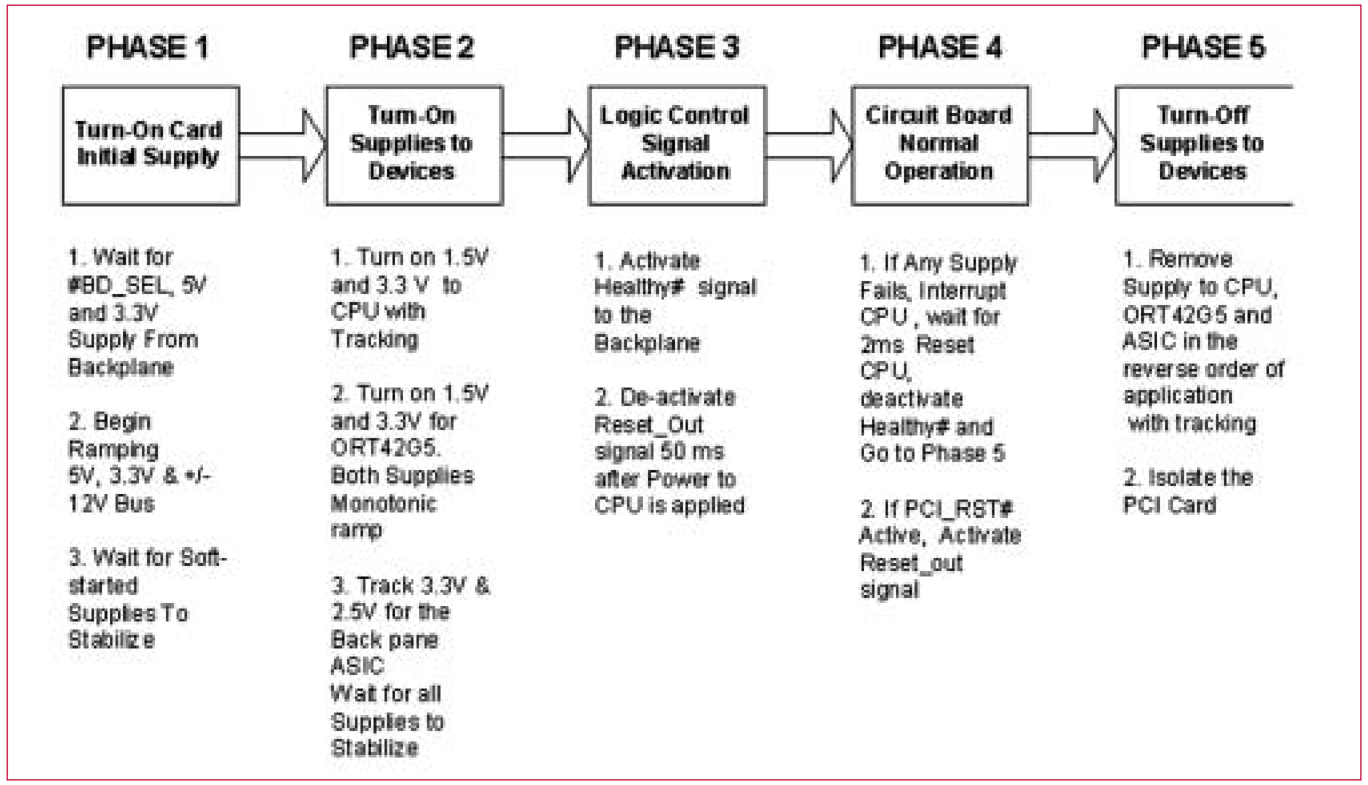

Figure 2. Five Power Supply phases of the cPCI Circuit Board.

Apart from the requirements of the individual devices, the design also calls for monitoring power supply voltages during normal operation. If any supply voltage falls below threshold, the CPU should be reset and the power supply to all devices should be recycled.

Overall system power supply activity can be subdivided into 5 phases. Figure 2 shows the five phases in the corresponding boxes. The actual power supply functions during those phases are indicated below the appropriate box.>

Power Supply Management Circuit Diagram

The complete power supply management of this cPCI Circuit Board, implemented using the ispPAC-POWR1208 device, is shown in the circuit diagram (figure 3).

The ispPAC-POWR1208 (called Power1208), integrates Lattice Semiconductor's ispMACH CPLD and ispPAC programmable analog technologies, resulting in a single chip that implements a flexible, cost effective, and convenient solution for the power management problem. With a "supply-ruggedized" ispMACH PLD at its core, the Power1208 device features 12 precision analog threshold comparators with on-chip voltage references for supply monitoring, 4 noise-immune digital inputs and 4 open-drain digital outputs for system control interfacing, 4 programmable (both maximum voltage and ramp rate) high voltage FET drivers for supply control and 4 programmable timers with an on-chip 250 kHz oscillator for delay control. The device has been ruggedized to operate in noisy power supply environments from 2.25V to 5.5V and is packaged in a 44-pin Thin Quad Flat Pack (TQFP) package.

In order to meet both cPCI hot-swap specifications and power supply sequencing and tracking requirements of individual multi-voltage devices, the power supply is divided into 2 sections.

The first section, using independent MOSFETs (Q1, Q2), limits the inrush current from the backplane. An intermediate power bus called the "Soft Started Bus" is powered through these MOSFETs.

