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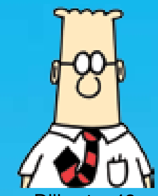
Special Report - White Goods

ISSN: 1613-6365

Power Systems Design EUROPE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Registration of copyright: January 2004
ISSN number: 1613-6365

Send address changes to: circulation@powersystemsdesign.com

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Volume 6, Issue 3

Moving on..

The hard face of our business is biting in with many working short time or finding themselves out of work, tough times indeed. The business has, as expected, certainly not improved since our last issue of the magazine and the news keeps rolling in, albeit not always as gloomy as some forecasters had predicted.

Pricing for commodity electronic other components is falling at a more moderate rate than might be expected, given plunging worldwide demand. However, chip makers should take little comfort from this development because the modest pace of erosion reflects the fact that pricing has already hit rock bottom in many commodity categories, according to iSuppli Corp.

During the period from February 2009 to January 2010, global pricing for commodity components is expected to decline at a relatively moderate pace of 1.1% per month, according to a forecast from iSuppli's Component Price Tracker (CPT) Index. This rate of decline is well within normal decreases as defined by Moore's Law and learning-curve factors.

In contrast, during the last major electronics downturn following the dot-com bust from June 2002 to May 2003, the average monthly price fell by 2.5%. iSuppli's CPT index tracks pricing trends for multiple commodity component categories, specifically analog-monolithic, capacitors, connectors, crystals, filters, logic, magnetics, memory, oscillators, printed circuit boards, rectifiers, resistors, diodes, transistors and LEDs.

On a more positive theme, we are now in deep preparation for the PCIM show in Nuremberg, Germany. The show runs from May 12 - 14th 2009 and is the No. 1 European meeting place for the power electronics, intelligent motion and power quality industry.

With the current economic outlook, the importance of a clearly targeted and top quality event like PCIM is obvious. Companies are pushing ahead with innovative new products and developments and are using their participation at Europe's leading event for power electronics to demonstrate their capabilities and newest trends to an authoritative trade audience.

Designer's Power Systems Design Forum

PSDE's panel discussion in the Forum, as well as vendor presentations will be on offer free to visitors to PCIM Europe 2009. I will run a forum where industry experts from major companies in our industry will provide insight and opinions on the special PSD theme of:

"**Power Design for Ecological and Economic Success**"

This reflects the need not only for energy efficient designs, but also the realistic requirement today for designers to deliver industry-beating and differentiated designs - on time and within a real-world budget. The forum will run from 4:00 - 5:00 pm on Wednesday 13th May. Please come along, I'll be very pleased to meet you there.

I hope you enjoy the issue. Please keep your valuable feedback coming in and check out our fun-strip, Dilbert, at the back of the magazine. We could all do with a smile!

All the best!

Editor-in-Chief, PSDE
Cliff.Keys@powersystemsdesign.com

PCIM Europe 2009

International Exhibition and Conference on POWER ELECTRONICS - INTELLIGENT MOTION - POWER QUALITY

Nuremberg, 12 – 14 May 2009

PCIM 2009, held again in Nuremberg this May, is the No. 1 European meeting place for the power electronics, intelligent motion and power quality industry.

With the current economic outlook, the importance of a clearly targeted and top quality event like PCIM is obvious. Companies are pushing ahead with innovative new products and developments and using their participation at Europe's leading event for power electronics to demonstrate their capabilities and newest trends to an authoritative trade audience.

The high standing of PCIM can be seen in the latest statistics. Many companies have booked larger booths or are taking part for the first time in Europe's most important exhibition for power electronics.

The main exhibits range from semiconductors, components and sensors, intelligent motion, motors and rectifiers through to power management systems, simulation and design software, as well as many of the latest developments in the power electronics sector.

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PSDE's panel discussion in the Forum, as well as vendor presentations will be on offer free to visitors to PCIM Europe 2009.

Power Systems Design Europe and N. America editor, Cliff Keys, will run a forum with industry experts will provide insight and opinions on:

"Power Design for Ecological and Economic Success"

This reflects the need not only for energy efficient designs, but also the requirement for the designer to achieve this on time and within a real-world budget. The forum will run from 4:00 – 5:00pm on Wednesday 13th May.

Tutorials and Conference

PCIM Europe 2009 gets underway with ten tutorials on Monday, 11 May 2009. In these, prominent experts will be sharing their knowledge of specific power electronics topics. The PCIM Conference will be held in parallel to the Exhibition.

Jobs Platform

The lack of engineers remains an important issue and is particularly true for the power electronics industry. Thanks to the Semica careers stand (booth 212 in Hall 12), PCIM Europe 2009 will provide the electronics market with a jobs platform for those seeking work as well as potential employers.

ECPE Pavilion

A further highlight is the pavilion being organised by the ECPE (European Center for Power Electronics e.V. – the industrial and research network for power electronics in

Europe) in hall12 (booth 569), which together with leading European Centers of Excellence (university and research institutes) will be presenting an overview of its activities in the field of power electronics.

The conference program and further details about PCIM Europe 2008 are available at www.pcim.de

www.pcim.de

REpower Lays Foundation Stone of New Development Centre

Germany's third-largest wind turbine manufacturer, REpower Systems AG, celebrated today the laying of the foundation stone for a new development and administration centre in Osterrönfeld (district of Rendsburg-Eckernförde). In the presence of the Minister for Science.

Economic Affairs and Transport in Schleswig-Holstein, Mr. Werner Marnette, the Mayor of Osterrönfeld, Bernd Sienknecht, and further invited guests, the Executive Board hosted the traditional ceremony on the Kiel Canal site.

REpower CTO Matthias Schubert stressed in his greeting the solidarity of the company with Schleswig-Holstein and Rendsburg.

Minister for Economic Affairs, Mr. Marnette, praised REpower's decision to continue to invest in Schleswig-Holstein and create jobs;

according to him, this is a positive signal particularly in these fraught economic times and proves that wind energy represents an important source of energy for the future. "The booming industry in Schleswig-Holstein with over 7,000 direct and indirect workers increasingly turns out to be the mainstay of the economy. Statistically, almost 40% of the region's electricity consumption are being covered by wind energy" , said Mr. Marnette.

In Rendsburg and Büdelsdorf, REpower currently employs almost 400 people in development and other technical and operative departments, a majority of these are engineers. They are expected to relocate to the new administration building in Osterrönfeld in February 2010.

www.repower.de

New CEO and Company Structure for CT-Concept

CT-Concept Technologie AG, the worldwide market leader in IGBT gate drive units, has reorganized its structure in order to support future growth. The newly formed CT-Concept Holding AG will own the IPR and thus all forms of driver licensing and cooperation. CT-Concept Technologie AG will continue to act as the operational division covering development, production, logistics, sales and marketing.

After presiding over more than 22 years of successful business growth, the founder and chairman of CONCEPT, Heinz Rüedi, is taking a step back from active involvement and will continue as CEO of CT-Concept Holding AG.

The board of directors named Wolfgang Ademmer as the new CEO of CT-Concept Technologie AG who's duties commenced on May 1st.

Ademmer, 41, was formerly Senior Director at Infineon Technologies AG responsible for power electronics for hybrid vehicle and white goods since 2005. Prior to this position, he directed and handled the IGBT power module business at eupec GmbH as Vice President Sales & Marketing, establishing a solution-oriented strategy to cope with market trends, including a business plan for IGBT drivers.

Wolfgang Ademmer (left) and Heinz Rüedi (right)

"In Mr. Ademmer, we have found the ideal candidate to lead us to the next leap in growth. Thanks to his sound experience in the power semiconductor market and the excellent technology base at CONCEPT, he will provide the strategic direction to extend CONCEPTs market position and help us to tap new markets," said Heinz Rüedi, founder of CONCEPT.

"Knowing CONCEPT for more than ten years, I'm excited about our potential to create further success in a healthy market. Stimulated by the macroeconomic demand for more electricity, the market for medium and high-power converter solutions will grow steadily, unlike the purely end-consumer driven markets. With our products we will help to create efficient and reliable solutions in all medium and high-power applications, with an emphasis on a cost/performance ratio that competes with in-house developments" added Ademmer.

www.igbt-driver.com

CamSemi Secures Award for Clean Technology

CamSemi has received its second major industry award in just three months by being named as 'University Spin-out of the Year' in the New Energy Awards 2009. The company recently received the Start-up of the Year award from The National Microelectronics Institute and is also short-listed for two Business Weekly 2008 awards.

CamSemi was chosen as overall winner against five other finalists in the spin-out category on the strength of its disruptive energy-saving technologies, 'cost efficient' products and sustained commitment to the 'green agenda'. The judging panel included leading academics, policy advisors, industry executives and investors from the UK's clean technology sector.

From the left: Nick Warburton, CFO and Ted Wiggans, VP Operations at CamSemi receiving a certificate and sapling from Professor Dennis Hawkes from the UK's Sustainable Environment Research Centre.

This latest award was presented at an event held on Wednesday 25 February with over 400 attendees at The Natural History Museum, London.

In addition to the title and certificate, each of this year's ten winners has been given a specific plot of land under the Healthy Planet Guardian scheme. CamSemi is adopting a one hectare plot – around the size of one and half football pitches or a baseball field – in the Great Fen wildlife project, not far from the company's Cambridge office.

www.camsemi.com

TI Projector Development Kit available from Digi-Key

Electronic components distributor Digi-Key Corporation, recognized by design engineers as having the industry's broadest selection of electronic components available for immediate shipment, announced that it is stocking Texas Instruments' DLP Pico Projector Development Kit, a fully integrated and miniaturized light projection solution that can be quickly and easily integrated into the design process for new industrial, medical, and consumer products.

Available now exclusively on Digi-Key's global websites, the Pico Projector Development Kit (Digi-Key part number 296-23836-ND) is a new way of enabling developers to integrate digital projection into their own innovative applications. Potential applications for this kit include simple 3D measurement applications, virtual cosmetics, augmented reality, battery or USB powered display applications, projection of video and images, and miniature applications that do not have space for a large display.

The Pico Projector Development Kit includes an HVGA resolution, DLP projection device with a light engine that uses three solid-state color LEDs as a low power light source. The kit also includes a power supply cable and video cable specifically for connecting to a BeagleBoard, a development board that contains the OMAP35x processor and is supported by an open-source Linux community. The Pico Projector Development Kit is specifically designed to interface with the BeagleBoard to expedite development.

"We are very excited about offering TI's DLP Pico technology to our customers. The Pico Projector Development Kit will enable the development of a wide array of embedded systems in the high-growth medical, industrial and consumer segments, creating flexibility and options on how information and content is shared. With regard to the pairing of the pico projector and the BeagleBoard, it will be fun to see what engineers come up with using these two gadgets," said Mark Larson, Digi-Key president and COO.

www.digikey.com

Ultra-Small 3A DC-DC Converter Radically Increases Power Density

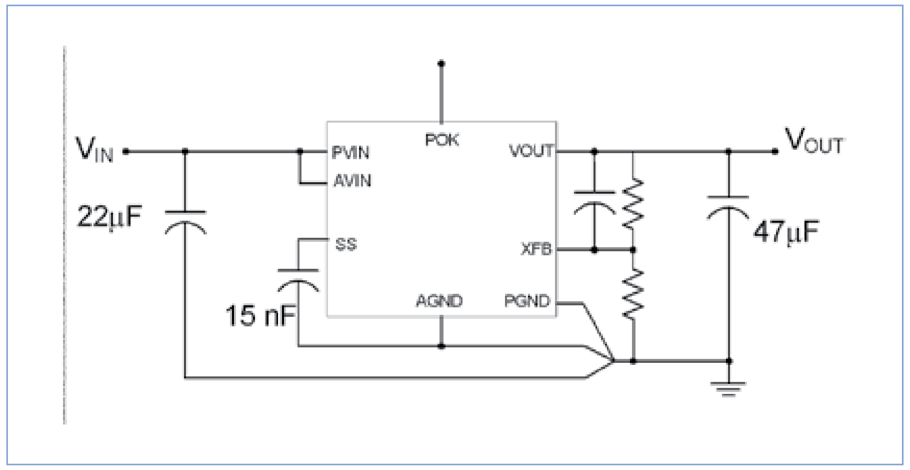
Enpirion has just launched its ultra-small 3A synchronous buck DC-DC converter with an integrated inductor, delivering a radical increase in power density over competing solutions. The EN5337QI is a power supply on a chip (PwrSoC) in a tiny 28mm^2 package - less than half the size of Enpirion's previous 3A solutions, and one-third the size of competitor's offerings. With a power density of 149W/in^2 (23 W/cm^2), the EN5337QI sets a new standard for low-power switching regulators.

The EN5337QI features the ability to synchronize to an external clock to eliminate or move beat frequencies out-of-band. It is specifically designed to meet the precise voltage and fast transient requirements of present and future high-performance, low-power processor, DSP, FPGA, memory boards and system level applications in a distributed power architecture.

Advanced circuit techniques, ultra high switching frequency, and very advanced, high-density, integrated circuit and proprietary inductor technology deliver high-quality, ultra compact, non-isolated DC-DC conversion.

The Enpirion solution significantly helps in system design and productivity by offering greatly simplified board design, layout and manufacturing requirements. In addition, a reduction in the number of vendors required for the complete power solution helps to enable an overall system cost savings.

"Designers are being challenged to pack more functionality into smaller PCB form factors, while improving overall system power efficiency," said Dr. Ashraf Lotfi, Enpirion's founder and CTO. "To address these challenges, designers need power solutions like the EN5337 that can deliver high-efficiency power in a very small form factor."



Enpirion's 3 A power converters are ideally suited for high-volume, mass-market electronics such as DTV, audio, computing, multi-function printers, set-top boxes/DVRs, and storage. The EN5337QI is an excellent choice for product designs that are space-constrained, noise-sensitive, and require high efficiency and simple, reusable power solutions.

As with all of Enpirion's products, the 3A part was developed using advanced circuit techniques, ultra-high switching frequency, and proprietary integrated-inductor technology. The result is a highly-efficient, low-noise power solution that consists of very few parts and is extremely easy for developers to use – attributes that Enpirion has become well-known for in the industry.

"Enpirion has the technology edge, the flexibility, and the commitment to market solutions with smaller footprint, lower parts count, and higher speed at competitive BOM cost," according to a report by the Power Sources Manufacturers Association (PSMA). "They are leading the industry at providing PwrSoC product. Enpirion has a definite technology-leading edge in designing and developing PwrSoCs, as well as in inductor technology

The EN5337QI is available now, and pricing is set at $2.50 for quantities of 1000 parts.

www.enpirion.com

Green Electronics

Compelling benefits for our daily lives

By Ralf Keggenhoff, Senior Business Marketing Manager, Fairchild Semiconductor

In few areas, the impact of modern ecodesign can be felt stronger than in modern household equipment. Many features have been implemented, including LED lighting inside refrigerators, variable frequency drives for the compressor and fan inside the same appliance. These features also include induction-heating stovetops that direct the heat exactly where it needs to go; vacuum cleaners that use more efficient switch-reluctance motors to improve suction per input power; and dishwashers and washing machines are moving from an old inefficient asynchronous motor to a brushless DC motor, which offers improved reliability and efficiency. And all of these advanced features are made possible through sophisticated semiconductor solutions.

In a more detailed example, in many of our kitchens, old refrigerators are rattling along, not only noise but also energy-consuming. Let's quantify this: An old refrigerator with a universal AC motor is being temperature-controlled with a hysteretic switch, leaving the motor running at full power when the refrigerator is too warm, and inefficiencies in the motor are highest (and noise from operation is highest, too!). A modern refrigerator of similar volume and speed of the compressor adapted to run at just the right speed is estimated to consume only 219kWh per year, as compared to its "grandfather" at 740kWh per year. At €0.21 per kWh, this equates to a saving of 521kWh/a, or €109.- per year – this implies amortization in only three years!

Traditionally, it has not been easy to convey the potential energy and cost savings to consumers who are comparing price tags in a shop. The energy labeling that is now mandatory in the European Union is helping, but only gives a relative indication about the savings, not an absolute number – unfortunately, few consumers are spotted in the shops, with calculators in their hand, trying to estimate the cost-of-ownership of their new appliance.

But there are other, less obvious advantages to the new ways of cooking, cooling and cleaning. In an electronically-controlled BLDC drive system, the motor can be built to consume less copper and iron, and at the same time making construction easier and reducing manufacturing cost. The improved efficiency means less effort and hence money is spent on cooling the system, particularly important for the cold air circulation fan in a refrigerator, where the motor – due to its reduced losses – can potentially be place inside the cold compartment. Induction heating stovetops can show improved reliability, since the large temperature cycles really only occur at the surface of the plate. And in dishwashers, reliability of operation is improved, as the pump can rotate backwards for a moment should some object be blocking it – a feature that was pretty much impossible previously, without having the pump disassembled.

In conclusion, the savings consists of energy savings mostly in operation, ending up with savings to the actual consumer. But at the same time, the system cost can be improved, with estimated savings of between 5 and 20 percent of the system cost, depending on the particular system, by using ecodesign-compatible solutions. These savings are really helping to offset the cost for implementing all of the new features consumers like us are looking for.

www.fairchildsemi.com

White Goods Still Offer Medium Term Opportunities

IMS Research has been analyzing the major home appliance (MHA) market in detail for more than a decade, and the situation today is as bad as we can recall. Falling house sales and reduced consumer spending due to the global recession have combined to severely impact market volumes in 2008, and the immediate outlook for 2009 is also bleak. Despite this, we believe a trend towards more efficient and sophisticated appliances will present considerable opportunities to power electronics suppliers in the medium and long term.

By Jason DePreaux, Power Analyst, IMS Research

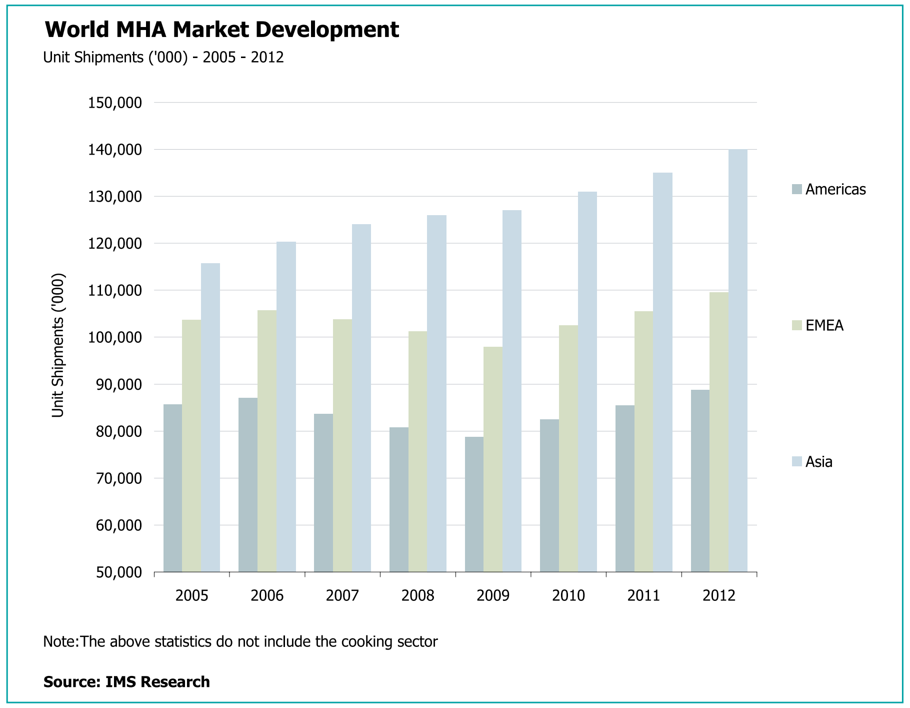
The slowdown in the North American and European MHA markets has been underway for some time. In the US and Western Europe, MHA shipments in 2008 were down around 10% from what were already low 2007 levels. Another fall is predicted in 2009. Even Eastern Europe, which had been consistent in returning positive growth, witnessed a sharp pullback in shipments in 4Q08, contracting 15% year-on-year. While the situation is somewhat more encouraging in Latin America and parts of Asia, where growth is projected to be flat to slightly positive, MHAs sold in these regions tend to be the lowest cost, most basic models, and therefore have much lower electronic content.