The second section, referred to as the "Device Power Bus", is powered by individual power supply bricks and MOSFETs. The tracking requirement of the PowerQUICC processor can be implemented using a bootstrapping method. However, it results in a non-monotonic ramp of 3.3V at the CPU's I/O pins. While that non-monotonic ramp acceptable for the CPU, it does not conform to the ORT42G5's power supply requirement. Hence the 3.3V is routed through another power MOSFET. The backplane ASIC requires the 2.5V and 3.3V to track. 4 power supply busses in this card are required to address all the requirements simultaneously. The supply busses are:

- 1.5V supply, generated using 1.5V brick for powering CPU's core and the ORT42G5.
- 3.3V for the CPU's I/O is fed through the MOSFET Q5.
- 3.3V for the ORT42G5, Backplane switch ASIC and the remaining ICs on the board is supplied through the # MOSFET Q3 to facilitate monotonic ramp. This supply is enabled along with the 3.3V of the CPU.
- 2.5V brick powered by 5Volts, is for the Backplane switch ASIC core. Power supply tracking between 2.5V and 3.3V supplies, as required by the ASIC, is implemented by MOSFETs Q4 & Q3.

Power Management Algorithm

The power management algorithm is implemented on the embedded CPLD of the Power1208. As can be seen, the ispPAC Power Manager device controls the soft-start, sequencing, tracking, and monitoring of power supplies efficiently while generating supervisory signals required both by the cPCI bus and on-board components.

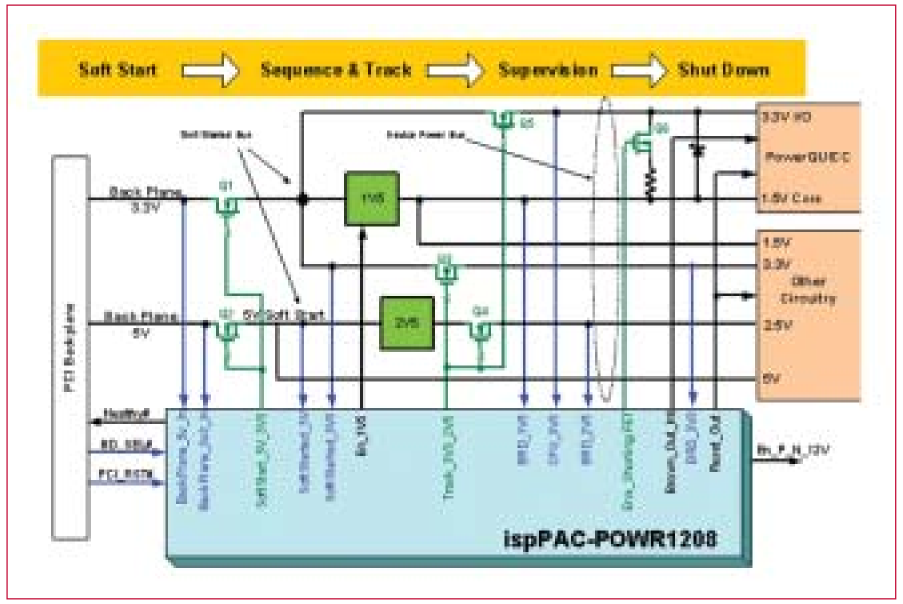

Figure 3. Power Management of the cPCI Circuit Board Using ispPAC-POWR1208.

Implementing Power Supply Management on the cPCI Circuit Board Using the PAC-Designer Software

Power supply sequencing and monitoring designs can be implemented on Power1208 devices using Lattice's popular PAC-Designer version 2.1 software. The PAC-Designer software is an intuitive PC-based schematic design entry and simulation tool. The user can design complex sequencing and monitoring functionality easily using PAC-Designer's newest feature, LogiBuilder, which uses a series of easy-to-use pull-down menus to define sequences and conditions to monitor.

To implement the design using the PAC-Designer software:

1. Set the Monitoring threshold values for each analog input by selecting the appropriate threshold value from a pull down menu.
2. The Power Supply Ramp Rate Control is implemented by setting the MOSFET gate drive characteristics for the HVOUT outputs. This is set by a pull down menu as well.
3. Power Supply Sequencing, Tracking and Supervisory Signal Generation Logic can be defined easily using just five point-and-click instructions in the LogiBuilder section.
4. Verification using PAC-Designer's waveform simulator can verify the completed design.
5. ispDownload to Power1208 Device - The complete and verified design can be downloaded to the Power1208 device through the device's JTAG port.

The complete power supply management program is implemented in 14 steps as shown in the screen capture of Figure 4.