In spite of the slump in market volumes, MHAs have seen increases in the amount of advanced technology they are using in recent years. Examples of new appliance technologies include more efficient designs, electronic displays and touch controls, and advanced sensing technology. The key drivers of higher electronic penetration; namely tougher energy standards and consumer preferences, are projected to persist even as shipment levels drop.

Government action continues to provide momentum for more efficient MHA designs. Mandatory comparative labeling schemes are in place in the US, EU, and parts of Asia. These systems rate appliance efficiency based on a variety of metrics including electricity consumption and water use. Just a few years ago the EU added new ratings (A+ & A++) for cold appliances that have helped drive sales of the most efficient refrigerators. The recently passed American Recovery and Reinvestment Act contains a boon for energy efficient home appliances in the form of rebates for qualifying Energy Star appliances worth $300 million. With governments seeking to reduce energy consumption and consumers becoming more mindful of their environmental impact, MHAs are becoming smarter in the way they use energy. This is good news for power electronics suppliers.

Changing consumer preferences have helped contribute to the growing adoption of advanced features. The United States, traditionally a top-load washing machine market, has rapidly embraced front-load style. Currently one in every three washing machines sold is a front-loader, up significantly from just a few years ago when the figure was under 10%. The trend is set to continue as stricter Energy Star ratings in coming years will not be met by many current front-load offerings. Other trends like LCD displays, touch controls, and even integrated television in refrigerators are being embraced more by the "IPod generation" of users accustomed to thumbing jog wheels and navigating menus.

The combination of more efficient home appliances and growing consumer



acceptance for advanced feature sets has had a direct effect on the amount and sophistication of electronic content found in a typical appliance. Tougher efficiency standards mean that MHA makers are incorporating more complex systems that allow precise control. One example is replacing a traditional on/off motor control with an inverter based motor control; particularly effective in washing machines and room air conditioners where penetration of this feature is greatest.

The increased prevalence of electronic displays means more microcontrollers and possibly also driver ICs. The recent emphasis by governments on developing a "Smart Grid" has also given a new lease of life to developments surrounding "connected appliances." Thus far, the concept has yet to materialize in any tangible volumes, but should standards be established, it could have an enormous effect on the use of electronics in MHAs. The growing electronic content of MHA bodes well for semiconductor companies, and we are predicting that total MHA semiconductor market revenues will grow by nearly 20% by 2012.

In the face of challenging market conditions, there are reasons for optimism as stringent efficiency standards and advanced features become more common in MHA design.

www.imsresearch.com

DESIGN TIPS

Frequency Response of Switching Power Supplies – Part 3

Injecting signals into the power supply

In this article, Dr. Ridley continues the topic of frequency response of switching power supplies. Previous articles showed how a frequency response analyzer pulls out a single test frequency from a broad range of noise and signal. This third article shows how an analyzer can be connected to measure the essential transfer functions of a power supply and its components.

By Dr. Ray Ridley, Ridley Engineering

Measurement of Passive Components

As mentioned in previous articles in this magazine[1-3], all passive power components should be characterized across the frequency range over which they are required to function. This includes dc measurements for magnetic components, out to 30MHz, the limit of conducted EMI measurements.

Figure 1 shows the test setup for high impedance measurements (greater than 1ohm), typically used to characterize magnetics. This is used to measure magnetizing inductances, leakage inductance, resonances, and winding capacitances. Details of such measurements are given in[1-2]. Power magnetics are usually custom and should be measured to confirm performance. Off-the-shelf parts should also be measured since they are usually inadequately specified by vendors.

Figure 2 shows the test setup for low impedance measurements, down to as low as 1mOhm. This setup is used to characterize power capacitors, and will show capacitor values, resonant frequencies, and equivalent series resistances. All of these quantities can have significant variation depending on the type of capacitor used, temperature, bias point, and batch sample. Most manufacturers do not provide enough accurate data to properly design a power supply, making this an essential measurement for any power capacitor[3].

Audiosusceptibility Measurement

In the aerospace industry, it is usually a requirement to measure the input bus to output voltage transfer function, also referred to as audiosusceptibility. This involves the inconvenient process of modulating the input voltage with the frequency response analyzer. More elaborate electronic power sources may have the capability of producing this perturbation, but we usually have to build a circuit to do customized injection, tailored to the specific input voltage and current levels of the converter.

Figure 3 shows a method to inject into the input rail of a power supply. A series-pass FET is used, and its gate is modulated via an isolation transformer. In setting up this test, make sure the FET is rated for the full input voltage, and properly heatsinked for the full input current.

Since the input voltage of a power system is typically higher than the allowable range of a frequency response analyzer, it is common to buffer the signal measured at the input voltage. This can be done with a high-voltage differential probe, or using an oscilloscope with a Signal Out feature.

Input Impedance Measurement

The same injection technique as used for audiosusceptibility allows the measurement of input impedance, as shown in Fig. 4. Input impedance is a requirement for most aerospace power systems, and very useful for any large scale systems where power supplies are connected together and system interactions are crucial.

For input impedance, the analyzer measures the perturbation of the input voltage and the perturbation of the input current, using a suitable current transducer.

Output Impedance Measurement

Two setups are available for measuring output impedance of a power supply. In the first, shown in Fig. 5, a passive circuit is used via a coupling transformer, and DC blocking capacitor. This test setup can only generate a small current into the output of the power supply due to the limited drive capability of the frequency response analyzer. It is typically useful down to around 10mOhm output impedance.

For higher current power supply measurement, a higher drive current is needed, and this can be achieved as shown in Fig. 6.

Control-to-Output Measurement

Before closing a control loop around a switching power supply, the characteristics of the power stage must be measured. These can be highly variable

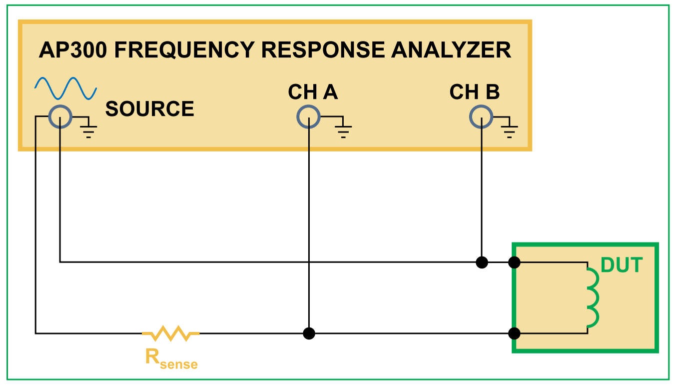


Figure 1: Setup for high impedance measurements, usually used to characterize magnetics and small capacitances.

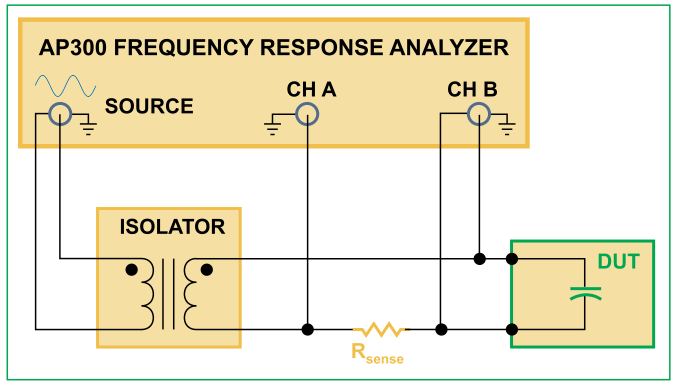


Figure 2: Setup for low impedance measurements, usually used to characterize power capacitors.

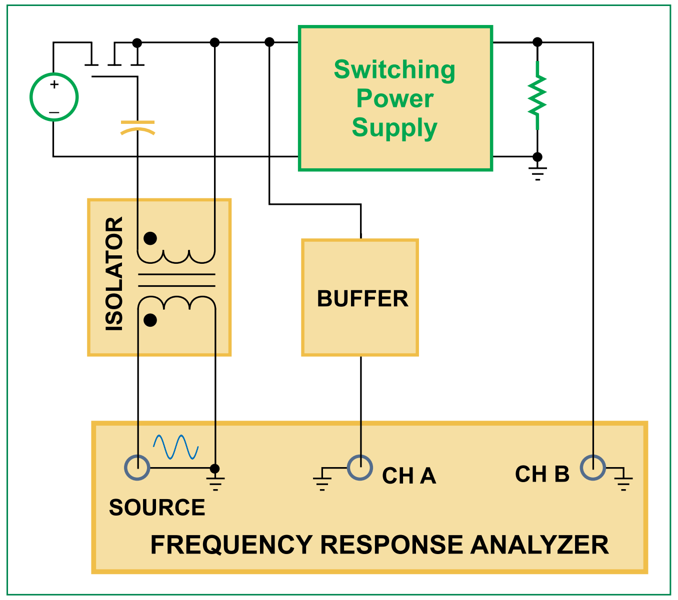


Figure 3: Setup for input-output conducted noise, or audio-susceptibility, measurement.

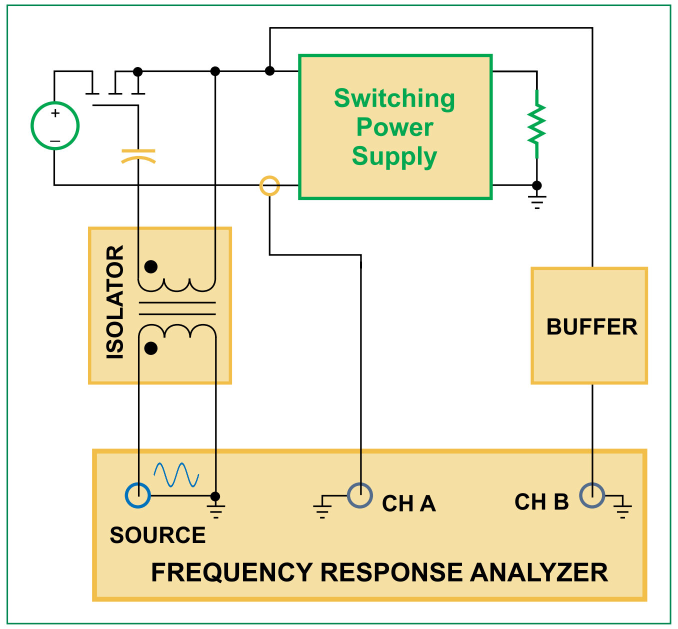


Figure 4: Setup for input impedance measurement.

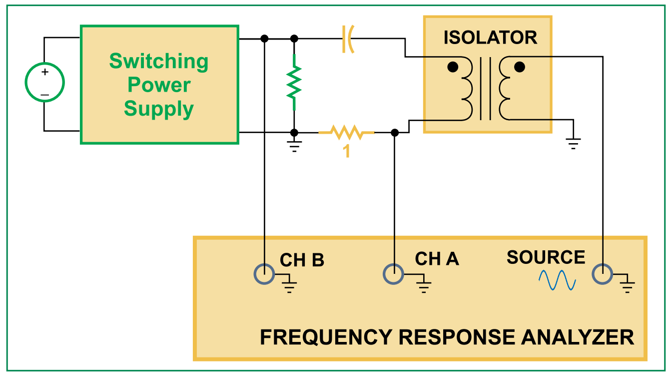


Figure 5: Setup for output impedance measurement for low power outputs.

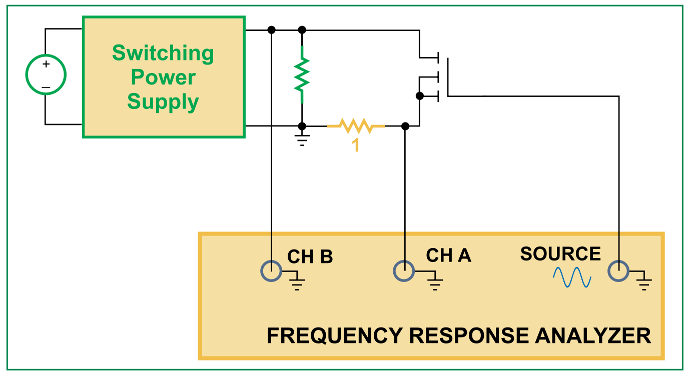


Figure 6: Setup for output impedance measurement for high power outputs.

depending on load, input voltage, and component parasitics, making measurement essential.

It is a common industry practice to set the duty cycle of the PWM controller using a potentiometer which adjusts the control voltage as shown in Fig. 7. The control voltage can then be modulated by ac-coupling to the source of the frequency response analyzer. Care must be taken to keep the power supply operating in its small-signal region at all times, so the proper sized signal must be injected.

Loop Gain Measurement

Once the power stage has been measured, the feedback compensation is designed, and the loop is closed around the system. A very special technique is then used to inject the test signal into the closed loop system, as shown in Fig. 8.

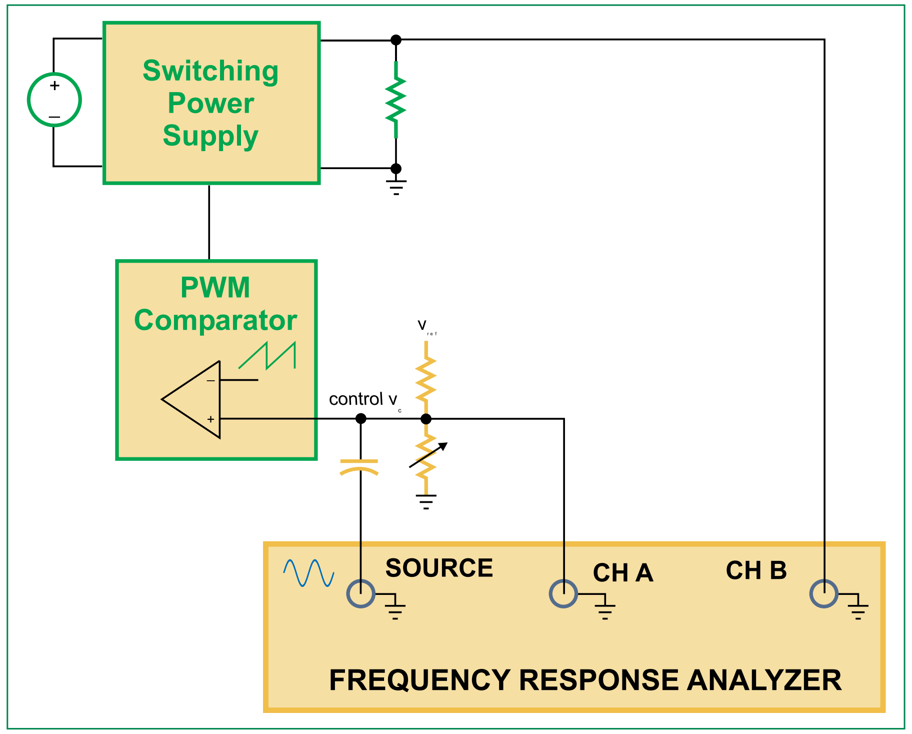


Figure 7: Setup for output impedance measurement for low power outputs.

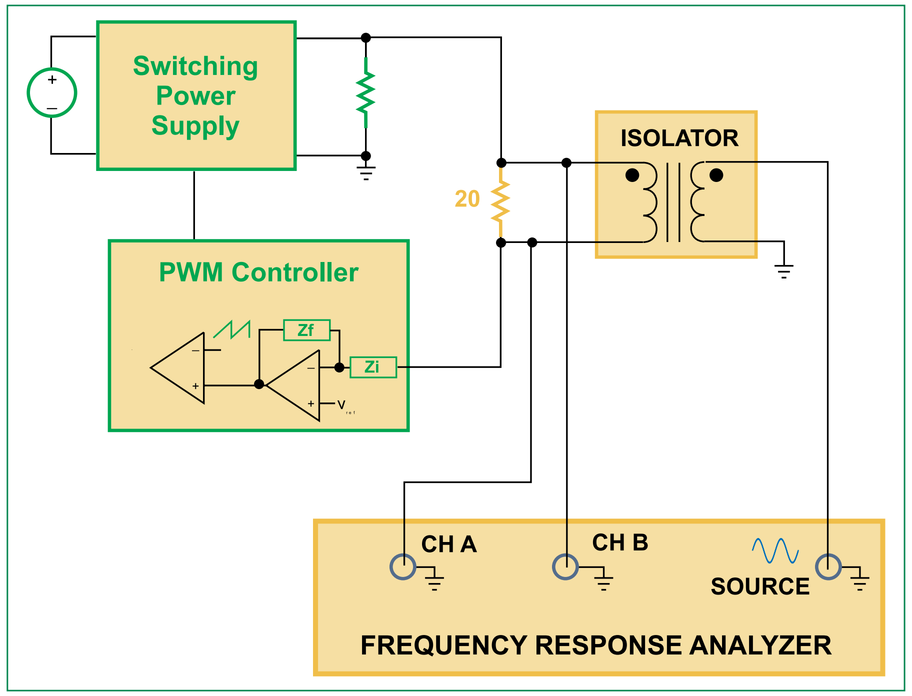


Figure 8: Setup for output impedance measurement for low power outputs.

The test voltage is injected differentially across a 20-ohm resistor via a transformer isolator as shown. With this technique, the loop is kept closed in order to regulate the output voltage, but the voltage impressed across the resistor allows the measurement of the open loop gain. In effect, we are electronically breaking the loop, forcing a difference between the loop input and output signals on either side of the resistor. The next article in this series will discuss this in more detail.

Loop measurement is a very powerful design and diagnostic tool. It allows the compensation design to be verified and adjusted for any nonidealities that may arise in the system. It is also a very sensitive measure of almost all of the components in the power system, and can be used to verify that all of the components are correct.

Summary

This article has provided eight of the most common frequency response test circuits used for characterizing power supplies. All of these tests are useful for ensuring the design of a rugged system, and should be a part of the complete documentation package. For many commercial power supplies, the measurement of audiosusceptibility and input impedance is omitted due to the difficulty of signal injection, but these are also essential for more complex power systems, and a requirment for most aerospace systems.