As can be seen, the LogiBuilder program steps that correspond with the 5 power supply phases of power management are:

- Phase 1 – Step 0 and Step 1 –

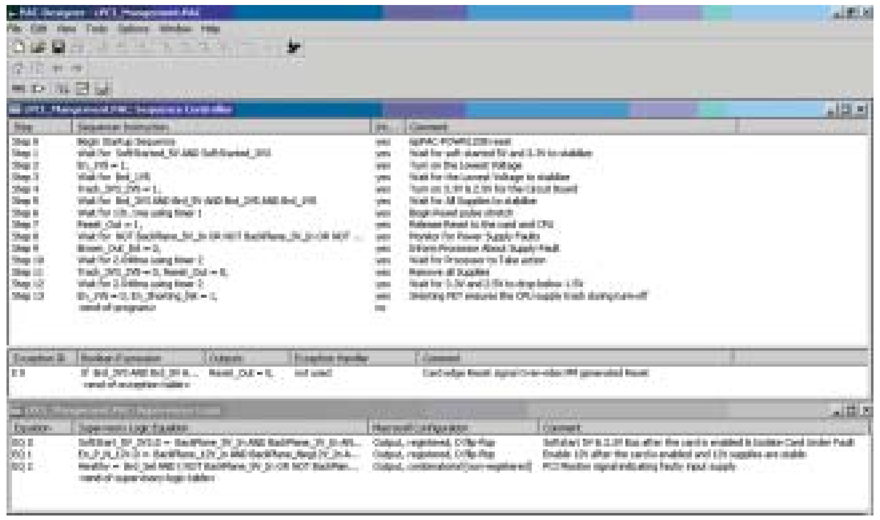

Figure 4. LogiBuilder Program for cPCI Circuit Board Power Management.

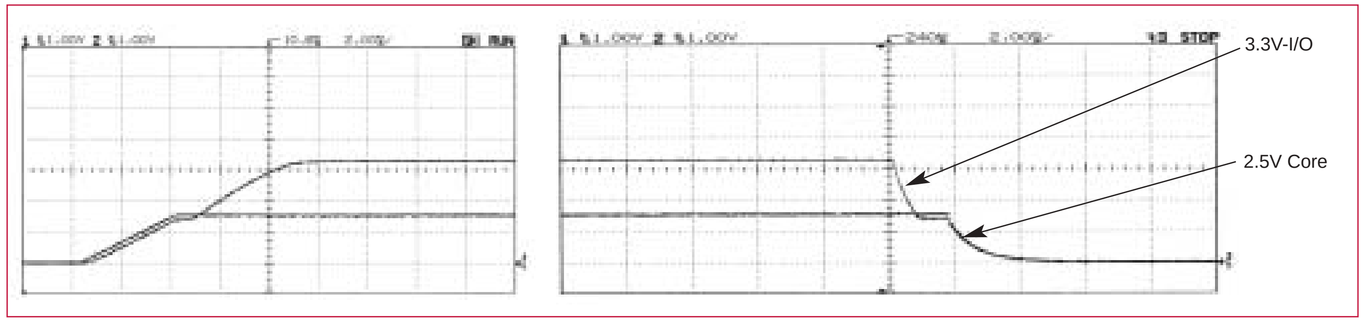

Figure 5a. Oscilloscope waveform showing 1.5V and 3.3V Bootstrapping at PowerQUICC Processor

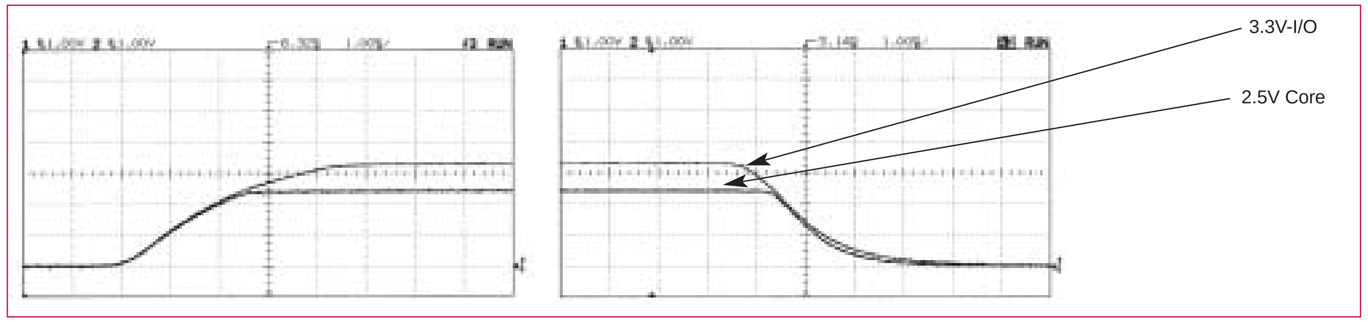

Figure 5b. Oscilloscope waveform showing 2.5V and 3.3V tracking at ASIC.

Waiting for soft started power supplies to stabilize Equation 0 in Supervisory Logic Window enables Soft Start MOSFETs

- Phase 2 – Step 2 to Step 5 – Applying the correct power supply to each device
- Phase 3 – Step 6 and Step 7 – Pulse stretching of CPU-Reset
- Phase 4 – Step 8 – Card normal operation, Step 9 – Low-Voltage interrupt
- Phase 5 – Step 10 to Step 13 – Turning the power supply off

This LogiBuilder program is then compiled and the resulting JEDEC file is then downloaded into the ispPAC Power Manager device through its JTAG pins.

The design was implemented and the following oscilloscope screen shots (figure 5a & 5b), shows that the I/O voltage tracks the core voltage during power supply ramp up.

The programmable mixed-signal ispPAC-POWR1208 device manages all power supplies on the cPCI circuit board, effectively managing the card under power supply fault conditions and finally isolating it.

Additionally, the ispPAC-POWR1208 device has well thought-out resources to meet the requirements of individual circuit board designs through programmability. The discrete component based solution, on the other hand, while being inflexible and occupying larger board area, fails to address all aspects of power management.