References

1. *"High Frequency Power Transformer Measurement and Modeling", Power Systems Design Magazine, Design Tips Archive, January/February 2007. http://www.powersystemsdesign.com*
2. *"High Frequency Power Inductor Design", Power Systems Design Magazine, Design Tips Archive, March 2007. http://www.powersystemsdesign.com*
3. *"Capacitors for Switching Power Supplies", Power Systems Design Magazine, Design Tips Archive, May 2007. http://www.powersystemsdesign.com*

www.ridleyengineering.com

On the Road

Reported by Cliff Keys, Editor-in-Chief, PSDE

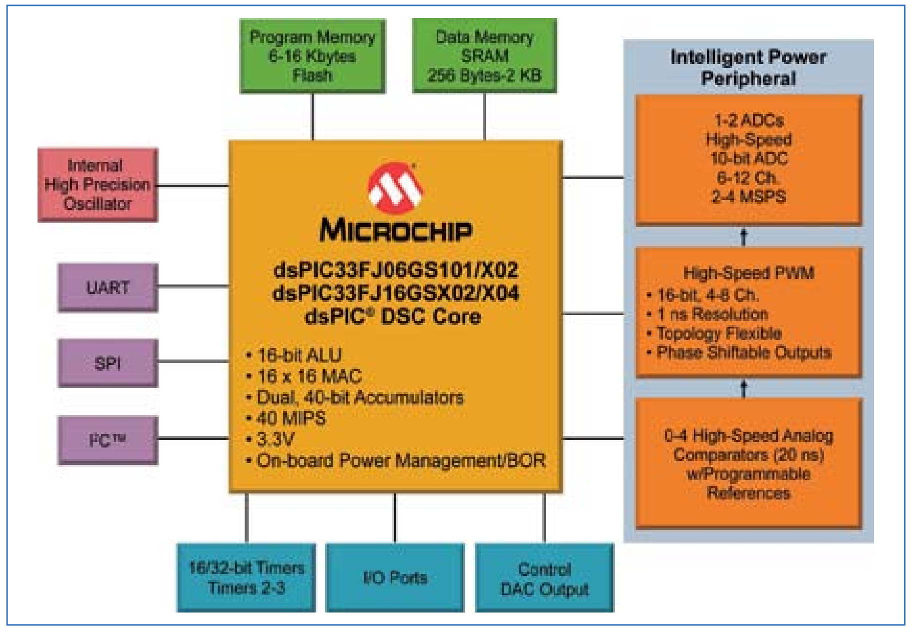
Microchip Technology

On my trip to Washington DC in February and March, I had the opportunity to talk with Bill Hutchings, who is the Power Product Marketing Manager for the High Performance Microcontroller Division of Microchip. The company is launching a new series of digital signal controllers (DSCs). The real-world advantages of digital power are now an accepted part of the industry's landscape and Microchip are taking a strong position to help make it easy for designers to take advantage of the much-needed time and cost saving benefits that digital power implementation can offer.

Microchip Simplifies Digital Power Implementation

AC/DC reference design demonstrates digital power advantages

Microchip Technology has just announced an AC/DC reference design based on the new dsPIC33F "GS" series of digital-power Digital Signal Controllers (DSCs). This reference design demonstrates how digital-power techniques are applied to reduce component count, lower product cost, eliminate oversized components, and incorporate topology flexibility to innovate the best solution for the application.



Microchip's dsPIC33F "GS" series for digital power conversion.

Bill told me that the definition of digital power in today's terms equates to digitally integrated and controlled power products that provide monitoring and supervisory functions and configuration, and that extend to full-loop control using digital algorithms.

The market for this technology is reported to be 1.4 Billion Units in 2013 with >40% CAGR, which just underlines the acceptance of this 'new' technology. The drivers are of course the benefits a designer can bring to the bottom line; efficiency, cost saving, higher density and reliability. With applications in every market segment including the 'hot and unfriendly' areas such as automotive, the potential is huge.

The challenge is to make it easy for the designer to be able to realize these benefits and do a good job for his company in delivering a fast and durable solution that differentiates the end product from competition. The need to do this and to adapt to this new innovation in today's marketplace has indeed never been greater.

Microchip's Digital Power AC/DC Reference Design unit works with a universal input voltage range and produces three output voltages. The continuous power output rating of the unit is 300 watts. The front-end Power Factor Correction (PFC) boost circuit converts universal AC input voltages to a 420 VDC bus voltage.

A full-bridge transformer isolated buck converter, incorporating a phase-shift Zero Voltage Transition (ZVT) circuit, produces 12VDC @ 30amps from the 420VDC bus. The phase-shift ZVT converter also provides output-voltage

isolation from the AC mains input. A multi-phase synchronous buck converter then produces 3.3VDC @ 69 amps from the 12VDC bus, and a single-phase buck converter produces 5VDC @ 23 amps from the 12 VDC bus.

The AC/DC Reference Design includes many advanced features and high performance to support today's increasing demands for efficiency and control, and to reduce operating costs and minimize system cost while maintaining high levels of reliability. Key design specifications include the following:

- Universal Inputs (85V - 265V AC, 45 - 65Hz)
- Boost PFC (PF > 0.98)
- Soft-start (programmable)
- Full-bridge ZVT (soft-switching)
- Synchronous rectification
- 12-Volt intermediate bus
- Multi-phase Synchronous Buck converter 3.3V output
- Single-phase 5.0V output
- Automatic fault handling
- Remote power-management capabilities
- Flexible start-up capabilities
- Greater than 90% efficiency on each of the four power-conversion stages

The reference design is powered by one of Microchip's new dsPIC33F "GS" series of DSCs, which controls the PFC boost circuit and the primary-side ZVT full-bridge circuit. A second "GS" series dsPIC33F monitors the 12VDC bus voltage and controls the four buck converters. The two dsPIC® DSCs communicate across the isolation boundary via Universal Asynchronous Receiver Transmitters (UARTs). Complete documentation, including software and Gerber files, can be downloaded for free from Microchip's Web site at http://www.microchip.com/SMPS.

Bill explained that Microchip wants to make the implementation as painless as possible and is committed to supporting its customers by helping design engineers develop products faster and more efficiently. Customers can access four main service areas at http://www.microchip.com. The Support area provides a fast way to get questions answered; the Sample area offers free evaluation samples of any Microchip device; microchipDIRECT provides 24-hour pricing, ordering, inventory and credit for convenient purchasing of all Microchip devices and development tools; finally, the Training area educates customers through webinars, sign-ups for local seminar and workshop courses, and information about the annual MASTERs events held throughout the world.

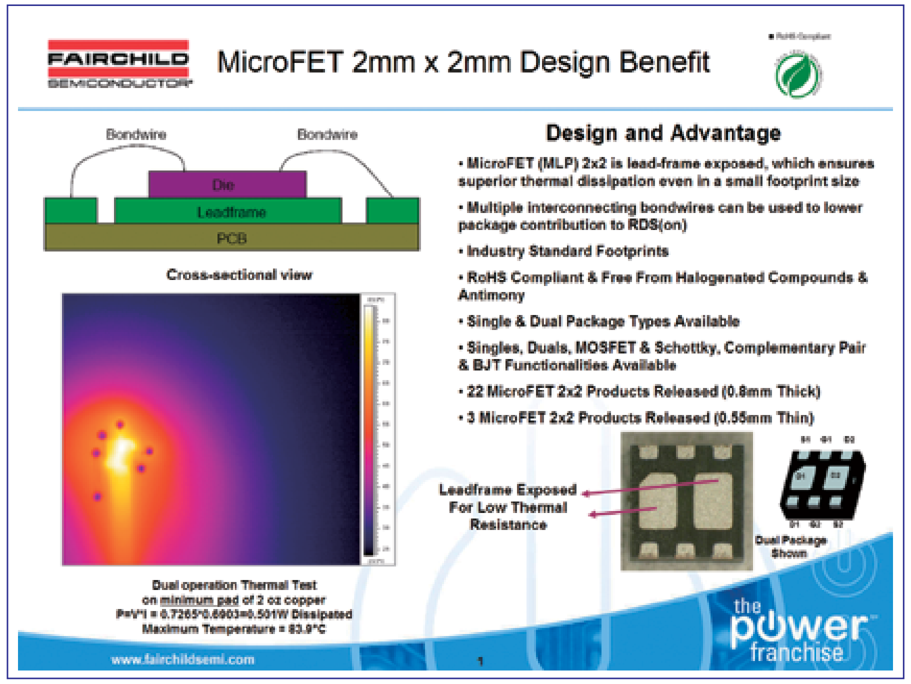
www.microchip.com

Fairchild's New MicroFET™ (0.55mm) MOSFETs

I talked with Phil Brace, Fairchild's Technical Marketing Manager for Low Voltage Products, in the Ultraportable Market, about the company's new power MOSFET products. Although the industry is literally 'peppered' with these devices making it difficult to make a selection for a design, these new devices offer the designer clear industry-level advantages. These new devices can dissipate 60% more power than MOSFETs in conventional SC-70 packaging.

Reported by Cliff Keys, Editor-in-Chief, PSDE

Fairchild Semiconductor has launched a new range of ultra-thin and highly efficient MicroFET products. The FDMA1027PT, a 20V dual P-Channel PowerTrench® MOSFET, the FDFMA2P853T, a 20V P-Channel PowerTrench® MOSFET with a Schottky diode and the FDMA6023PZT a 20V dual P-Channel PowerTrench® MOSFET with ultra low $R_{DS(on)}$. These new MicroFET devices are housed in 2mm x 2mm x 0.55mm MLP packages. They are 55 percent smaller and 50 percent lower in height than 3mm x 3mm x 1.1mm MOSFETs that are typically used in many low-voltage designs. This thin package option satisfies the requirements for ultra-slim form factors associated with next generation portable products such as cell phones and media players.



Each of the new devices are designed for greater efficiency, addressing the power challenges of feature-rich functionalities that tax battery life. Utilizing Fairchild's proprietary PowerTrench® MOSFET process that reduces conduction and switching losses, these devices offer excellent power dissipation and low conduction losses.

From Phil's presentation slide, the advantages for the portable device designer are clear. The superior thermal performance that can be achieved in this tiny, low-profile package due to the exposed drain pads and terminals enable a high performance, high density design in an ultra thin form factor that can differentiate in a fiercely competitive and crowded market.

Compared to similar sized devices housed in 2mm x 2mm SC-70 packaging, the new MicroFET products offer hefty 60 percent lower conduction losses and are able to dissipate 1.4W of power, compared to 300mW with SC-70 packages.

The MicroFET family, with its compelling advantages in compact packaging and high performance to address the needs of battery-charging, load-switching, boost and DC-DC conversion, utilize lead-free (Pb-free) terminals and have been characterized for moisture sensitivity in accordance with the Pb-free reflow requirements of the joint IPC/JEDEC standard J-STD-020. All of Fairchild's products are designed to meet the requirements of the European Union's Directive on the restriction of the use of certain substances (RoHS). MicroFET products are free from halogenated compounds and antimony. Samples are available now with delivery 8 weeks ARO.

www.fairchildsemi.com

PSDE Green Power
ENERGY EFFICIENCY

White Goods Design Techniques

Sensorless PMSM motor control

Until recently, sophisticated motor-control techniques for more efficient and quieter appliances were only available as proprietary solutions from a select group of vendors. Now, a new generation of Digital Signal Controllers (DSCs) supports the cost-effective implementation of advanced motor-control algorithms which increase the energy efficiency of motors.

By Jorge Zambada, Applications Engineer, Digital Signal Controller Division Microchip Technology Inc.

Consider the example of a washing machine that requires a fast response to both agitation and spin processes through speed changes in the motor. To enable the washing machine to achieve this, the designer would need to deploy advanced motor-control algorithms. Although there are a number of advanced techniques for motor control, Field-Oriented Control (FOC) has emerged as the leading technique for conserving energy and building quieter washing machines. This article assumes that the designer has a working knowledge of the FOC algorithm and is therefore ready to implement sensorless FOC-based control of Permanent Magnet Synchronous Motors (PMSM) using DSCs.

Using PMSM-based sensorless FOC control of the motor in an appliance offers the greatest cost benefit as well as other advantages: The sensorless FOC technique overcomes restrictions placed on some applications where position or speed sensors cannot be deployed. In certain compressor applications, for example, the motor could be flooded in oil, resulting in constraints on the placement of wire-harnesses. A PMSM also provides very high efficiency because of the constant rotor magnetic field, produced by the permanent magnet on the rotor. In addition, its stator magnetic field is generated by sinusoidal distribution of the windings and, compared

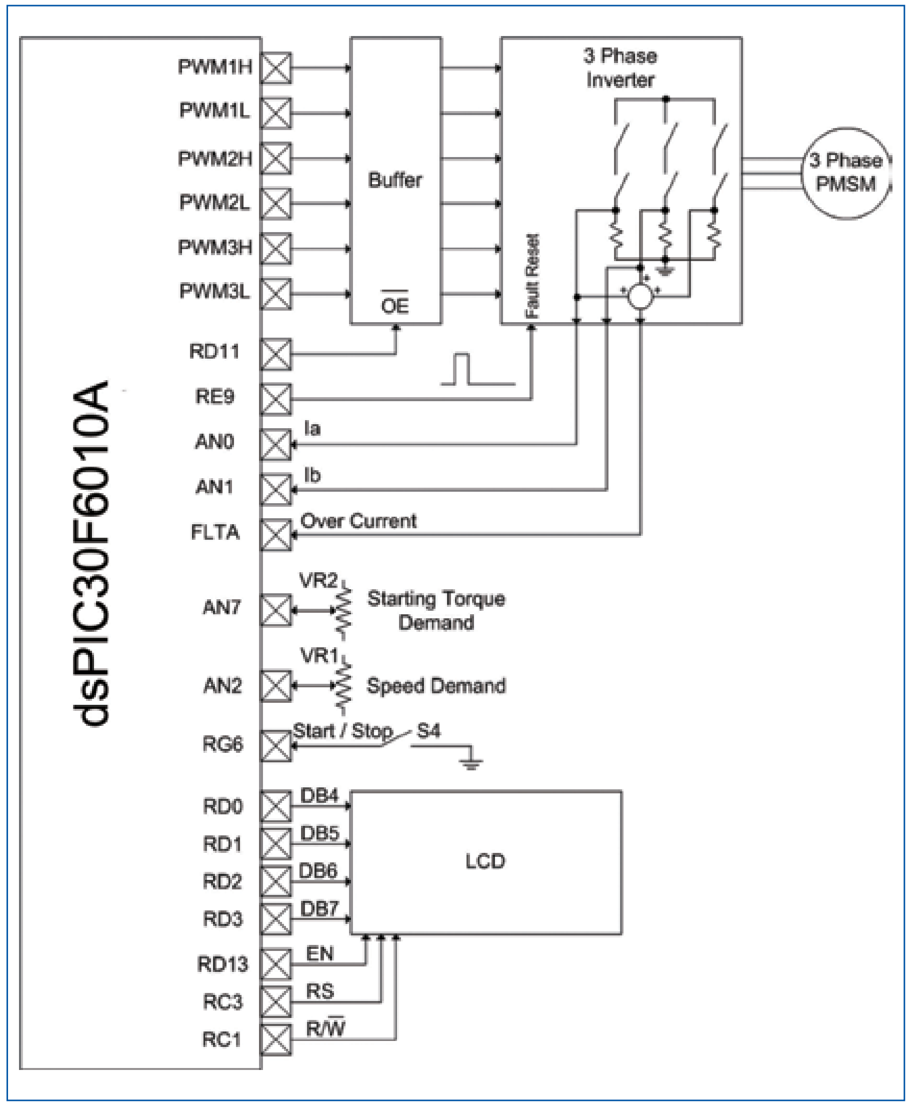


Figure 1: System overview.

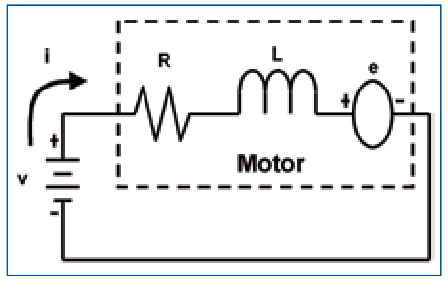


Figure 2: Electrical model of the PMSM.

to induction motors, it offers a very high power/size ratio. With no brushes, PMSM motors are also lower levels of electrical noise than DC motors.

Motor-control peripherals

DSCs which have their peripherals optimised for motor control simplify the design of appliances such as washing machines: these peripherals can include Pulse Width Modulators (PWMs), Analogue-to-Digital Converters (ADCs) and quadrature encoder interfaces. When executing controller routines and implementing digital filters, DSCs help designers to optimise code execution by executing the MAC instructions and fractional operations in a single cycle. For operations which require saturation capabilities, DSCs can help designers to avoid overflows by offering hardware saturation protection.

DSCs need fast and flexible ADCs for current sensing, which is a crucial function in motor control. Microchip's dsPIC® family of DSCs features ADCs that are capable of converting input samples at a rate of 1 Msps, and handling up to four inputs simultaneously.

Multiple trigger options on the ADCs enable the use of inexpensive current-sense resistors to measure motor-phase winding currents. For example, triggering A/D conversions with PWM modules allows the use of inexpensive current-sensing circuitry, by sensing inputs at specific times when switching transistors allow current to flow through sense resistors.

The development toolset

Development of the DSC-based design is eased with Microchip's FOC motor-control firmware based on the dsPICDEM™ MC1 Motor Control Development Board. The Data Monitor and Control Interface (DMCI) tool, which is a module within the MPLAB® Integrated Development Environment (IDE), can be used to test and debug the FOC algorithm. The DMCI tool provides a quick and dynamic IDE, which allows designers to graphically represent the application feedback. For example, the DMCI's IDE provides project-aware navigation of programme symbols (variables) that can be dynamically assigned to any combination of slider, direct input or Boolean controls. These controls can be used interactively to change the values of programme variables within the DMCI IDE. Further, the graphs can be dynamically configured for viewing programme-generated data.

The system block diagram in Figure 1 clearly shows that there are no position sensors attached to the motor shaft, although there are sensors for current measurements on the motor. These sensors feature low-inductance resistors that are part of the inverter function block. The PMSM windings are driven by a 3-phase inverter with current-sensing and fault-generation circuitry built into the power inverter to protect the system against excessive currents.

Sensorless FOC for PMSM

Sensorless control of PMSM implements the FOC algorithm by estimating the position of the motor. The position is estimated using the currents and voltages of the motor, in conjunction with a motor model to measure the motor position indirectly, via an observer. The electrical model of the PMSM comprises the winding resistance, winding inductance and back EMF, dependent on the motor speed (see Figure 2). The motor position is estimated by assuming that the PMSM's model is the same as that of a DC motor.

From the motor model in Figure 2, the input voltage can be obtained using the following equation:

$$v_s = Ri_s + L\frac{d}{dt}i_s + e_s$$

Solving for i_s gives the motor current:

$$\frac{d}{dt}i_s = -\frac{R}{L}i_s + \frac{1}{L}(v_s - e_s)$$

Where:

i_s: Motor current vector
v_s: Input voltage

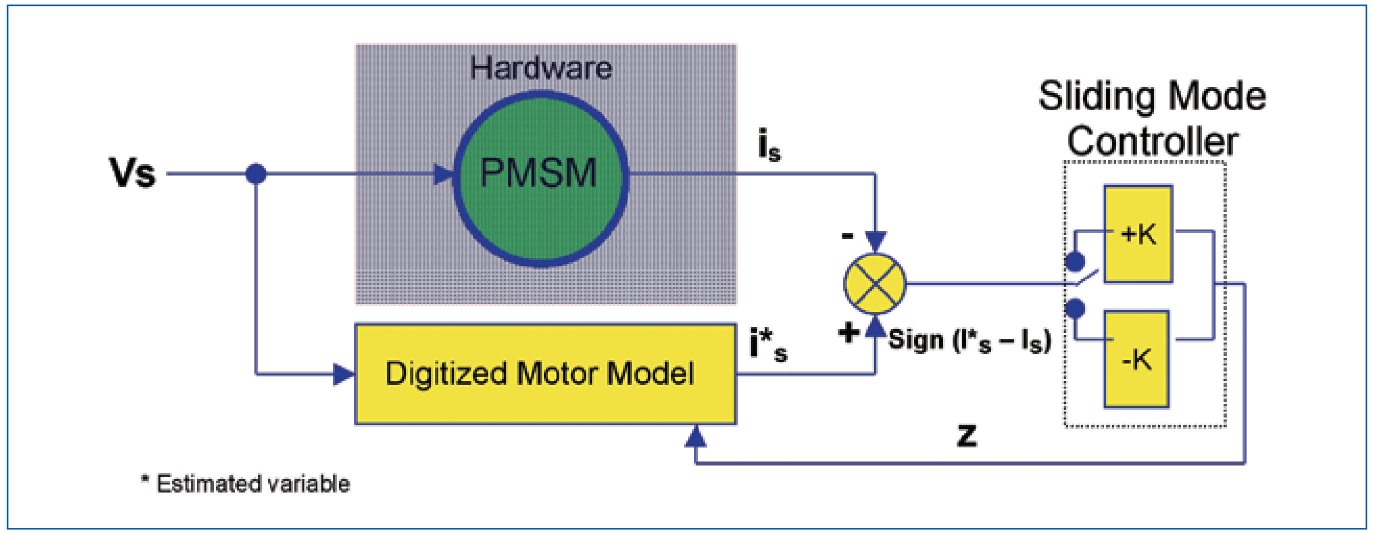


Figure 3: Current observer model.

e_s: Back EMF vector
R: Winding resistance
L: Winding inductance

In the digital domain, this equation becomes:

$$\frac{i_s(n+1)-i_s(n)}{T_s} = -\frac{R}{L}\cdot i_s(n)+\frac{1}{L}\cdot\left(v_s(n)-e_s(n)\right)$$

Again, solving for i_s yields:

$$i_s(n+1)=\left(1-\frac{R}{L}\right)\cdot i_s(n)+\frac{T_s}{L}\cdot\left(v_s(n)-e_s(n)\right)$$

Current observer

A current observer model helps to measure the back EMF indirectly, by ensuring that the input to the motor is equal to the input to the motor model. The motor and motor model are fed with the same input, but the motor model has a closed-loop controller to ensure that the estimated value matches the measured value. For example, at any given time, if the motor input voltage and current are the same as the model, then the back EMF can be observed by solving for e_s.

For the observer model compensation, a sliding mode controller is implemented to track the input reference and force the error to zero, between the measured current is and the estimated current i^*_s. Depending on the error sign, the slide-mode controller will either apply a positive feedback gain K or a negative feedback gain K to get the estimated current to match the measured current. Once the estimated and measured currents match, and observing that input voltages are the same for both the motor and its model, back EMF can be calculated.

Estimating back EMF

From the motor model, and after making sure that the input currents and voltages match between the model and the actual motor, the correction factor z can be filtered to provide the back EMF. For this step, a first-order digital low-pass filter is used, with the equation:

$$y(n)=y(n-1)+T2\pi f_c\cdot\left(x(n)-y(n)\right)$$

To filter z to get e^*_s, the value of f_{pwm} is substituted in the equation below to give:

$$e(n)=e(n-1)+\left(\frac{1}{f_{pwm}}\right)\cdot 2\pi f_c\cdot\left(z(n)-e(n)\right)$$

Where:
e(n): Next estimated back EMF value
e(n-1): Last estimated back EMF value
f_{pwm}: PWM frequency at which the digital filter is being calculated
f_c: Cut-off frequency of the filter
z(n): Unfiltered back EMF, which is output from the slide-mode controller

The value of the cut-off frequency can be determined through trial and error, depending on the selection of the slide-mode controller gain. The relationship between back EMF and the rotor position is given by:

$$\theta = \arctan\left(e_{s\alpha}, e_{s\beta}\right)$$

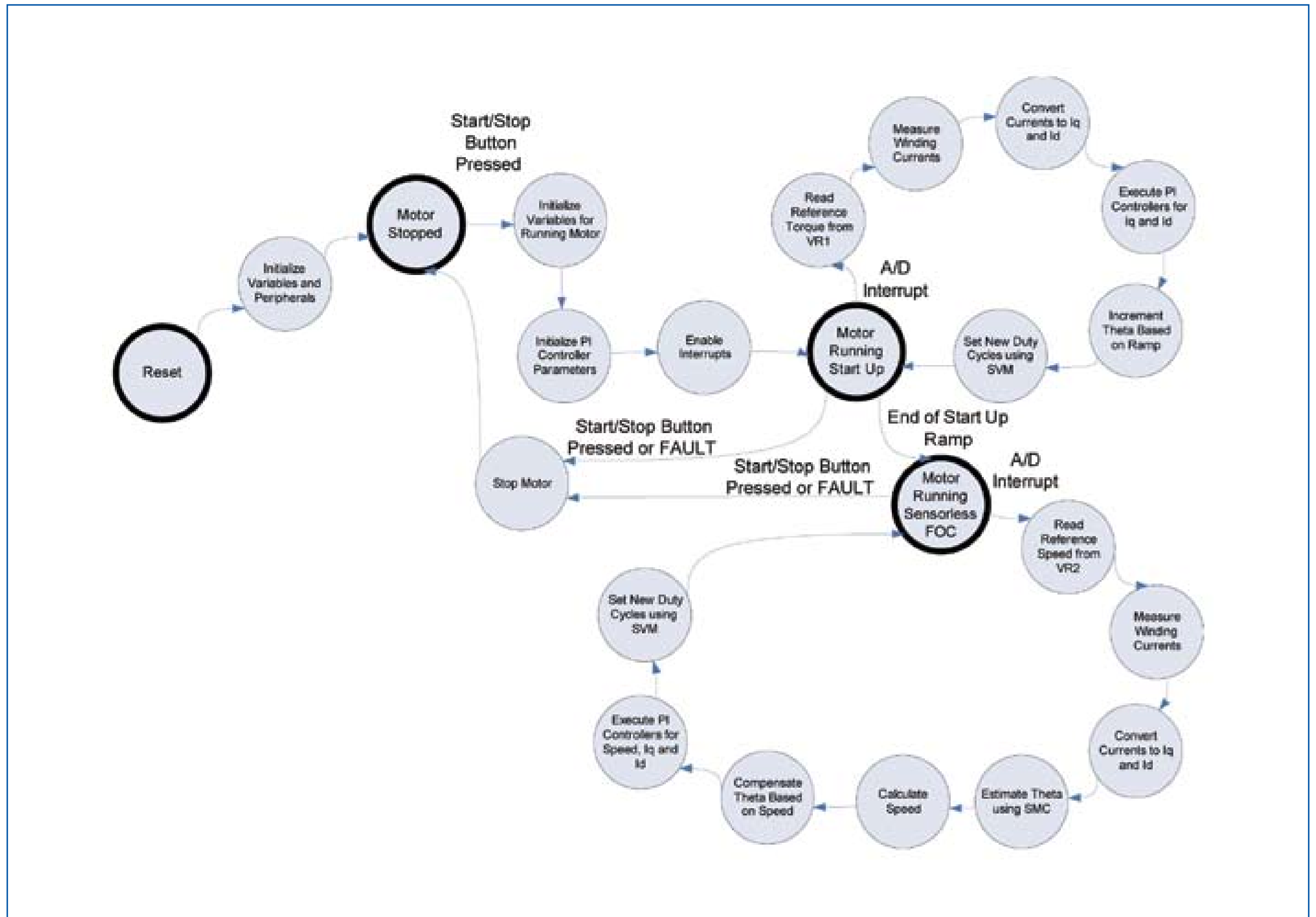


Figure 4: Energising motor windings.

Calculating speed

Due to the filtering function applied during the theta calculation, some phase compensation is needed before the calculated angle can be used to energise the motor windings. The amount of theta compensation is dependent on the rate of change of theta, or speed of the motor. The theta compensation can be performed in two steps: first, the speed of the motor is calculated, based on the uncompensated theta calculation. Then, the speed is used to calculate the amount of compensation. The speed calculation is performed by summing theta values over M samples, and then multiplying the accumulated theta by a constant.

This is given by:

$$Omega = \left(\sum_{\text{AccumThetaCnt}=0}\left(\text{Theta - PrevTheta}\right)\right)\cdot K$$

Where:
Omega, *ω(n)*: Angular velocity of the motor
Theta, θ(n): Current theta value
PrevTheta, θ(n-1): Previous theta value
K: Amplification factor for desired speed range

The FOC algorithm is executed at the same rate as that of the PWM. The algorithm is configured by ensuring that the PWM triggers ADC conversions for the two windings, using two shunt resistors. A potentiometer is then used to set the reference speed of the motor. The ADC interrupts are enabled to execute the algorithm.

Motor start-up

Since the sensorless FOC algorithm is based on the back-EMF calculation, the motor needs to run at a minimum speed to get the back-EMF value. Therefore, the motor windings must be energised with the appropriate estimated angle (see Figure 4). This is implemented by a motor start-up sub-routine: when the motor is at a standstill, and with the start/stop button pressed, the dsPIC DSC generates a series of sinusoidal voltages which set the motor spinning. Whilst the motor spins at a fixed acceleration rate, the FOC algorithm controls the currents i_d and i_q. The increment of the angle theta (commutation angle) is based on the acceleration rate.

Software state machine

Visualising the FOC algorithm as a software state machine helps to describe the operation of a sensorless FOC control for PMSM (see Figure 5). First, the motor windings are de-energised and the system waits for the user to press the start/stop button. Once the start/stop button is pressed, the system enters the initialisation state where all variables are set to their initial value. The start-up sub-routine is then executed, where current components for torque (i_q) and flux production (i_d) are controlled by the FOC and the commutation angle (theta) is generated in a ramp mode, to start the motor spinning and reach a minimum speed to run the estimator.

After going through the start-up sub-routine, the system switches over to sensorless FOC control, where the speed controller is added to the execution thread, and the Slide-Mode Controller (SMC) begins to estimate theta. On entering the sensorless-FOC control state, the reference speed is continuously read from an externally connected potentiometer and the start/stop button is also monitored to stop the motor.

Any fault in the system will cause the motor to stop and return to the 'Motor Stopped' state, until the start/stop button is pressed again. Figure 5 shows the states of the software and the conditions that make the system transition to a different state.

DSC design advantages

A major advantage of deploying DSCs in motor control is the availability of a common design platform which makes the production of appliances more efficient. Appliance manufacturers now have an economical way to offer a range of models with PMSMs, or other types of motor, with sensorless FOC algorithm control. In reality, these are software-based motor-control designs that enable rapid customisation to address multiple markets. Instead of implementing entirely new hardware, all that is required is a change in the FOC algorithm parameters and modification of the control block's power section.

Firmware IP protection is a major issue for manufacturers who frequently deploy appliance design teams which collaborate across multiple geographies. It is easy to imagine a scenario in which a number of design teams, based in different locations, could work in parallel to implement FOC firmware, develop the appliance front panel, and complete the final system integration. In developing their designs, these teams will have claims to their own IP. Microchip's dsPIC DSC family offers CodeGuard™ security (www.microchip.com/codeguard), which helps to protect IP in collaborative design environments by separately securing IP segments.

Conclusion

This article has outlined how designers can take advantage of the latest generation of DSCs to implement advanced motor-control techniques, such as the FOC algorithm, in appliance applications. Since programming DSCs is similar to programming microcontrollers, designing the motor-control algorithm and testing prototypes can be achieved quickly. Another important advantage is that fine-tuning the motor control is made easier with powerful IDE-based tools, such as the DMCI, which allows designers to easily port their algorithms across a variety of motor platforms, including PMSM, BLDC, Brushed DC and ACIM motors.

References:

Microchip application note, AN1078 on sensorless Field Oriented Control of PMSM Motors using dsPIC30F or dsPIC33F Digital Signal Controllers, and application notes for motor control of ACIM (AN984, AN908 and GS004) and Brushless DC (AN901, AN957, AN992, AN1017) motors, using dsPIC30F motor-control DSCs are available at www.microchip.com/motor

The dsPICDEM MC1 Motor Control Development Board is available at www.microchipdirect.com.

www.microchip.com

Power in Transit

Power capacitors for electric vehicles

Electric vehicles are in widespread use. Hybrid cars are now a common sight on our roads as people look to find more environmentally-friendly forms of personal transport – and as a reaction to spiralling oil prices - and there are many other commercial and public electric vehicles, such as trains, trams, buses and industrial trucks and equipment in everyday use.

By Gilles Terzulli, Power Film Capacitor Marketing Manager, AVX Corp., St Apollinaire, France

The electronic systems and components that have enabled the realisation of such a wide variety of electric vehicles have all experienced a major evolution, including the DC link power capacitor.

The purpose of capacitors in electric vehicles is to prevent ripple currents from reaching back to the power source, and to smooth out DC bus voltage variations. Capacitors are also used to protect semiconductors – originally thyristors, but now IGBTs.

Metallised film has become the capacitor technology of choice for electric vehicle and other medium and high power applications. There are several reasons for this.

One major advantage is the ability of film capacitors to overcome internal defects. The latest dielectric films used for DC filter capacitors are coated with a very thin metallic layer. In the case of any defect, the metal evaporates and therefore isolates or fuses the defect, effectively self-healing the capacitor. The total capacitance is divided into elementary cells (sometimes several million) protected by fuse gate. If there is a weak point, the particular cell where the weak point is located will be insulated by fuses blowing.

Capacitance decreases as function of the ratio between elementary cell surface and total surface of capacitor, so there is no complete failure and no short circuit, only a minimal capacitance decrease which can be useful as a measure of ageing.

Metallised film capacitors from AVX are designed to meet CEI 1071 standards. This means they are able to handle multiple voltage surges of up to twice the rated voltage, without significantly decreasing product lifetime. It also means the designer need only account for nominal voltage requirements when specifying the system.

Metallised film capacitors also offer significant space savings when compared to devices manufactured using other technologies - such as aluminium electrolytic - if high RMS current handling is a requirement.

AVX has significant experience in developing power capacitors for automotive application, dating back to 1995. Currently the company offers a range of metallised film devices based on cylindrical (puck) or flat bobbin modular building blocks. This approach has several benefits. Firstly, the arrangement of the capacitors can be optimised to suit the available space, resulting in great volumetric efficiency. Second, the arrays are current- and inductance-balanced by AVX and suffer no expansion problems across a temperature range of -55 to +125degC. Lastly, because the individual capacitor building blocks are manufactured on process-controlled, automated lines, quality and cost-effectiveness are assured.

An application note from AVX discusses some design considerations concerning metallised film capacitors used in electric vehicle applications.

DC link filter: high current and capacitance value design

In an electric car or fork lift truck where energy is supplied by batteries the capacitor will be used for decoupling. Film capacitors are particularly well suited for this use, since the main criteria for DC link application is the device's RMS current withstanding capability.

If we take the following typical electric car data:
Working voltage: 120Vdc
Ripple voltage (Uripple) allowed: 4Vrms
RMS current (Irms): 80Arms @ 20kHz

The minimum capacitance value will be determined from the equation:

$$C = Irms / (Uripple \times 2\pi f) = 159\mu F$$

If we were to attempt the same calculation using electrolytic technology we need to take into account the fact that you need a 1µF capacitor to handle 20mA, so in our example, in order to handle 80 Arms the minimum capacitance value would be:

$$C = 80/0.02 = 4000\mu F$$

Therefore we see it is much better to use a much lower rated film device, saving cost and space.

Overvoltage

If we consider the example of light traction application, such as metros, tramways or electric buses, the DC link voltage wave form is represented in figure X.

In such applications, discontinuities can occur when power is transferred between from the catenary or messenger wire to the train. When contact is not completed, energy flows from the DC link filter, decreasing the voltage. Therefore, as soon as the contact is re-established, an overvoltage appears. In the worse case the voltage change would be equal to twice the catenary voltage, resulting in an overvoltage almost twice the rated voltage. However, film capacitors can handle this level of overvoltage.

In comparison, to do the same task using electrolytic technology the capacitors would need to be significantly larger - around twice the size for a rated voltage of 1000V, reaching a surge voltage of 2000V.

Protection of semiconductors

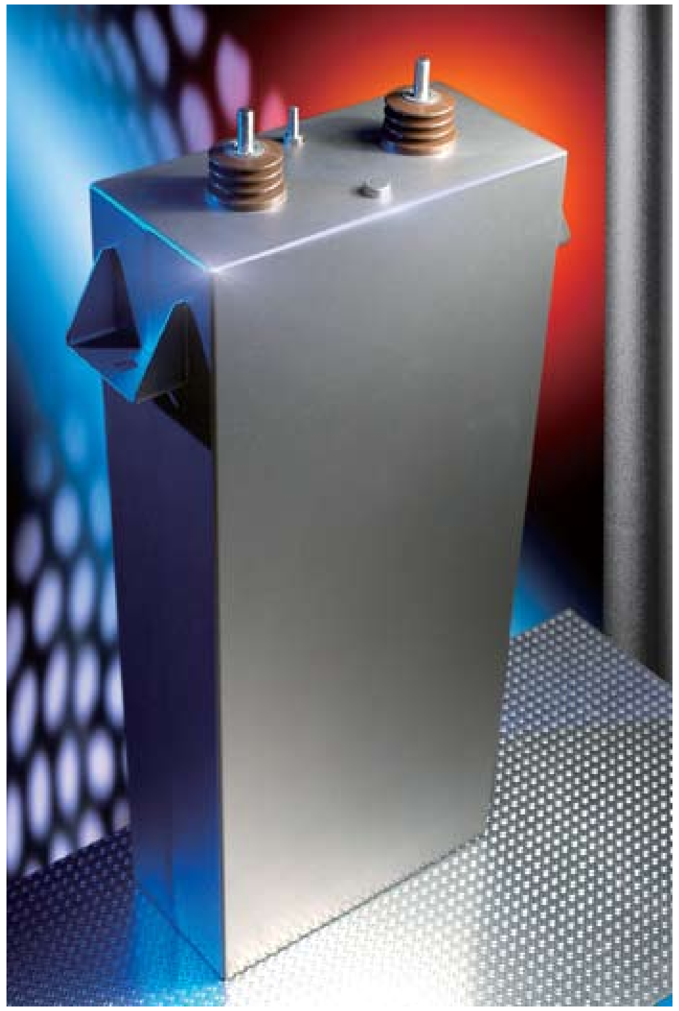
The first electric vehicle applications used thyristor technology, but subsequently many applications are now based around IGBTs. DC link capacitor development has had to match the evolutions in semiconductor technology not only electrically, but also mechanically to deliver the lowest parasitic inductance. AVX offers several families of film capacitors designed to operate optimally with both thyristors and IGBTs.