The PAC-Designer software supports interfacing the ispPAC Power Manager device to various power supply arrangements. Power supply management algorithms can be specified quickly using the LogiBuilder's 5 basic instructions.

The integration and programmability of the ispPAC-POWR1208 device coupled with the PAC-Designer software tool increases reliability of the circuit board whilst reducing board space, cost and time to market.

www.latticesemi.com

Integrated Power Supply Controller

The offer for more flexibility and intelligence

The ADM1041 secondary side controller offers current sense, voltage sense, share bus and OrFET control. An SMBus interface means that the part can be programmed over the SMBus.

By Brendan Daly, Analog Devices

The question of integration on the secondary side of AC-DC redundant power supplies has been largely neglected by semiconductor manufacturers. This has resulted in hundreds of discrete building block components such as opamps, transistors, resistors, capacitors and digital logic to perform the various secondary side control and monitoring. A recent addition to this is the demand for more communication between the power supply and the rest of the system. This trend towards intelligent power supplies with a digital interface is now becoming a standard requirement for most new designs. There are parts available which offer some integration, such as current sense, voltage sense or OrFET control, but all still require a lot of external circuitry, and a microcontroller and EEPROM to provide the intelligence. However, none of these parts offer the level of integration or intelligence offered by the ADM1041, from Analog Devices. It incorporates current sense, voltage sense, share bus and OrFET control.

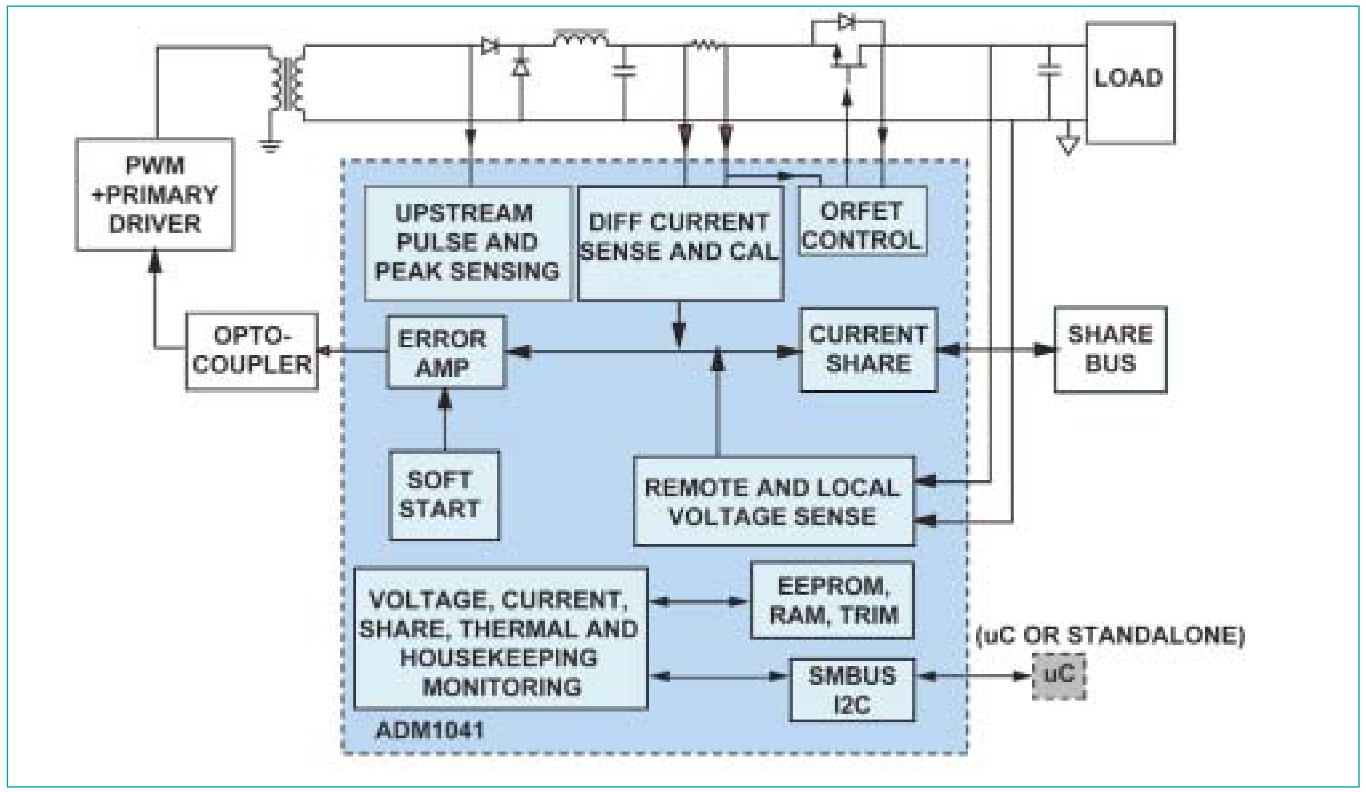

Figure 1. Block diagram of the ADM1041.

This new part, which is also I2C compatible, can also communicate over the SMBus, and has built-in EEPROM. This allows huge flexibility in setting up a power supply, and can dramatically cut design and development time. This article describes the trade offs of existing discrete solutions against an integrated solution, like the ADM1041. Figure 1 shows a block diagram of the typical secondary side functions contained in a redundant power supply.