As an example of the success AVX has enjoyed with its power film capacitor families, products supplied by the company helped break the world speed record for conventional trains. In April, 2007, a French-made TGV with a 19.6MW (over 26,000-horsepower) capacity and special wheels reached 574.8km/h (357.2 mph), beating the previous record of 515.3 km/h (320.2 mph) set in 1990.

The high energy power film capacitors used in the TGV are part of the Trafim™ family. They offer significantly reduced weight and volume and are specified at 3mF, 1890Vdc (DKTFM546); 2.5mF, 2630 Vdc (DKTFM603); 1.67mF, 4000Vdc (DKTFM537); and 1mF, 4000Vdc (DKTFM538).

More, AVX's metallised film capacitors exhibit exceptional reliability in the field with zero catastrophic field failures over the company's history of over 150,000 large oil-filled DC filter products shipped to customers with over 3 billion hours of operational life in a variety of harsh and demanding applications.

www.avx.com



AVX high energy power film capacitor.

Metallised film has become the capacitor technology of choice.

Solving Current Source Design Challenges

Simple, high performance two-terminal current source

Compared to other analog circuitry, current source design appears relatively easy on the surface, but in reality it is more complicated than meets the eye. While high quality voltage sources are commonplace, current sources, as components, have remained elusive. Furthermore, two-terminal current sources generate a new set of problems, especially if high accuracy and stability over temperature are desired.

By Robert Dobkin, Vice President, Engineering & Chief Technical Officer, Linear Technology Corporation, Milpitas, California, USA. Christian Kück, Field Applications Engineer, Linear Technology Corporation, Ascheberg, Germany

A current source must operate over a wide voltage range, have high DC and AC impedance when connected in series with unknown reactance and exhibit good regulation and a low temperature coefficient. For optimal two-terminal solutions, no power supply bypass capacitor should be used since it degrades AC impedance.

A new device, the LT3092 from Linear Technology, overcomes the problems of earlier two-terminal current sources. It has better than 1% initial accuracy and a very low temperature coefficient. Output currents can be set from 0.5mA to 200mA, and current regulation is typically 10ppm per volt. The LT3092 operates down to 1.5V or up to 40V. This gives an impedance of 100MOhms at 1mA or 1MOhm at 100mA. Unlike almost any other analog integrated circuit, special design techniques have been used for stable operation without a supply bypass capacitor, allowing it to provide high AC impedance as well as high DC impedance. Transient and start-up times are about 20µS.

Figure 1 shows a basic diagram of Linear Technology's LT3092 current regulator. The architecture is similar to Linear's LT3080 voltage regulator, but it uses a PNP transistor as the output device instead of an NPN. Internal circuitry is differential and buffered, with a regulator to isolate it from power supply changes. This isolation allows stable operation without bypass capacitors. Additionally, for environments that may have power supply reversal, the LT3092 is immune to damage from reverse power supply voltage and does not conduct current, so it protects the load.

The internal current source and the offset of the amplifier are designed to reject power supply changes by 100dB or better, so the regulation is very good. Setting the RSet down to zero allows the output to be adjusted down to zero.

A small voltage is impressed upon an external set resistor, 20k in this case, to generate a 200mV reference. That forces 200mV across a current-determining resistor R, and the total current is then equal to 0.2V divided by R (plus 10µA). The current regulator works from about 1.5V across it up to 36V, and the current regulation and temperature stability is extremely good. As a two-terminal current source, the load can be either in the positive leg or in the ground leg of the circuit.

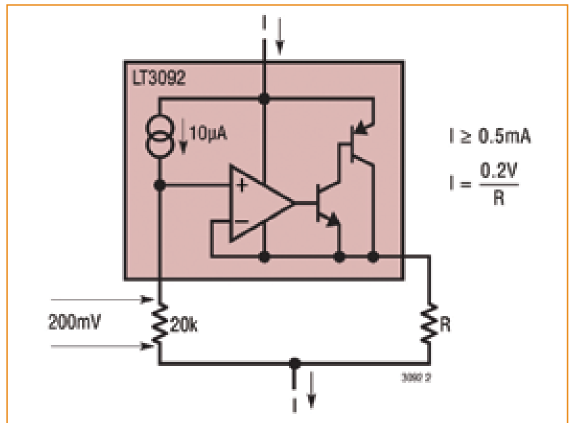


Figure 1: Two-terminal current source.

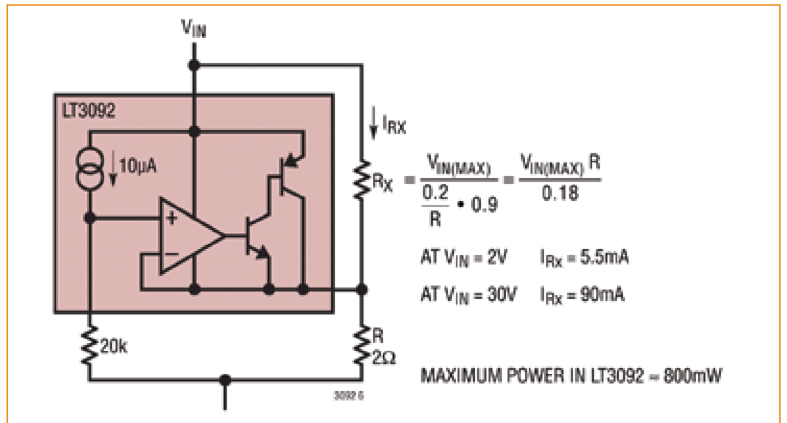


Figure 2: Reduced dissipation.

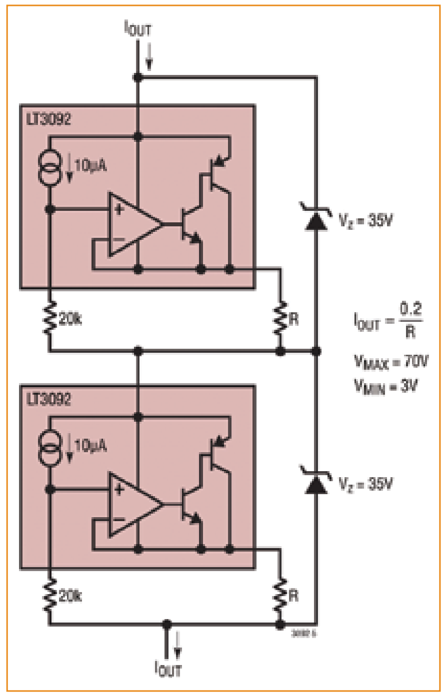


Figure 3: Stacked current sources for higher operating voltage.

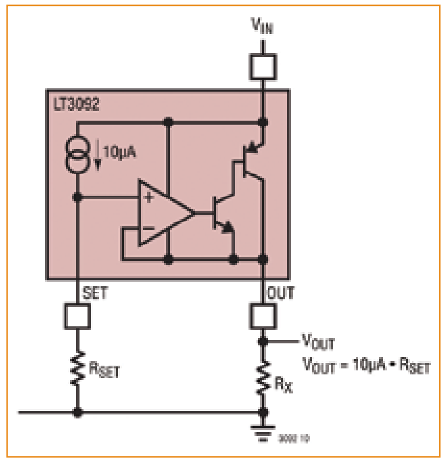


Figure 4: Intrinsically safe regulator—no capacitors needed.

The 200mV generated reference is chosen to equalize the errors due to changes in the internal current source and in the offset of the amplifier with supply voltage. With supply changes, the internal current sources change approximately 50pA per volt. The offset of the internal op amp changes less than 5µV per volt. Assuming worst case for both the current source and the offset of the amplifier, a 200mV reference contributes equal error from both the amplifier and the internal current source. If the 200mV is increased to 500mV using a 50k resistor, the contribution of the internal op amp offset declines. This improves the regulation of the current source against supply changes. However, the regulation of the loop is so good that in all but the most extreme cases, 100mV to 200mV across the set resistor will be fine.

Reducing power dissipation

For high set currents and high voltage, there is considerable power dissipation in the LT3092. For example, 30 volts and 100 milliamps equals 3 watts of dissipation, which can result in significant temperature rise depending on the thermal resistance of the PC board. An external resistor can shift a portion of the power to the resistor and reduce the power dissipation in the LT3092. Figure 2 shows the basic current source with a resistor RX from the input to the output of the device. As long as the total current is more than the current through RX, regulation is not impaired and the current source impendence does not change.

Current through RX is within the feedback loop and gets compensated as the voltage from input to output changes. The current flows through the internal PNP transistor or the external resistor while the feedback loop keeps the total current constant.

For good regulation and to ensure reasonable margin, the current through RX should not be any larger then 90% of the desired current for the device at the maximum voltage. The formulas in the illustration show how to choose RX so that the current through RX always leaves at least 10% of the current flowing through the LT3092. This drops the maximum internal power down by shifting some power to the external resistor. The result is a significant reduction in device dissipation, as well as a reduced rise in temperature. There is negligible effect on the performance of the circuit by including this external resistor.

Increasing voltage compliance

For higher voltages, current sources can be stacked to operate at a higher total voltage. Figure 3 shows stacked current sources.

Two current sources are set up for the same currents and a voltage-limiting Zener is placed across each of the current sources. At low voltage, whichever current source has the incrementally higher current will saturate and the current will be controlled by the other current source. As the voltage increases, at some point the Zener breaks down and starts to conduct. Then the voltage across the saturated current source starts to increase and it regulates the current as the voltage continues to increase. When the current control goes from one current source to the other, there is a small discontinuity in the output current equal to the error between the two current sources. Typically this is less than 1% and again no bypass capacitors are needed to make the device work.

Intrinsically safe as a voltage regulator

The LT3092 will act as a voltage regulator that needs no output capacitor. "Intrinsically safe" applications are usually designed with low current, and small or no capacitors. Figure 4 shows the LT3092 as a 200mA regulator. As a voltage regulator, the 10µA current that's generated internally flows through an external RSet resistor. This 10µA times the RSet value impresses a voltage on the Set pin. The internal voltage follower provides the same voltage at the output pin as the Set pin. The load is connected from the output pin to ground.

Conclusion

As a new IC, the LT3092 solves current source design, which is a more difficult challenge than a voltage regulator design. Current source values of 1mA up to high currents are achievable using a single unit or paralleled units. Regulation against line, load and temperature is excellent and unique design techniques have made the device operable without bypass capacitors even though there is a complex feedback circuit internally. This device adds a versatile component to a designer's toolbox.

www.linear.com

Aggressive Power Management

Achieving high-performance, low power processing engines for portable devices

With the wave of higher data rate and media content available, media-intensive portable devices are expected to be used almost continuously while relying on battery capacity similar to that of a voice-centric device. The portable devices that make use of these networks must be conscious of both power and performance. Power conversion efficiency today is already over 90%, and any improvement to the DC/DC converter itself would only provide minor impact to the overall system. Therefore, it has become necessary to use new techniques to manage energy at the system level.

By Mark Hartman, Application Manager and Joy Taylor, Marketing Manager – National Semiconductor

The main source of processor power loss comes from dynamic switching and static leakage losses. Dynamic losses increase with operating frequency and number of gates. Static leakage loss increases as process geometry decreases. A simple equation can describe the combined dynamic and static power loss:

$$P_{LOSS} = (\alpha C V_{DD}^2 f) + (V_{DD} I_{LEAK})$$

Where,
α = factor related to effective % of gates switching
C = circuit capacitance, a constant proportional to the number of gates and parasitic routing
f = clock frequency

The dynamic portion of the power loss equation ($\alpha C V_{DD}^2 f$) is due to the charging and discharging of the each transistor and its associated capacitance. The leakage portion of the power loss equation ($V_{DD} I_{LEAK}$) is due primarily to gate and channel leakage in each transistor. Each of the power saving methods discussed below effect one or more of the variables in PLOSS equation. When to use which methods depends on many factors related the device and the application.

Voltage and Frequency Scaling

The energy consumed in a processor is the power loss times the time:

$$E = \{(\alpha C V_{DD}^2 f) + (V_{DD} I_{LEAK})\}t$$

The dynamic term includes α(factor related to effective % of gates switching), C (circuit capacitance, a constant proportional to the number of gates and parasitic routing), V_{DD} (supply voltage), and f (clock frequency). Dynamic energy is the energy used to charge and discharge circuit nodes inside the logic, basically when 1's and 0's change state. Dynamic energy is proportional to V_{DD}^2.

It is readily seen why a common energy saving technique employed in digital circuits involves scaling down the frequency (f) and voltage (V_{DD}) of the processing engine to reduce energy expenditure. Note that dynamic energy is independent of frequency and time because energy is dependent on how many 1 and 0 transitions a given task requires inside logic. Dynamic energy can be reduced by scaling down V_{DD} for a yield of V_{DD}^2 in energy savings; while static energy can be reduced by an order V_{DD}.

Dynamic Voltage Scaling (DVS) vs. Adaptive Voltage Scaling (AVS)

Two popular approaches to voltage scaling are dynamic and adaptive voltage scaling. Dynamic Voltage Scaling (DVS) is an open-loop approach that adjusts the voltage and frequency in pre-characterized parings or with a voltage vs. frequency look-up table. Adaptive Voltage Scaling (AVS) is a closed loop approach that constantly adjusts the supply voltage to maintain a minimum margin.

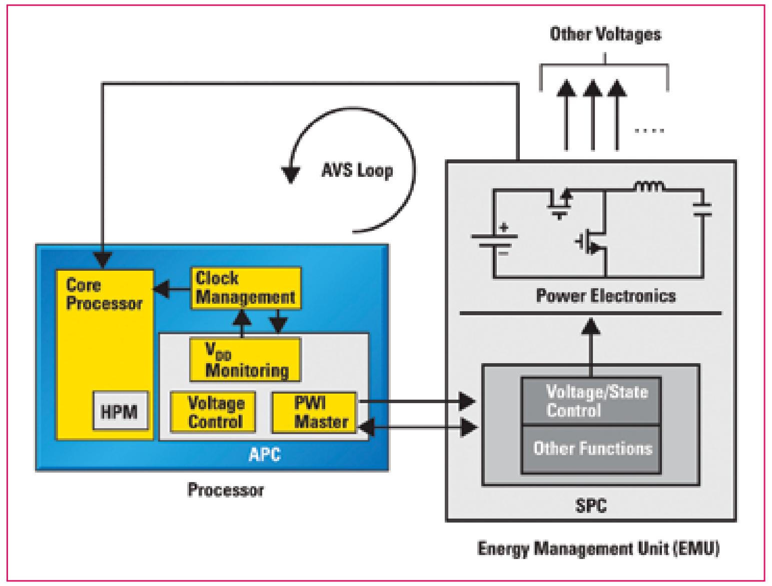


Figure 1: The Adaptive Voltage Scaling (AVS) loop and its components.

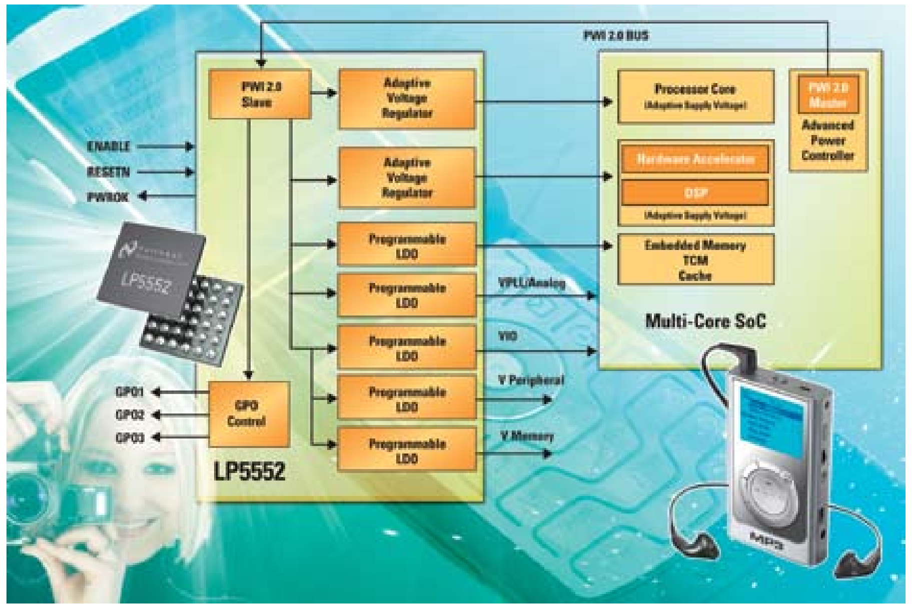


Figure 2: AVS Implementation with PWI 2.0.

The DVS system utilizes a pre-characterized voltage/frequency table that the processor uses to optimize dynamic power. When the processor wants to scale frequency, it looks up the corresponding voltage and commands the power supply to transition to that voltage. These voltages need to be high enough to maintain functionality over all parts and temperatures, and power supply variation. While this open-loop approach yields a reasonable amount of energy savings, it cannot realize all the energy savings possible.

AVS utilizes real time process and temperature feedback from the processor to provide the lowest voltage for any given condition. The voltage is updated continuously through a closed loop that is formed between the processor and power supply. When the processor wants to scale frequency, the loop optimizes the supply voltage autonomously, and provides a flag to the processor when it is safe to scale frequency. Since the AVS loop uses feedback from a performance sensor on the processor, it can adjust for process, temperature, and power supply variation, reducing voltage margin over the DVS system.

Adaptive Voltage Scaling (AVS) Implementation

AVS is a system level power management approach. The key blocks in the system are illustrated in figure1. The Advanced Power Controller (APC), licensed by National Semiconductor, provides the AVS loop control and all voltage/frequency scaling handshaking. The PowerWise® Interface (PWI) is an open standard interface developed by National Semiconductor. This two-wire serial interface provides the necessary bandwidth and protocols for AVS. Finally, the Energy Management Unit (EMU) provides the voltage scaling and regulation.

The Adaptive Power Controller (APC) handles all aspects of voltage control, and has the ability to actively minimize the power consumption of the host processor. It is realized in synthesizable RTL and has the following functional components: (i) Hardware Performance Monitor (HPM), (ii) digital loop filter and (iii) PowerWise® Interface (PWI) master module. These elements work together to allow accurate voltage control from the external power supply.