Even though a power supply designer might not like it, cost is usually the primary concern when designing a power supply. Component cost, maintaining inventory, development, test and production all factor into the cost of a design project. The flexibility that the ADM1041 offers the power supply designer results in easier and quicker development of a new design. It is a lot quicker to reprogram a register, than re-solder several components when developing an AC Sense circuit. Also, the level of integration provided by the ADM1041 results in a much lower BOM count and cost than an equivalent discrete solution. This also saves issues with inventory and ordering. Figure 2 shows a typical application solution for the secondary side of a redundant power supply using an ADM1041. Further examples of cost saving advantages are also discussed later.

The end users of AC-DC power supplies are increasingly looking for the ability to interface to the power supply from the rest of the system. A discrete solution requires microcontroller, EEPROM, and a host of digital logic blocks to perform the monitoring functions. The SMBus interface of the ADM1041 allows it to communicate with a microprocessor or other systems on the bus. This results in more flexibility to perform load sharing, or more advanced sharing configurations, such as thermal balancing to improve reliability. The ADM1041 incorporates EEPROM on-chip, which stores the setup contents for the registers. The register contents are lockable, meaning the the power supply can be sent into the field without the worry that the end user will overwrite the register values, and hence cause a failure in the field. There is also spare EEPROM on board, which can be used to store the programming information of a microcontroller, or to store fault events, and when they happened. The on-board EEPROM also allows stand-alone operation. This can remove the need for a microcontroller. User friendly interface software is available to allow the designer to very quickly program the ADM1041, without having to worry about register maps, consulting the datasheet, or writing code. Figure 3 shows the OCP programming window of the interface software.

Extra digital logic is required to provide the capability of debugging a system that fails in the field, or during the design stage. During a fault event in a power supply, the internal status registers of the ADM1041 allow the user to see real-time flags to determine the source of the fault. Latched status registers are also available, which remember if a fault has occurred at some time in the past. This is useful for tracking down intermittent fault conditions, in bench testing and in field testing. This added intelligence means that much more sophisticated fault conditions can be monitored and controlled. For example, the OCP time-out is programmable, as is the ADM1041's reaction to an OCP event. It can be set to constant current operation, or to shut down the power supply in the presence of an OCP event. Figure 4 shows the various monitoring flags of the ADM1041.

Production cost is critical, but something that is often an afterthought for power supply designers. Using a discrete approach, trimming out errors due to sense resistors and other compo-

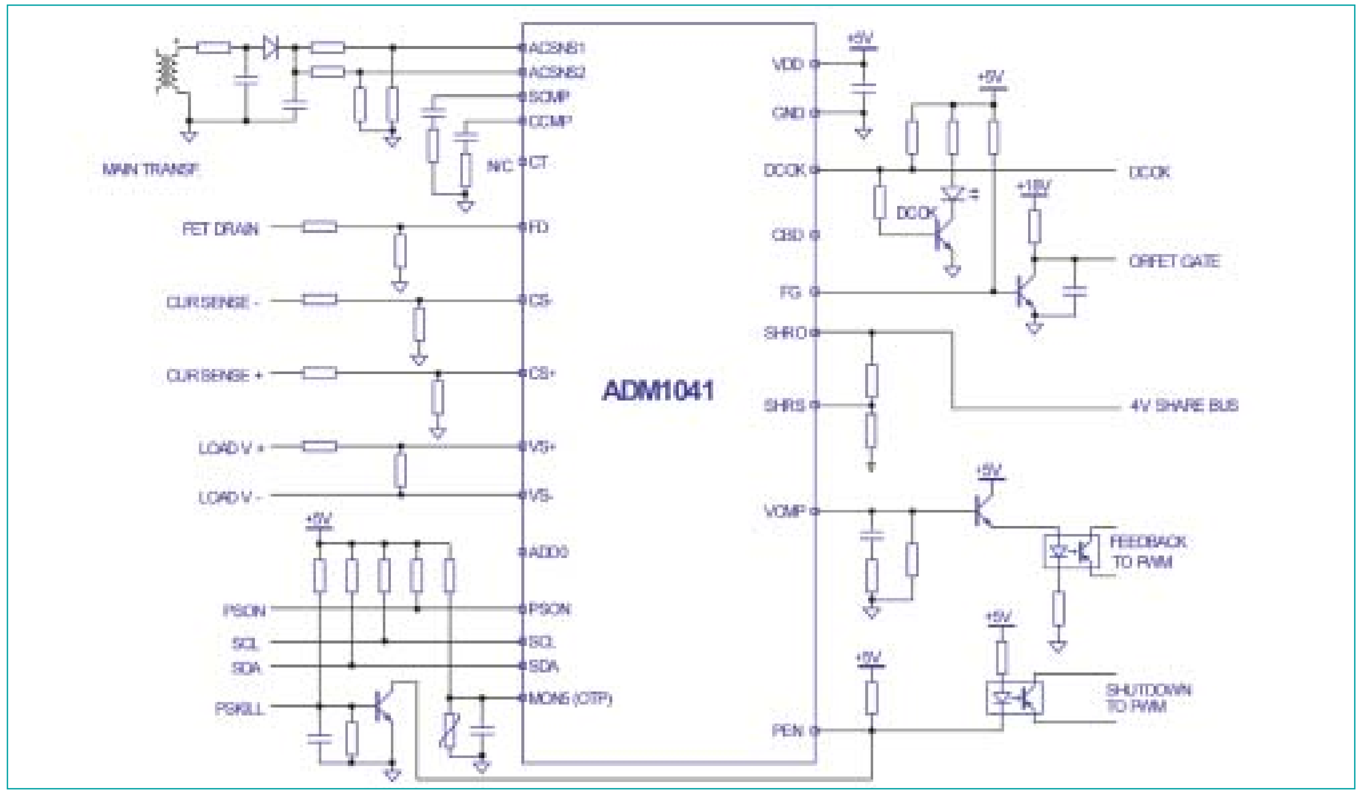

Figure 2. A typical application solution for the secondary side of a redundant power supply using an ADM1041.

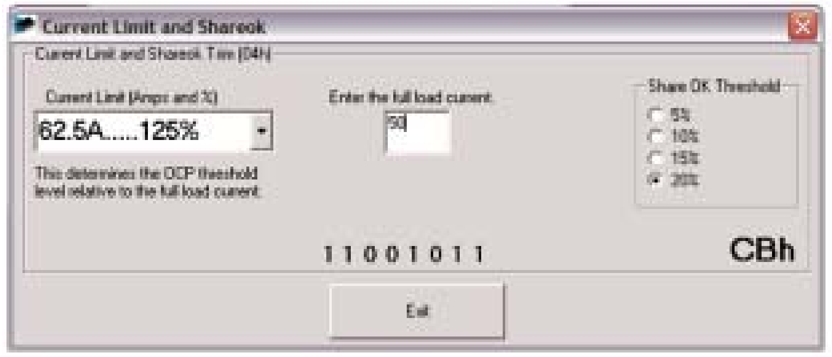

Figure 3. The OCP programming window of the interface software.

Figure 4. Various monitoring flags of the ADM1041.

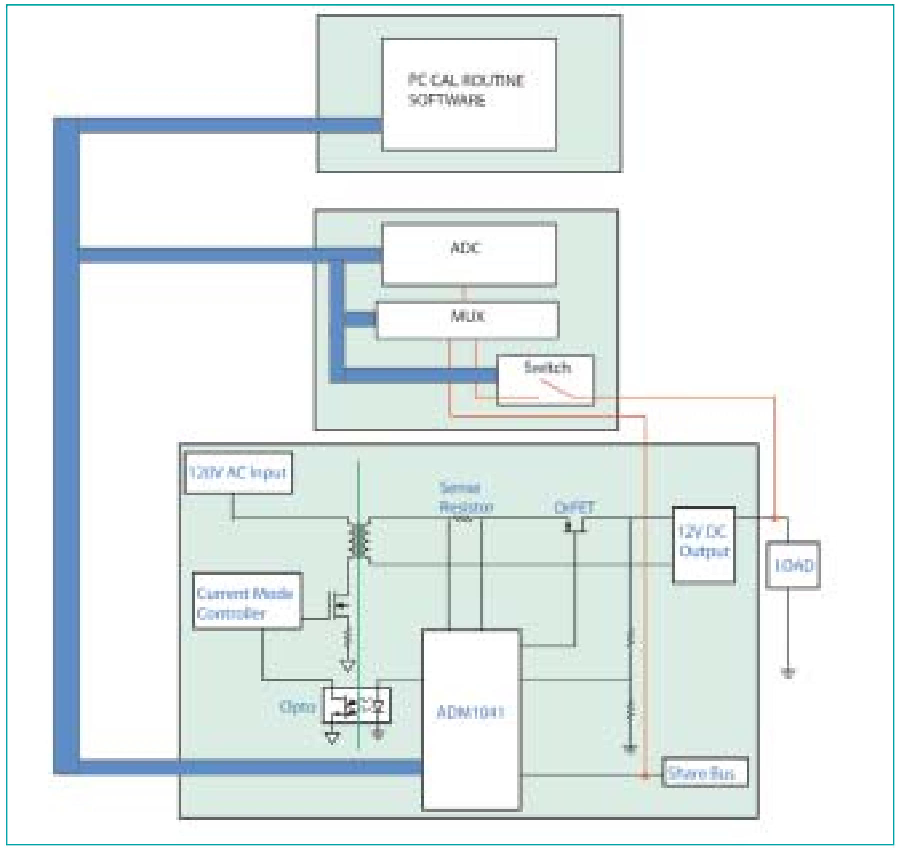

Figure 5 shows a possible production trim setup.

nents is often performed by an operator tweaking potentiometers. This can be a relatively expensive process, that can still leave errors. The ADM1041 integrates the ability to perform this trimming on-chip. A simple software algorithm is available for production test, where an ADC or automated tester takes the place of the operator, and the software calibrates the ADM1041 trim registers. This means there is no more need for operators at final test, thus saving production costs and time, as well as ensuring consistent trimming in each unit. It is possible to trim the load voltage and the current sense circuit, to correct for common mode and differential mode errors that are introduced by resistor tolerances and amplifier inaccuracies. This is a particular advantage in high volume applications, as throughput is vastly improved over the traditional method. Figure 5 shows a possible production trim setup.