The hardware performance monitor (HPM) and digital loop filter are used in AVS to measure the performance of the digital circuit for a given operating performance requirement. The measurement data from the HPM is processed in the digital loop filter and sent to the PWI master to output a voltage request to the power supply. The APC can also be used for DVS through a programmable voltage-vs.-frequency lookup table.

PWI is a simple and fast (up to 15MHz), two-pin serial interface specifically designed to meet the needs of AVS and DVS while offering extensive programming options for versatile applications. Two version of the PWI are available: PWI 1.0 and 2.0. PWI 1.0 supports a single master and a single scaling domain. This is ideal for simple processor designs with only one scaling voltage domain. PWI 2.0 supports up to two masters and 4 scaling domains for more complex systems. The advantage of multiple scaling domains is that the application can further optimize dynamic power loss by independently scaling different parts of the processor. For example the processor could have a core and a hardware accelerator that scale frequency and voltage independently. Both version of the PWI provide general power management control such as shutdown, sleep, wakeup, etc. In addition to the scaling domains, both the PWI also provide commands to set voltages for auxiliary supplies such as PLL, I/O, and memory.

Conclusion

Processor design for today's media centric mobile devices is challenging in many ways. More and more data intensive applications are being introduced as portable devices and the networks they connect to become faster and more capable. Achieving higher performance and integration requires lower process geometries and higher clock frequencies. In the wake of these trends, aggressive power management techniques have become increasingly necessary. Both leakage and dynamic power loss must be accounted for in order to successfully design an efficient system. Fortunately, an array of techniques can alleviate excessive power loss in both leakage and dynamic switching. Every application is different, but with the right use of techniques discussed here, both a high performance and low power processor design can be achieved.

For more information about PowerWise® Adaptive Voltage Scaling Technology, please visit www.national.com/analog/powerwise/avs_overview

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Solving PSU Challenges in the Supply Chain

High-quality design and production resources at the VAR level

In projects where a suitable off-the-shelf power supply cannot be found, bringing up a custom PSU design in-house can be difficult and time consuming; but there is another way.

By John Quinlan, Engineering Manager, UR Group, Swindon, UK

High-tech products serving any modern market – whether consumer or professional – must improve continuously to meet customers' demands. Reaching the market first with each new product generation carries attractive rewards for brands. But designers seeking to establish new benchmarks for aspects such as features, performance, energy consumption or miniaturisation may find that standard power supplies cannot match their ambitions. For instance, if a PSU of sufficient power density or having the required outputs or special features such as digital control is not available, or if a suitable form factor cannot be found, the product may fail to fulfil its specification.

On the other hand, modern design projects typically cannot contemplate a custom solution. Bringing up a PSU design poses a significant risk for a small project team. Tough challenges include achieving the required number of outputs within tight size restrictions, ensuring satisfactory output-power quality, implementing mandatory features such as power-factor correction, and meeting standards for noise emissions. If the project presents specific demands, such as to match the noise performance of a linear PSU using a more efficient switched-mode unit, the design may prove too difficult to complete. Engaging an independent PSU design specialist, however, would likely add significantly to overall project costs.

Get the Knowledge

As well as these technical challenges, aspects such as testing can also be expensive and require specialised skills. Essential steps requiring specialised knowledge include writing a suitable compliance specification, and ensuring that the unit is designed to the appropriate safety standards such as IEC60950 for general-purpose equipment, EN60601-1-1 for medical equipment, or relevant ETSI standards for telecom equipment.

As an alternative for product designers needing a customer power solution to achieve new performance benchmarks, UR Group's power supply design team places the necessary technical skills within the supply chain. The team is able to quickly configure custom PSUs, taking advantage of close links with suppliers to achieve advanced performance at a cost-effective price and within suitable lead times.

Custom PSU Design

Among recent successful projects, the team has configured PSUs for a customer project to upgrade TETRA base stations to implement dual redundancy and add new cards supporting functional enhancements that were required by the end customer. The upgrade demanded a 75% reduction in power supply size, from a 12HP-wide unit to just 4HP. By using the latest Vicor PSU chip technology, UR's designers were able to meet the new form-factor constraint while also implementing extra features such as an I^2C interface and embedded EEPROM. This has allowed data such as the unit serial number and software revision number to be stored easily, enabling improvement such as faster status verification and updating by field maintenance staff.

UR Group's power supply design team can quickly configure custom turn-key assemblies.

In the medical sector, health authorities are looking to technical solutions to reduce waiting times and improve delivery of treatment. One customer developing a more compact, low-cost laboratory-grade blood analyser contacted UR to improve power-supply noise performance for better repeatability while at the same time reducing the PSU's power consumption and saving weight. Ensuring accurate measurements on blood samples requires an instrument with ultra-low ripple on the DC power rail, and this had originally been met using a linear supply. But efficiency was less than 50% and the linear unit's bulk contributed to overall weight of more than 20kg. By designing a custom switched-mode PSU with filtering optimised to match the linear unit's output characteristic, UR was able to boost operating efficiency to over 85% while also helping to reduce overall weight to below 10kg.

Special requirements on aspects such as form factor often dictate a custom solution. The Internet-services market provides a powerful example, as ISPs demand standardised equipment but can have widely varying power-supply requirements. Most sites will have a standard AC line, requiring bulk conversion to 5V DC. In other locations, identical equipment may be required to operate from a DC source such as a 48V DC feed with battery back-up. To help one customer deliver a cost-effective solution to both types of requirements, UR built a DC-DC converter within the same dimensions as the chosen AC-DC unit. The output filtering was optimised to meet all necessary ETSI standards, and the design incorporated additional features including a power-good signal to communicate DC-supply or battery status, as well as support for dual redundancy.

Equipment destined for harsh environments can often place stringent requirements on the power supply, which off the shelf units may not be able to meet. A recent project to design power supplies for a pilot public-access Wi-Fi scheme demanded fan-free operation throughout a wide ambient temperature range. The contracted equipment supplier found that off-the-shelf units of suitable physical size and power rating could not guarantee an acceptable MTBF under the operating conditions specified. UR was able to configure a convection-cooled PSU less than half the size of the nearest comparable off-the-shelf alternative, which demonstrated satisfactory operating lifetime under specified operating conditions in the field.

Meeting demand: the newly expanded UR warehouse and the manufacturing area.

The demand for custom PSU solutions to withstand harsh environments also extends to military equipment, such as vehicle-mounted systems suitable for 24V operation and capable of withstanding large variations in input voltage. Most standard PSUs cannot survive the large energy surges present in the electrical infrastructure of a military vehicle. Some of the techniques used to overcome such challenges within a short timeframe and at a cost-effective overall price have included working with original PSU vendors to re-optimise existing off-the-shelf units to pass national and overseas military qualifications.

The Value of the VAR

Associated skills normally applied to complete a design ready for integration with the end product include PCB design, supervisory electronics, metalwork design and supporting documentation. Moreover, since appreciable production capacity is also available, taking advantage of PSU expertise in the supply chain is not only a convenient way to mitigate design risk and manage project resources, but can also be an effective route to market.

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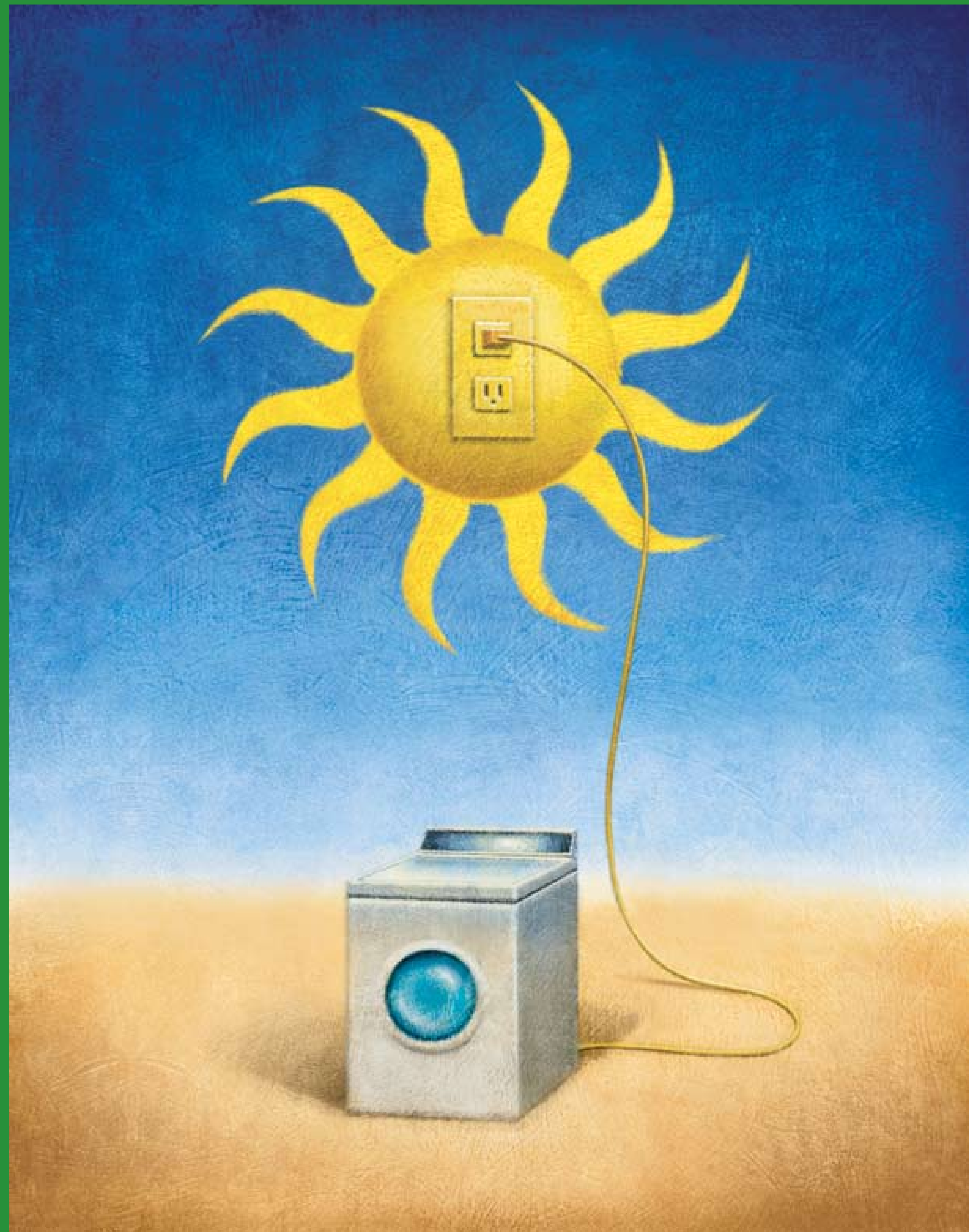
Power Systems Design EUROPE

PSDE Green Power ENERGY EFFICIENCY

White Goods



Cooling White Goods

Maximizing performance and efficiency with AC and DC fans

When it comes to household appliances, designing products with cooling fans is becoming more than just an issue of cooling. From refrigeration units to convection ovens to venting ducts over stove ranges, the functions served by fans and fan trays not only include cooling and circulating air, but can include increased functionality, maximizing energy efficiency, simplifying BOMs and decreasing production costs.

By Bob Knight, President, Knight Electronics, Orion Fans

In white goods applications, AC and DC fans must be capable of operating within extreme temperature ranges, from very cold freezers and refrigerators to extremely hot convection ovens. Different materials and designs are available to achieve the necessary performance and reliability across a variety of applications. For example, low-noise fans in refrigeration units, coolers and range hoods are being used to perform different functions while reducing the amount of noise normally present in older product designs. AC fans constructed to Class B and Class F UL insulation standards are being specified for higher temperature applications ranging from 130ºC - 155°C.

Low-noise fans are often selected for refrigeration and wine cooler applications to prevent condensation yet not contribute significantly to audible noise levels. Condensation can build up on the inside of these units, forming not only on the glass, but within the enclosure itself. The use of an internal fan creates just enough air movement to prevent condensation. The same situation exists in store refrigeration units. The appearance of condensation in the enclosed case or on the glass can imply food is not properly frozen. Low-noise fans are employed in these applications not only to prevent condensation build-up, but to minimize the noise level and reduce power consumption. These types of fans are available in both AC and DC configurations.

Another way fans can be used to maximize performance is through the use of high-temperature construction. A high temperature fan with higher insulation Class B or F construction often eliminates or reduces premature failures caused by inadequate airflow in hot areas. AC fans are often utilized in high temperature applications such as oven control assemblies and forced air convection units. The temperature of Class B insulation is specified at 130°C, while the temperature of Class F insulation is specified to 155°C. These maximum temperatures at which the plastic and insulation materials are rated includes the normal temperature rise of the fan, so care must be taken to ensure these ratings are not exceeded when designs are contemplated.

Components exposed to high heat are susceptible to failure over time, with fans being no exception. The classification of the insulation system is based on the lowest rated component in the system, or in this, case the fan. The materials and parts specified in the construction that affect the insulation class include the motor winding, the wire and the insulation on the wires, the enamel coating on the magnet wire, as well as the visible parts of the fan or fan tray such as the frame and impeller.

Orion's fans are capable of employing high insulation Class F materials for use in high temperature oven applications.

AC and DC smart control fans ensure optimal operating conditions while maximizing energy efficiency in microwave and oven applications.

Increasing Functionality and Maximizing Energy Efficiency

The functionality of fans has also increased dramatically, to the point where product manufacturers are now utilizing fans with "smart" controls. Such controls include tachometer output, locked rotor alarm, pulse width modulation (PWM) input, and thermal and constant speed controls. These special functions provide end users with intelligent control options and feedback that increase functionality and optimize fan performance, while also minimizing energy consumption. With controls like these, manufacturers are able to better monitor airflow and operating temperature, ensuring the fans are operating properly and at optimal conditions.

Tachometer output, for example, provides design engineers with an accurate means of monitoring and reporting a fan's rotational speed, as well as indicating if the fan's speed falls below a certain RPM. This can be used as a lower cost alarm or indicator by monitoring the fan speed to determine relative temperature. Typically, the tachometer output option is available as either a 5V TTL signal, or as an "open collector" signal.

Fans and fan trays equipped with locked-rotor alarms indicate whether a fan is running or has stopped by transmitting a high or low output signal, minimizing fan downtime and averting an overheating situation. A PWM option also allows users to digitally control the speed of the fan through an existing bus system or PLC.

Fans or fan trays with thermal speed control employ a thermistor-controlled circuit that increases fan speed only when the temperature rises above a determined set-point. This reduces overall energy consumption by lowering fan speed when temperatures within the enclosure are below the set-point. Thermistor control circuits can be mounted directly in the fan hub or remotely mounted via a lead wire, and can be positioned anywhere within the enclosure, giving design engineers the flexibility to regulate fan speed based on ambient temperature in a specific area. The constant speed function senses variable input voltage, which causes variations in power output, and maintains the fan's constant speed regardless of input voltage fluctuations.

Fully assembled and tested fan trays provide appliance manufacturers with additional benefits by lowering supply chain costs, reducing lead times on materials, reducing the number of SKUs, reducing parts inventory, improving quality and lowering overall production costs. Not only does the tray provide a complete solution, it reduces part numbers and stocked inventory of cooling parts from tens to one. Tray manufacturers like Orion Fans also assemble, test and ship when needed, reducing lengthy lead times.

Conclusion

Today, AC and DC fans have more demands placed on them than simply cooling and controlling airflow in white good applications. With an extensive number of capabilities now available, including higher temperature ranges, speed controls and tachometer output signals, to name a few, manufacturers of white goods are using fans as a means of providing increased functionality, maximizing energy efficiency and decreasing end unit cost.

www.orionfans.com

Energy Efficient White Goods Need Accurate Control

Surface-mount current transducers open up new applications

With the demand for better efficiency moving into the domestic market, manufacturers are now required to re-evaluate their products. No longer are these appliances simple in electrical design. Motor drives especially are required to run more efficiently and more effectively, avoiding wastage and vibration noise.

By Stéphane Rollier, Bernard Richard and David Jobling, LEM, Geneva, Switzerland

Traditional current transducers are unsuitable for the fast developing and changing markets such as domestic electrical products and air conditioning systems because they are too big and expensive. Smaller and lower-cost transducers are now making current measurement a reality in these vital everyday systems.

LEM, a market leader in providing innovative and high quality solutions for the measurement of, electrical parameters used in a broad range of applications in industrial, traction, energy and automotive markets, has developed the Minisens integrated current transducer. This industry-leading device combines all the necessary

electronics with a Hall-effect sensor and magnetic concentrators in a single eight-pin, surface-mount package (Fig 1). Characteristics such as sensitivity and isolation can be varied by changing the design of the PCB layout.

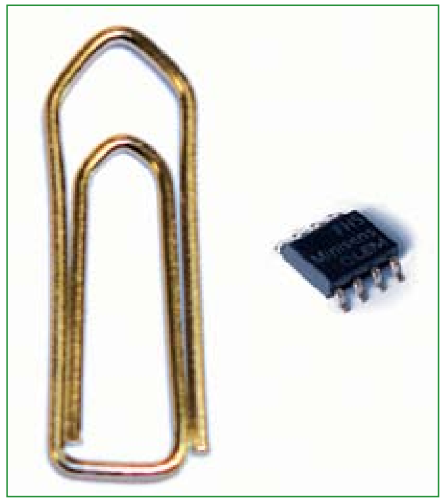


Figure1: LEM's Minisens in a tiny SM package.

The most common way to use Minisens is to locate it over a PCB track that is carrying the current to be measured. To optimise the function of the transducer, some simple rules must be applied to the track dimensions. By varying the PCB and track configuration, it is possible to measure currents ranging from 2 to 100 Amps.

One possible configuration places the IC directly over a single PCB track (Fig 2).

In this configuration, isolation is provided by the PCB and currents in the range from 2 to 20A can be measured.

Isolation can be improved by placing the transducer on the opposite side of the board, but still directly over the line of the track. The thickness of the board and the track itself will both affect the sensitivity. Sensitivity is also affected by the width of the track (Fig 3). It is important to note that sensitivity is greater for thinner tracks. However, the thinner the track, the quicker the temperature rises.

The maximum current that can be safely applied continuously is determined by the temperature rise of the track. The use of a track with varying width gives the best combination of sensitivity and track temperature rise. To maintain temperature levels, the width, thickness and shape of the track are very important.