A major design headache at present is the demand for ever increasing power density. In server applications, figures like 10W/in3 are now commonplace, as end users demand more power in smaller form factors. This is a Catch-22 situation, as higher power outputs require larger power components to be employed. So, PCB real estate becomes even more valuable. By integrating all of the secondary side control functions on a 24 pin QSSOP package, the ADM1041 saves valuable area for this increase in power density. Multi-chip solutions and discrete solutions also lead to layout and routing headaches, and grounding issues. The ADM1041 also can be used with a thermistor to control a fan, as thermal management becomes more critical with increased power density.

Many power supply designs are custom designs, whereby an existing product is tweaked slightly for different customer requirements. And in the vast majority of projects, the designer tries to re-use previous designs, or sections of designs, that have been thoroughly characterized, tested and proved in the field. Even small changes to a discrete approach can lead to several new components being used, which will all need to be characterized thoroughly. The ADM1041 has internal registers which can be configured to suit a custom application. This allows the designer to re-use the tried and tested circuit, and just reprogram the registers of the ADM1041 for each new project. This saves design, development and characterization cost and time. Changing OCP (overcurrent protection) limits or the power supply start-up time is as straight forward as changing the appropriate register, and shipping to the customer. Software is also available to design the feedback loop, and incorporates bode plots for optimizing the loop design. The designer inputs basic parameters and specifications, and the software designs the filter. Figure 6 shows the front panel of the Voltage Loop Design Software.

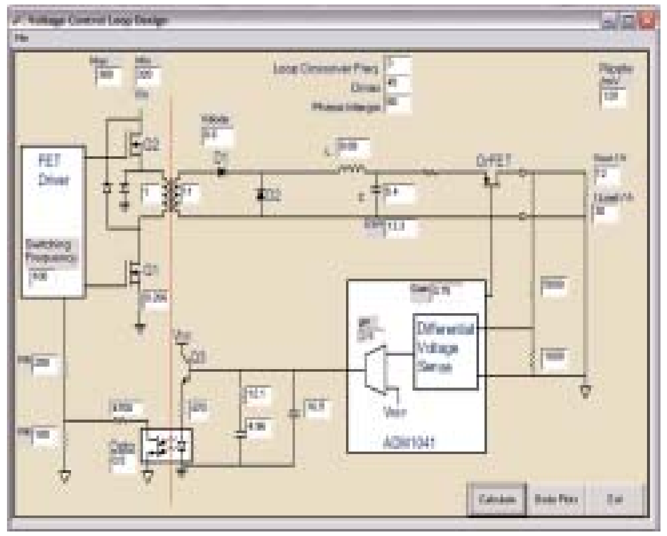

Figure 6. Front panel of the Voltage Loop Design Software

When a Power Supply designer gets the specifications for a new project, the challenge is obvious. Less expensive, higher power density, smaller form factor, faster turn-around, higher integration, more functionality and intelligence. A discrete approach to power supply design cannot achieve this. The requirement for highly integrated and flexible single chip solutions is clear.

www.analog.com

High-current, wide-bandwidth current probes

LEM has introduced the first of a new range of high frequency LEM~flex current probes. The HFR3000 provides a wide dynamic measuring range up to 3000A AC at frequencies from 1Hz to 1MHz. The new probe is intended for use with oscilloscopes and recorders providing accurate, non-intrusive measurement of sinusoidal, pulsed and other complex waveforms.

The HFR3000 probes are available with three head lengths – 200, 500 and 800 mm. The flexible measuring head has a diameter of only 6mm, allowing it to be used in confined spaces. The unit is supplied with a 1.5 metre output cable, simplifying non-intrusive AC measurements in many different applications such as power electronic converters, induction heating, welding systems, motor and generator control drives and capacitor discharge systems. Typical accuracy is ±1% of nominal current.

The unit can be powered either via an optional external power supply (provided with adaptors for worldwide use) or by a 9V PP3 battery with low-battery indicator. This offers a flexible, lightweight solution to AC measurement requirements without the need to load the test circuit.

The HFR3000 current probes are fully compliant with IEC 1010 safety requirements and rated 600V CATIII. This provides confidence when working in hazardous voltage areas. Conformance to EMC standards ensures high reliability through reduced susceptibility to electromagnetic influences.

www.lem.com

Building Block Synchronous Buck Converters

International Rectifier has introduced the iPOWIR iP1203, a fully-optimized, full-function 15A single output synchronous buck converter device that achieves over 90% efficiency at full load. The iP1203 is a flexible solution that addresses requirements from 5.5Vin to 13.2Vin and 0.8Vout to 8Vout, maintaining a full load capability of 15A.

The power building block is designed to simplify DC-DC point-of-load (POL) converters for network processor units (NPUs) and ASIC power rails within networking and telecommunication systems. The iP1203 is ideal for use in two-stage distributed power architectures being fed from either a regulated isolated brick or an unregulated DC bus converter.

Offering superior power density, the iP1203 building block integrates a full-function PWM control IC, trench MOSFETs and passive components enabling excellent thermal performance at raised ambient temperature without de-rating.

The iP1203 addresses important networking and telecommunications power system requirements such as hiccup over-current, over-temperature and over-voltage protection, external synchronization, power good and soft start.

The building block is housed in a land grid array (LGA) package measuring 9mm x 9mm x 2.3mm. The iP1203 uses thermally-enhanced mold compound, enabling dual-sided cooling capability and very low junction-to-case and junction-to-PCB thermal resistance for maximum current handling.