For low currents (under 10A), it is advisable to make several turns with the primary track to increase the magnetic field generated by the primary current. As with a single track, it is better to have wider tracks around the Minisens than

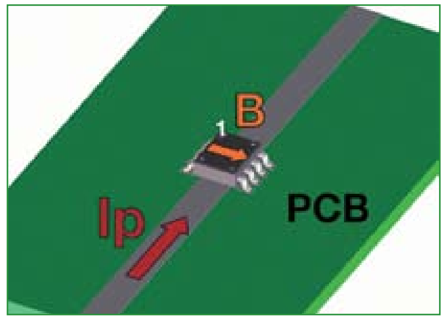
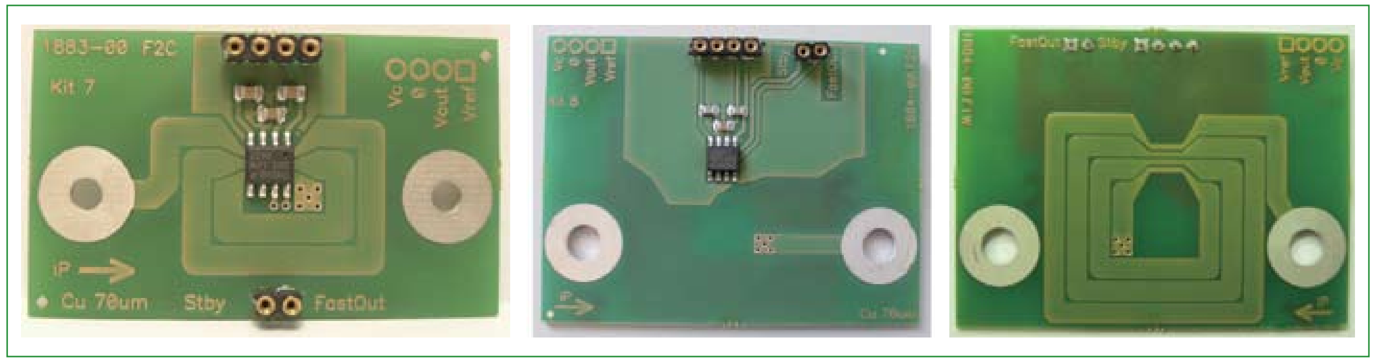


Figure 2: Typical PCB design with the track routed underneath the Minisens.



Figures 4 and 5: Possible 'multi-turn' designs.

under it to reduce temperature rise (Figs 4 and 5).

For example, a four-turn design (Fig 5) underneath the Minisens on the opposite side of the PCB provides a high insulation configuration. Another way to increase the sensitivity is to use a narrower track.

The sensitivity can be increased further by other techniques, such as using a 'jumper' (wire) over the Minisens to create a loop with the PCB track, or multiple turns can be implemented in different PCB layers. Larger currents can be measured by positioning the transducer farther from the primary conductor.

Many Minisens parameters can be configured by the on-chip non-volatile memory. This can be used to adjust the transducer's gain, offset, polarity, temperature drift and gain algorithm.

Two outputs are available: one filtered, to limit the noise bandwidth, and one unfiltered which has a response time of less than 3μs, for current short-circuit or threshold detection.

Minisens operates from a +5V power supply. To reduce power consumption in sensitive applications, it can be switched to a standby mode by means of an external signal. It is manufactured in a standard CMOS process and assembled in a SO8-IC package.

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

- Sensitivity (V/T) error (+/-3%)
- Tolerance on the initial offset at no field (+/-10 mV)
- Non-linearity error (+/-1.5%).
- However, this does not represent the accuracy in the final application, where several other parameters that influence the accuracy must be taken into account, including:
- The distance and shape variations of the primary conductor vs. the IC as well as the IC placement error on the PCB (the mechanical design parameters),
- The adjacent perturbing (stray) fields.

The final sensitivity depends on mechanical design parameters. Each inaccuracy or change will lead to a change in the final sensitivity.

The parameters that are subject to change due to variations in industrial production include:

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

These parameters must be closely controlled in the production process. Alternatively, in-circuit calibration of the Minisens can be used to avoid most of these errors. Two other parameters must be also be taken into account: sensitivity temperature drift at +/-300ppm/K and offset drift at +/-0.15mV/K.

By integrating all the necessary electronics and magnetics into such a small, easily mounted package, Minisens brings current sensing technology to many new applications, just at a time when it is needed most. The precise data provided by it enables power electronics to drive the motor more efficiently and with lower losses providing energy savings.

www.lem.com

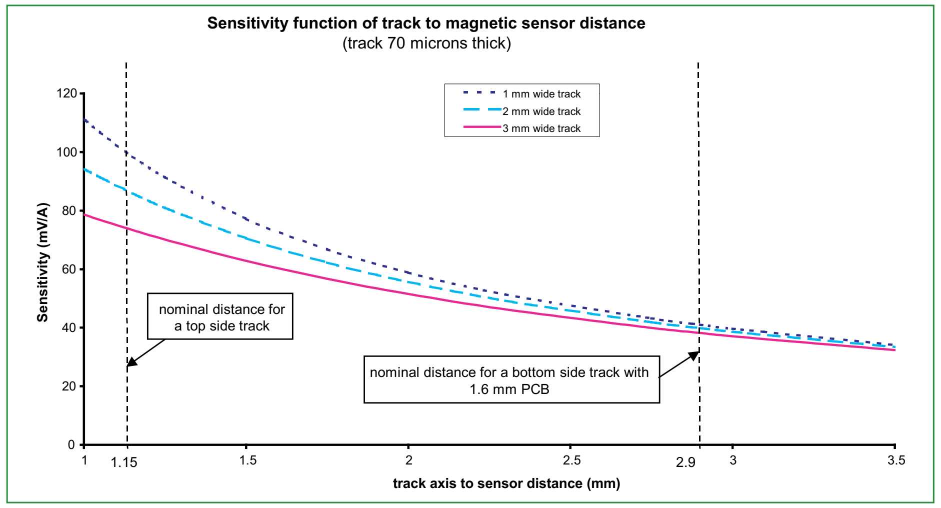


Figure 3: Sensitivity (mV/A) versus track width and distance between PCB track and the sensing elements.

Smart Energy Meters in Home Appliances

Help cut energy use

There are several strategies that can be put in place to reduce energy consumption in our homes. The most obvious is to develop more efficient appliances increasing the overall efficiency of the converters, motor drivers and control electronics. Most of the expertise developed for battery operated electronic devices can be transferred into power grid connected appliances.

By Cosimo Carriero, Senior Field Application Engineer, Analog Devices Inc

The next generation of appliances are being designed environmentally friendly to drastically reduce power consumption. In order to balance the higher costs associated with increased efficiency in some countries, governments are granting incentives to encourage people to buy these appliances.

But savings come also from smart energy use. Numerous studies show that simple awareness can produce savings of 20% or more. Given the opportunity to save money by curbing energy use and given the technology to take action to reduce it, consumers will take the action, with savings up to 50%. Monitoring is the critical first step in dealing with energy use in homes.

Smart Grid and Home Area Network

Monitoring of power consumption in homes brings to the concepts of Smart Grid and Home Area Network.

A Smart Grid is an electricity network that delivers electricity from suppliers to consumers using digital technology to save energy and cost. Use of robust two-way communications, advanced sensors, and distributed computing technology will improve the efficiency, reliability and safety of power delivery and use.

Smart grid features could expand energy efficiency beyond the grid into the home by coordinating low priority home devices such as water heaters so that their use of power takes advantage of the most desirable energy sources. Some of the benefits of such a modernized electricity network include the ability to reduce power consumption at the consumer side during peak hours.

Smart grid connected devices make up the Home Area Network (HAN). These devices empower consumers with real time control of their energy use communicating with the smart grid. Interoperability between products from different manufactures is one of the main challenges for an effective household appliances network.

Utilities, vendors and research institutes are working on the development of global standards.

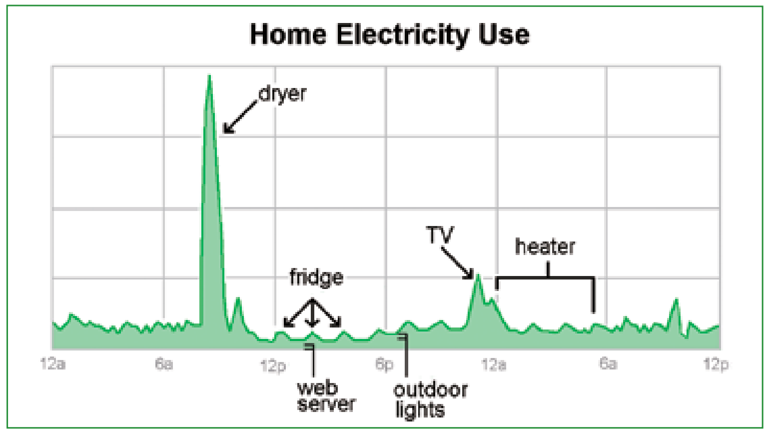


Figure 1. Home electricity use.

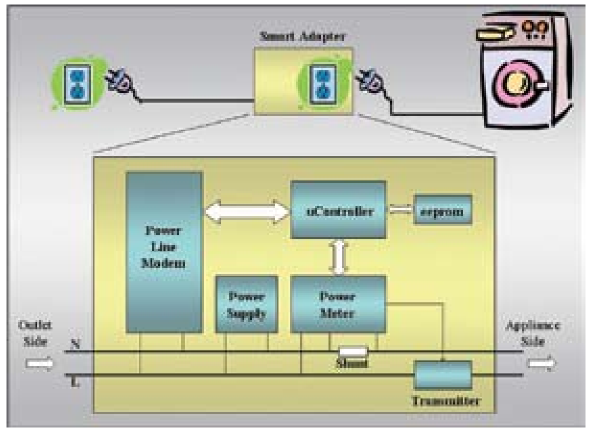


Figure 2. The smart adapter concept.

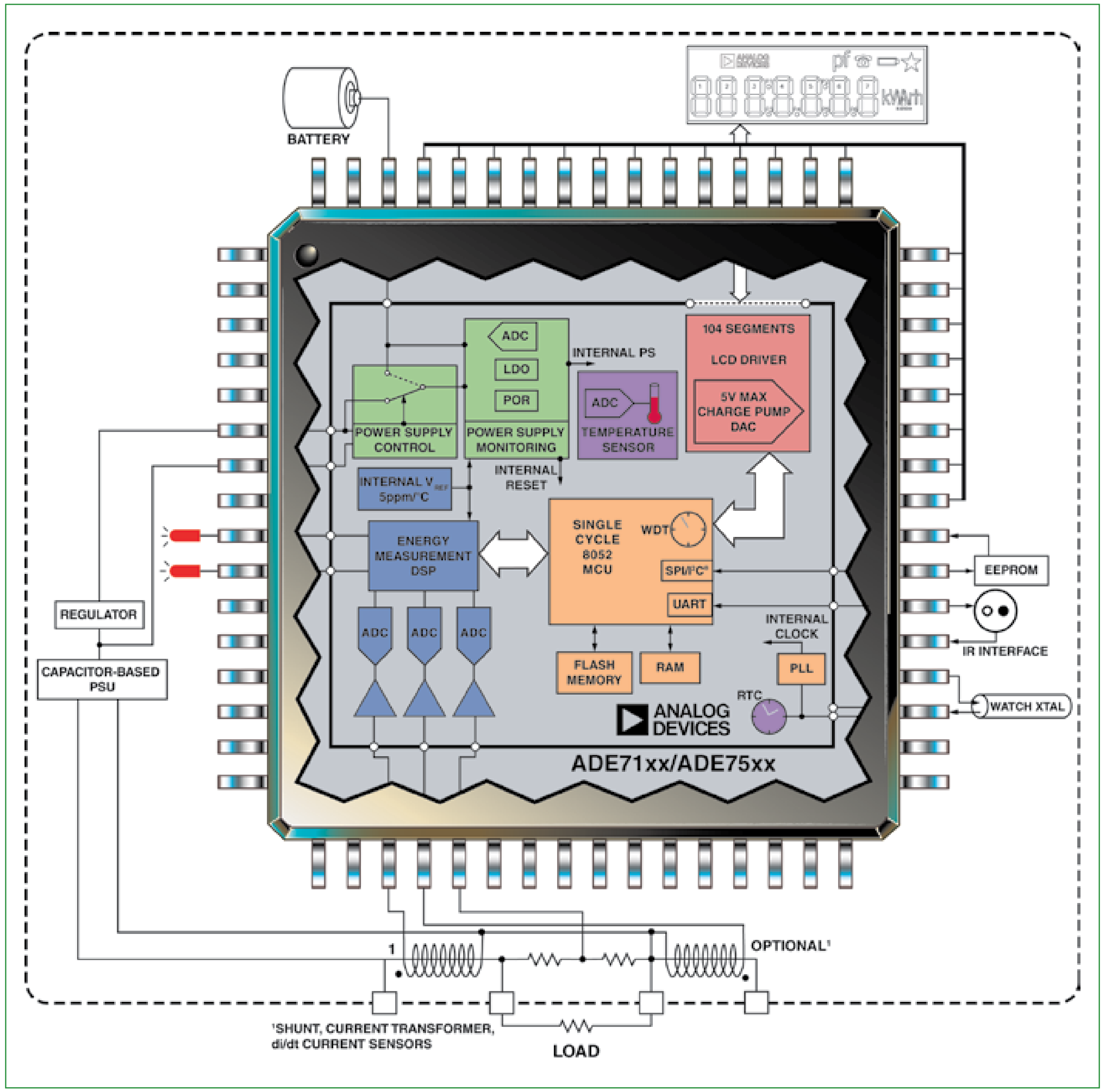


Figure 3. Energy meter system diagram.

One remarkable initiative is the Smart Energy Profile developed by the ZigBee Alliance, Homeplug Powerline Alliance, EPRI and leading utilities.

The significance of the Smart Energy Profile is that consumers will be able to purchase thermostats, in-home displays and smart appliances from any retail channel and register these with their energy delivery company in order to participate in advanced demand response and energy conservation programs. The future smart energy home will consist of heterogeneous devices capable of communicating with the energy grid.

Another remarkable initiative is Google Power Meter, a product which will allow consumers to see their own energy usage information and help them improve their efficiency in a variety of ways. To get access to energy information homes need to be equipped with advanced energy meters, called smart meters. Smart meters need to be coupled with a strategy to provide customers with easy access to near real-time data on their energy usage.

Google PowerMeter, now in prototype, will receive information from utility, smart meters and energy management devices and provide anyone who signs up access to his home electricity consumption right on his iGoogle homepage. The graph in Figure 1 shows how someone could use this information to figure out how much energy is used by different household activities.

The Smart Appliance

GE has launched in the US a program to introduce a suite of smart energy enabled appliances. The appliances will be enabled to receive a signal from their local utility and will react based on the internal programming. Some operation may be delayed from occurring during peak energy usage hours enabling the utility to easily manage peak load conditions. On the other hand consumers will benefit from the dynamic pricing being notified of critical peak pricing on a display on their appliances letting them know when higher rates are in effect. Appliances will be programmed to avoid energy usage during that time but consumers may choose to override the program, giving them ultimate control.

In Europe white goods manufacturers like Indesit Company have been working for a long time on the smart appliance concept. Indesit introduced in 1995 Margherita Datalogic, the first electronic washing machine and in the following years invested a lot on networking on line services and smart products able to generate, transmit and share information.

Indesit, in cooperation with University of Parma (Italy), has developed a low cost power line communication for electrical appliances networking. The idea is shown in figure 2.

It is based on the concept of Smart Adapter, a device for connecting to a network any electrical appliance. The smart adapter embeds a communication node (based on any protocol) and a power meter and is located between an electrical appliance and its outlet. The communication node ensures HAN connection; the power meter analyses the absorbed electric current and generates useful information (functional, statistical, diagnostic and energy consumption) related to the appliance itself. The connection to the HAN is by Power Line Modem, but it could be any standard protocol, including ISM band RF wireless communication standard like the IEE 802.15.4 (ZigBee).

A point-to-point technique called Power Modulation is used by the appliance to communicate with the smart adapter and is based on the modulation of an internal load; this modulation is detected and decoded by the power meter [1]. The smart adapter has the big advantage of moving away from the white goods the costs of the communication node that is still too high for this market.

Overview of Energy Measurement ICs ADE71xx/ADE75xx family

With more than 225 million energy meters using ADI's technology deployed worldwide, Analog Devices has delivered more energy measurement solutions than any other semiconductor company. The ADI Energy Measurement ICs combine industry-leading data conversion technology with a fixed function DSP to perform the calculations essential to electronic energy metering. Grid current and voltage are measured by means of dedicated analog to digital converters and analog front end electronics. Special care is devoted to the current channel, due to the very high dynamic range; a high resolution sigma-delta converter is combined with a programmable gain amplifier (PGA) in order to achieve high accuracy over a dynamic range of 1000:1. Moreover the devices are able to interface several current sensors; simple low cost shunts, current transformers and di/dt sensors like the Rogowski Coils.

The ICs can achieve four quadrant active, reactive and apparent power and energy measurement exceeding the main standards requirements like IEC 62053-21, IEC 62053-22, IEC 62053-23, EN50470-3 Class A, Class B and Class C, ANSI C12-16.

The wide bandwidth (14kHz) allows fundamental and harmonic measurement.

Also instantaneous and rms values of current and voltage are available and the meter can perform power line quality verification, detecting voltage sag, peak and zero crossing and measuring period/frequency.

Figure 3 shows the Energy Meter System Diagram featuring the ADE71xx, and ADE75xx product family that builds on Analog Devices' 10 years of experience in energy measurement to provide the best analog to digital converters combined with the advanced digital signal processing required to build an accurate, robust and fully featured energy meter with LCD Display.

Two analog inputs allow line and neutral current measurement for tampering protection. Another analog differential input is for voltage. The three analog inputs have dedicated 24 bits Σ-Δ ADCs. Each Analog input channel has one PGA with possible gain selection of 1, 2, 4, 8 and 16.

Other features are the embedded Battery Management which enables low power consumption in battery mode and optimal power supply management when line voltage is lost, and the low power Real Time Clock with nominal and temperature dependent crystal frequency compensation.

Table 1 is the single chip solution selection guide.

Conclusion

Smart Grids, Advanced Metering Infrastructures, Smart household appliances are seen as key potential technologies to improve energy efficiency, ultimately helping in the goal to reduce carbon emissions. Analog Devices is committed to providing innovative and energy efficient devices to enable this market and to doing its part in improving energy efficiency and promoting energy conservation.

www.analog.com

Part Number	Antitamper	W+VA+rms	VAR	di/dt	5V LCD	RTC	Flash (kB)	Package
ADE7166	Yes	Yes	No	No	Yes	Yes	8/16	64-lead LQFP
ADE7169	Yes	Yes	Yes	Yes	Yes	Yes	16	64-lead LQFP
ADE7566	No	Yes	No	No	Yes	Yes	8/16	64-lead LQFP
ADE7569	No	Yes	Yes	Yes	Yes	Yes	16	64-lead LQFP

Table 1. Selection guide

Taking Control in White Goods

More efficient electric motor control solutions

The international market for electric motors is vast and although the automotive and industrial sectors receive a large part of the attention, consumer devices and in particular white goods are rapidly becoming key application areas.