Visit IR at PCIM, Nürnberg,
7 – 9th June 2005 – Stand 201

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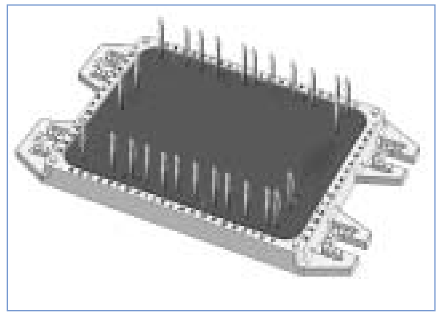
UL-60950-1Certification for DC/DC-Converters

Recom extended the UL-certification for their DC/DC-converters now from the POWERLINE to the well known ECONOLINE. 5 series with extraordinary high isolation of more than 4kVDC which are ideally suitable for any application with safety considerations are available now not only fully compliant to ROHS, they are as well certified according to UL-60950-1/CSA C22.2. Details for this UL-certificate for all models incl. All the available options for the series RP-xxxx (1W, 5,2kV), RxxPxx (1W, 5,2kV), RV-xxxx (2W, 6kV), REC3-xxxxSRW/DRW-H4 and -H6 (3W, 4kV bzw. 6kV), REC5-xxxxSRW/DRW-H4 and -H6 (5W, 4kV bzw. 6kV) can be found at www.ul.com using the UL-filenumber E224736 or via search für RECOM. All RECOM datasheets can be downloaded as PDF-files.

www.recom-international.com

ECO-TOP 1 Package Line



Powersem offers a new package line: ECO-TOP[T] 1. This power module will already be presented at PCIM 2005 in Nuremberg and will enlarge and accomplish POWERSEM's product range with respect to higher performances.

ECO-TOP 1 was developed in order to provide the Power Electronics Market with a power module in which an IPM circuit containing Three Phase Rectifier Bridge, IGBT Brake Chopper and Three Phase IGBT Inverter with current ratings from 30 to 80 Amps (inverter IGBT) can be realized. Besides, SIXPAC circuits with current ratings from 30 to 90 Amps (IGBT) are also available. With outline dimensions of 109 mm to 63 mm this solderable power module can also be used for highly integrated customized solutions or High Power AC Controller Modules covering current ranges from 3 x 30 up to 3 x 200 Amps.

Using the ECO-PAC standard height of 9 mm this new package ECO-TOP can be combined and soldered together (i.e. on the same PCB) with all already existing ECO-PAC 1 and 2 Power Modules. Featuring all the advantages of the ECO-PACs with reference to long term reliability and thermal/load cycling capability by the usage of DCB Technology, glass passivated chips and connection leads with expansion bends for stress relief, ECO-TOP 1 is especially suited to realize customized solutions within a short time.

Closing the gap between ECO-PAC 2 and ECO-TOP 1 Powersem is going to develop ECO-PAC 3 which will be available in a few months.

Visit Powersem at PCIM, Nürnberg,
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www.powersem.com

Configurable 400W to 2200W Power Supplies

XP Power has announc-ed its next generation of configurable power supplies that enables the company to offer an infinite choice of customized power solutions from 400 Watts to 2200 Watts, with samples available in 24 hours.

The fleXPower family of AC/DC power supplies has been designed to deliver class-leading power density in packages 25% smaller by volume than other products in the market. At the same time, a host of innovative features has been added: flexible series and parallel connectivity between units of different power levels, full medical and industrial approvals for safety and EMC, up to six outputs from 3.3VDC to 150VDC from a universal AC (85 to 264V) or DC (120 to 370V) input, floating controls and signals, field replaceable fans, an advanced logic interface, and an extended operating temperature range from -20°C to +70°C.

This additional flexibility will widen the appeal of configurable power supplies for electronic systems, particularly as the extra functionality and improved power density are offered at a reduced cost over earlier models.

The ability to interconnect units of different power levels enables system designers to closely specify the power level they need for each application without paying for excess power capabilities. This cuts overall system cost and improves efficiency. Greater system reliability is thereby achieved.

www.xppower.com

Multi-Standard Disk-Drive

Tests show exceptional results for new MIPHY macro-cell, which will be integrated in System-on-Chip designs for SATA, SAS, Fiber Channel, and PCI Express applications

STMicroelectronics revealed successful fabrication of the MIPHY (Multi-Interface PHY) Physical Layer interface IP (Intellectual Property) using 90nm technology. This macro-cell, the first to support Serial ATA (SATA) disk drives, as well as applications using the Serial Attached SCSI (SAS), Fiber Channel, and PCI Express serial interface standards has been designed by ST's engineers to be integrated with other functions into a System-on-Chip (SoC) and allow drive manufacturers to reduce costs by building and stocking one IC to operate in multiple drives.

By implementing and verifying the 90nm interface design now, ST is preparing for the migration of SoC products to 90nm technology later this year, benefiting from the lower power requirement and smaller physical size. Proven IP will be ready ahead of time to minimize the time-to-market for new products and reduce the development costs of new ASICs. In addition, the multiple-standard capability of the new macro-cell will enable fast design validation for different markets and will eventually yield the benefit of larger scale volume production while at the same time reduce costs for manufacturers by optimizing their engineering resources. **Visit STMicroelectronics at PCIM Europe Booth 12- 106**

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