By Vincent Mignard, Segment Marketing Engineer, Renesas Technology Europe

This sector represents a significantly different market from industrial control or automotive, with its own unique demands. It is characterised partly by the amount of power the motors need to deliver, which subsequently determines the type of motors used and the way they are controlled. Because of their low cost and simple control requirements, DC motors have for a long time dominated in this cost sensitive market. However, with renewed emphasis on power efficiency, as well as overall safety, more sophisticated motors are penetrating the consumer/white goods market. In fact, their use can create significant differentiation for suppliers, as they are typically smaller, quieter and more efficient than DC variants.

As a result, the motor of choice in this application area is now more likely to be a 3-phase brushless DC motor (BLDC) or induction motor. A BLDC can be as much as four times smaller than a DC motor, which in an appliance such as a washing machine or dishwasher can represent a massive space saving and enable much smaller appliances to be developed. In addition, the motor itself

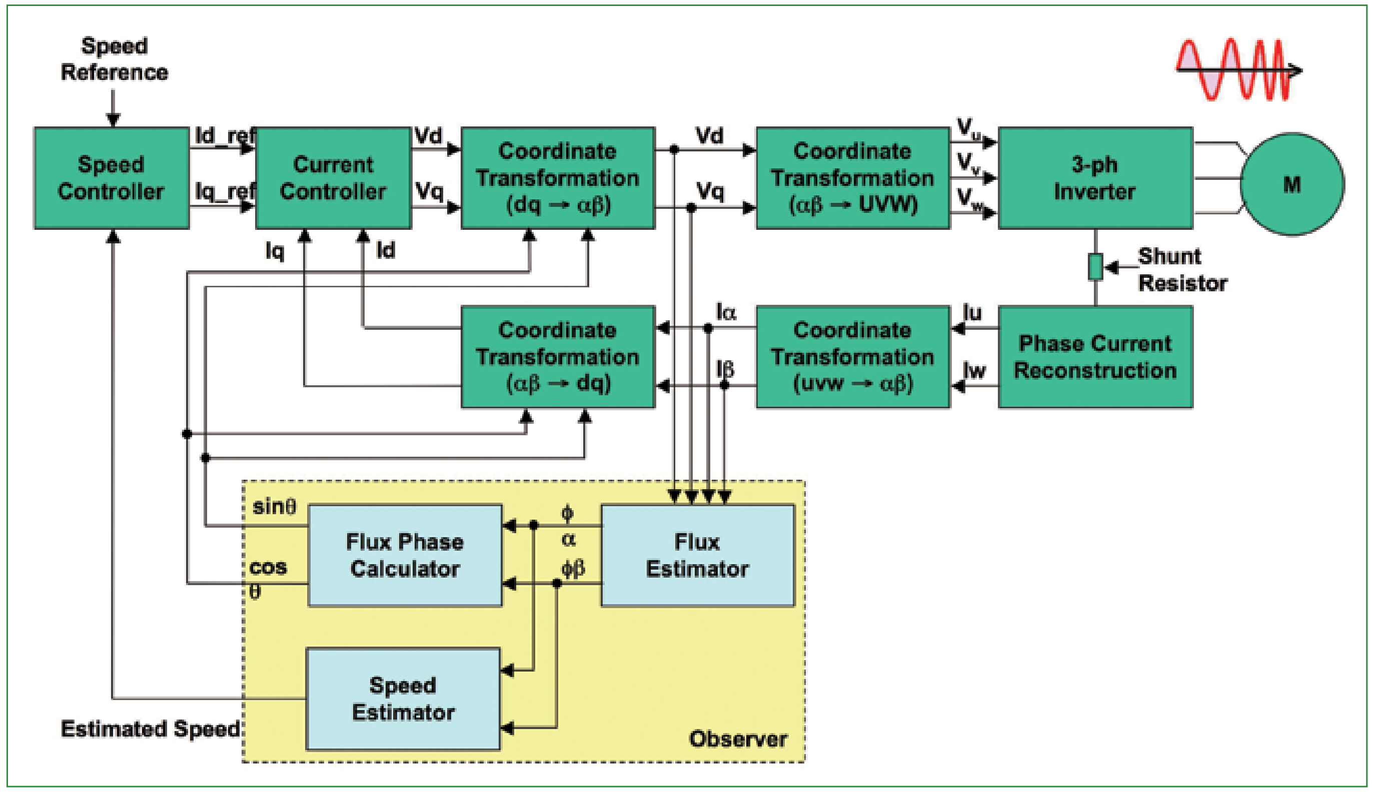


Figure1: Block diagram of sensorless field-oriented motor control.

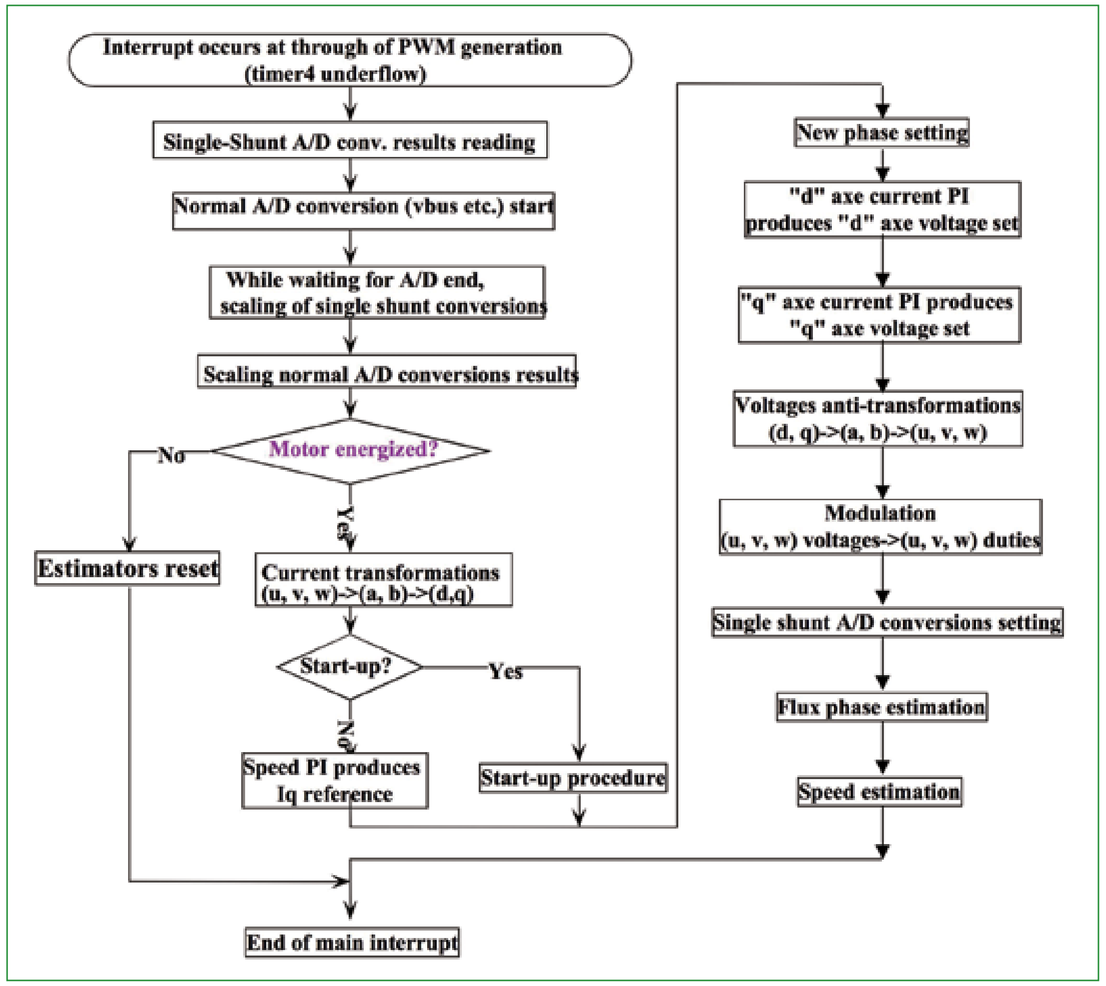


Figure2: Software sequences for a field-oriented motor control.

is much lighter so the torque to weight ratio is higher. Another advantage to using a brushless motor is that it does not generate any electrical noise.

Smaller, faster, cheaper

These applications can be classed as 'low power' applications; that is, the motors must deliver 1kW or less of power, and they could all benefit from the introduction of BLDC or induction motors. Their power requirement alone sets them apart from the industrial automation market where, by contrast, often multiple motors are needed, delivering far in excess of 1kW each. In industrial applications, the control systems will often need to communicate to each other in order to maintain safe and efficient operation, leading to complex and highly optimised control solutions.

Common to all electric motors, including those targeting the consumer sector or white goods applications, is a requirement for an external control system. While that control system may not be as complex as one found in an industrial automation application, the new class of low power motor, nevertheless, does require more sophisticated control solutions compared to those used for DC motors. In turn, this has created demand for a range of low power, low cost motor control solutions that meet the technical and commercial demands of the consumer and white goods markets.

Just as with most functions within embedded system design, choices exist; for a single, low power motor control system, the choice is largely between using a microcontroller (MCU) or a digital signal processor (DSP). In recent years, both MCU and DSP manufacturers have identified the need for control solutions that meet the needs of low power motor control for consumer products and white goods. This has given rise to variants that either offer greater integration of ancillary functions, such as amplifiers or other mixed signal devices, or solutions that offer less integration of peripherals but with concentrated efforts on 'tuning' their core architecture for control functions. The latter is particularly relevant for DSP variants, now targeting motor control applications through the commonly termed Digital Signal Controller (DSC).

For the most part, either an MCU or a DSP/DSC can be used to control the relatively more complex BLDC or induction motors, particularly in low power applications where, typically, only one motor is present. The choice of which to use can be dependent on many parameters.

For some applications, OEMs standardise on partitioning the control function from other system activities, in which case the DSP/DSC is ideal. Fundamentally, the their architecture was originally designed to perform complex algorithms which are largely loop based; they perform the same tightly constructed calculations repeatedly, very efficiently (in terms of processor cycles). For control functions, DSPs are less applicable and it is for this reason that manufacturers have developed the DSC variants.

This type of control system also needs to be able to respond, in real-time, to external events that may impact the motor's operation. Typically this could be a change in the motor's load, which must be compensated for as quickly as possible in order for the device to continue operating at maximum efficiency and within safety tolerances.

For this reason, the integration of control functions and the ability to adapt

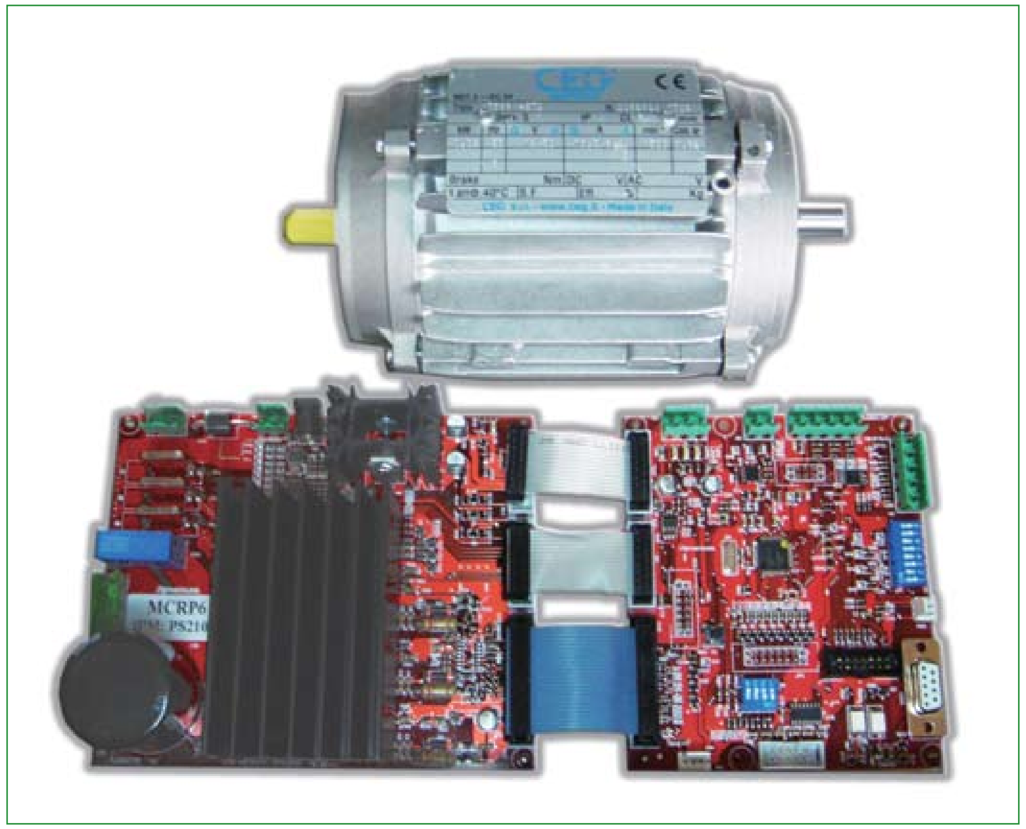


Figure3: Example of a MCU-based motor control reference platform.

the motor drive, in real-time and in response to external events, becomes more important. This is particularly relevant where commercial pressures demand that a single processing element provides both motor control and general housekeeping, typical of low power applications in the consumer space or white goods sector.

No soft option

In this regard, the continued development of microcontroller architectures and, more importantly, the drive towards faster silicon platforms on which to build them, has largely delivered the performance needed to obtain real-time control. However, fundamental to these platforms, and common between both MCUs and DSP/DSC architectures, is the role software plays in providing that control.

Developing the motor control algorithm, in software, is a crucial stage in creating an efficient motor control solution. The ease with which that software can be developed however is not necessarily common across platforms. For the vast majority of applications, the software will be developed in C/C++, the 'de facto' programming language for embedded systems. When targeting an MCU, it is far easier to develop, validate and port a control algorithm written in C between platforms; for DSPs it is more common for the tight loops to be coded at a lower level and much more dependent on the underlying hardware architecture, which not only makes porting them more difficult, but actually presents a greater challenge when tuning the software.

Moving to BLDC/induction motors provides the OEM with an extended roadmap for their product and a chance to differentiate by simply replacing the motor with the latest version, which may offer a greater power/weight ratio or better efficiency. However, taking advantage of that opportunity requires a certain amount of engineering work, predominantly in retuning the control algorithm for a different mechanical arrangement. The speed and efficiency with which an OEM can make that upgrade may well be governed by how easily they can adjust the software algorithm driving the motor. With an MCU approach, where the software is written in C/C++, these adjustments can be achieved easily, the same isn't necessarily true for a DSP/DSC based control system.

Manufacturers are also looking to take full advantage of the benefits a BLDC offers in terms of exactly how it is controlled. Increasingly, this means moving away from simple control algorithms based on the voltage and frequency applied to the motor, towards using a sensorless vector control approach. This makes the software more complex and, arguably, means it is even more important to retain accessibility to the MCU software by standardising on C/C++, as opposed to being forced to develop the algorithm at a lower level of abstraction.

Renesas provides a series of MCU-based motor control reference platforms (MCRP04/5/6).

It is very ease to tune the motor control by using a connected PC and GUI application. A simple header file allows you to adapt the operating parameters, such as start-up procedure, torque & speed range, and acceleration/deceleration ramps, to suit the application requirements. Tools also allow the fine-tuning of the motor control algorithm; considered an important aspect of any such MCU-based application.

The use of more complex but more efficient and cost effective electric motors in the consumer sector and, in particular, white goods is a trend that is set to continue. This will present OEMs with the opportunity to extend their products' life cycle, deliver greater differentiation and provide 'greener' solutions to the customers. However, it will also present them with some important decisions, which will require careful consideration before standardising on the solution that best meets their requirements.

www.renesas.eu

Pay Now, Live Later

Reported by Cliff Keys, Editor-in-Chief, PSDE

The green world seems to have slowed along with the rest of our industry. I expect the pause will be finite but as all business runs on money as its lifeblood, there needs to be a resurgence in revenues to bring it bouncing back. No-one can predict when this will be at the moment and I really do not blame the analysts in being economic with their forecasting of a broad return to 'normality'. Simple fact is, at the moment, it seems to be almost anybody's guess.

There are many reports in the US about Europe's lead in solar power installations due to the Government's stimulus to encourage the rapid development of renewable energy sources. In parts of Europe, house owners and businesses are paid a premium rate for producing green energy. In Germany, for example, house owners with a roof-top solar system can receive several times the rate over that paid to a coal-fired power plant. Of course, for this to work, a government must be committed in terms of actual funding rather than just words, to make it attractive enough in the medium term for the house owner to invest.

Today, solar energy represents less than 1% of the energy mix in the USA.

However, as a result of growing awareness about reliable, easily available technology, concerns about rising costs, energy security and supplies, and new state and federal tax incentives, deployment of solar energy has grown rapidly since 2005.

At the end of 2007, the U.S. had just over 3,400 MW of installed solar power. This included 750 MW of PV, 418 MW of utility-scale concentrating solar power, and 2,250 MW (thermal equivalent) of solar hot water systems.

The U.S. ranks fourth in the world for installed solar power. Germany is first, Japan is second, and Spain is third. Installed grid-tied solar PV grew more than 48% in 2007 compared to 2006. Growth was led by large-scale projects, but the pool-heating market continued steady growth of 8% and utility-scale grew 18%. Solar energy manufacturing grew 74% in 2007, led by expanded capacity of thin-film PV, silicon manufacturing and other equipment production.

Unfortunately, even solar along with other industries are feeling the pinch. Reports from the US and in Europe show that these industries are not immune to the financial crisis we are in. But if respective governments care enough about the implementation of renewable energy to avoid oil and coal dependency, and if the rhetoric we hear about 'saving the world' is really true, they will have to put real money on the table now. Words alas, can be a much cheaper option for an administration with epic financial problems to face.

www.powersystemsdesign.com/greenpage.htm

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Part Number	Package	V_{OFFSET}	V_{OUT}	IO+ & IO- (typical)	t_{ON} & t_{OFF} (typical)
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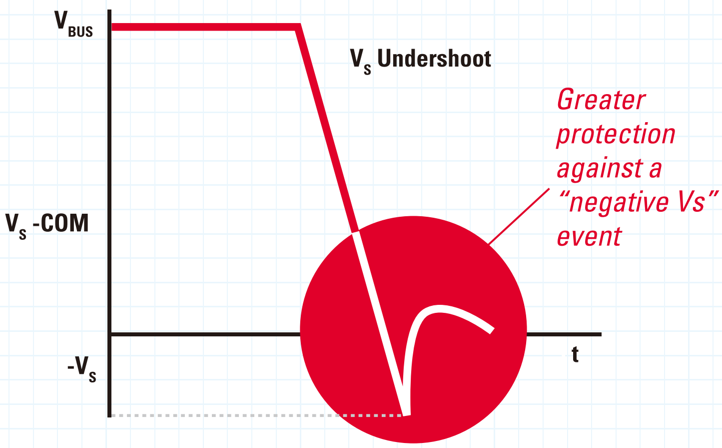
AUIRS2124S	SOIC8	600V	10V - 20V	500mA	140 ns & 140 ns



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