Design Article Archive

Abstracts of articles published in the January through December 2012 issues

January 2012:

Predictive Energy Balancing Enhances Control of Power Converters

by Tom Lawson, CogniPower, Malvern, Penn.

Abstract: Conventional pulse width modulation (PWM) control for switched-mode power supplies (SMPSs) must compromise two conflicting goals; stability versus agility. Various schemes for improving the outcome of the stability/agility compromise fill the literature, but do not dispatch the issue. However, a novel control technique known as Predictive Energy Balancing sidesteps the PWM control problem entirely. Through energy prediction, the phase lag of the output filter is removed from the feedback path. The underlying principle is that the voltage on the filter capacitor after the inductive energy from the switched inductor has been transferred can be calculated in advance. Given that information, the decision to switch from energizing the inductor to transferring inductive energy to the output can be made on the basis of the energy outcome at the end of the control cycle. That simple concept removes constraints that have long limited the performance of power converters. In this article, the underlying math and practical techniques for implementing Predictive Energy Balancing are explained, and experimental results are presented.

Notes: 6 pages, 5 figures. Read the full story…

Voltage-Mode Control Scheme Improves Buck Converter Performance At High Frequencies

by Suresh Kariyadan and Parviz Parto, International Rectifier, El Segundo, Calif.

Abstract: Higher operating frequency combined with jitter-free operation allows synchronous buck converter designs to run at higher closed-loop bandwidth, which results in the use of fewer output capacitors, saving board space and system cost. This article will explain the theoretical details of a new pulse-width modulator scheme for achieving jitter-free operation at high frequency and narrow duty cycle using a voltage-mode controller. This modulator scheme has been implemented in International Rectifier's IR3899 synchronous buck regulator, which also contains built-in features that provide enhanced flexibility in implementing point-of-load regulator designs. Test results will be presented to demonstrate the performance advantages of the new modulator scheme versus a traditional voltage-mode controller. In addition, the special features of the IR3899 will described.

Notes: 11 pages, 12 figures. Read the full story…

System-On-Chip Architecture Raises Performance Of Microstepping Motor Driver Designs

by Enrico Poli, Vincenzo Marano, and Giovanni Frezza, STMicroelectronics, Agrate, Italy and Schaumburg, Ill.

Abstract: In this article, a unique motor-drive architecture for microstepping will be presented. This architecture includes a novel approach to driving stepper motors based on voltage-mode control and an advanced motion engine controlled through an SPI interface. The novel voltage-mode approach

removes the need for sensing the motor's phase currents and eliminates the special efforts normally required in phase-current control systems to reach acceptable performance. In the end, this control method allows high microstepping resolution with an extremely reduced torque ripple. This control system has been integrated in a single-chip device, called dSPIN (the L6470), which also includes an advanced logic core that implements a set of positioning and speed commands, stall detection, as well as protection features. In this article, the key features and operation of dSPIN including its voltage-mode control technique are described and experimental results are presented.

Notes: 6 pages, 9 figures. Read the full story…

Current-Loop Control In Switching Converters Part 5: Refined Model

by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

Abstract: In the previous sections of this article, we have discussed the historical development of the various models of current-mode control, compared and contrasted those models, and derived various expressions that lay the groundwork for developing a refined version of the unified model originated by Tan and Middlebrook. Here in part 5, we now present a refined model of current-mode control that overcomes some of the limitations of the existing models that have been previously discussed.

Notes: 6 pages, 2 figures. Read the full story…

February 2012:

Livin' On The Edge: Switching Converter Slew Rate Is Key To Mitigating EMI In Automotive Environments

by Matt Jenks and Paul L. Schimel, International Rectifier, El Segundo, Calif.

Abstract: The state-of-the-art automobile can be viewed as a common chassis that attempts to enclose the RF soup that is radiated and conducted by an increasing plethora of onboard electronics. This spectral soup sees noise contributions from dc-dc converters running processors and computers, inverters running traction motors, choppers running pumps and many assorted motors, class D audio amplifiers, and switching converters for LED lighting and brush motor commutation to name a few. The primary focus of this piece is on the brushed dc motors and the choppers or drivers that run them. This article will discuss the noise output of these circuits, the applicable EMI standards and the points of sensitivity that drove those standards. The focus here will be on the edges of the switching converter waveforms and their impact on radiated noise.

Notes: 5 pages, 1 figure, 2 tables. Read the full story…

Design Article Archive

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A Guide To Selecting Battery Management Controllers When Designing Li-Ion UPS Systems

by Benjamin Sarpong, Texas Instruments, Dallas, Texas

Abstract: Uninterruptible power supply (UPS) systems based on lithium-ion (Li-ion) batteries are gaining market acceptance in niche markets. However, the system development of these units is quite fragmented. Every UPS manufacturer is incorporating a unique set of features. This lack of standardization makes it difficult for IC vendors to define battery-management controllers that provide an optimum set of capabilities at the right price point. As a result, chip makers must develop a number of different battery-management controllers for Li-ion UPSs. For UPS designers, the task of selecting the right battery-management controller requires an understanding of what features are available in these chips and how UPS design decisions impact the controller selection process and the complexity of their designs.

Notes: 4 pages, 2 figures. Read the full story…

Maximize The Accuracy Of Switching Loss Measurements In Power Supplies

by Michael Schnecker, Rohde & Schwarz, Columbia, Md.

Abstract: Measuring the loss of switching transistors in switched-mode power supplies requires significant dynamic range due to the low loss of these switching devices in the on state and the large voltage across them in the off state. While averaging is an effective way to improve the dynamic range of such measurements, the dynamic variation of the switching waveform results in distortions that limit the range of the measurement. This article explains the benefits of using an oscilloscope with a high effective number of bits (ENOB) and a high-resolution mode to measure switching loss. The combination of high ENOB and high-resolution mode can provide nearly the same performance as large averaging while preserving the waveform fidelity.

Notes: 8 pages, 10 figures. Read the full story…

Current-Loop Control In Switching Converters Part 6: Slope Compensation

by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

Abstract: The last installment of this article presented a refined model of current-mode control that provides a deeper unification of the quasi-static or low-frequency current-loop behavior with the sampling aspects by deriving the dynamics equations for transfer functions from the average current variable rather than the valley current. Here in part 6 of this series, the effect of slope compensation is included in the refined model. Specifically, we'll analyze the impact of three different slope-compensation schemes on the refined model, noting similarities and differences in the key waveform equations. We'll also note how the refined model with slope compensation compares to earlier models of current-model control. Finally, we'll examine the implications of this analysis in terms of establishing guidelines for converter design that ensure loop stability.

Notes: 12 pages, 1 figure. Read the full story…

March 2012:

Current-Loop Control In Switching Converters Part 7: F_{m0} In Models

by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

Abstract: This article on modeling of current-mode control concludes with a discussion of the PWM factor, F_{m0}. The refined model of current-mode control presented in part 5 is shown to be compatible with the major existing models when their limiting assumptions are factored in. This discussion refers back to expressions for the three slope-compensation methods derived in part 6. Finally, this lengthy process of modeling the current-loop ends by discussing the advantages and limitations of waveform-based models versus circuit-based models, and why it would be desirable to merge these two approaches.

Notes: 7 pages, 1 figure. Read the full story…

Magnetically Isolated Digital Coupling Circuit Solves Gate Drive and Communications Dilemmas

by Andrew Ferencz, Ferencz Consulting, Southborough, Mass.

Abstract: Power engineers often need digital isolation for a variety of reasons including controlling switches on the other side of an isolation barrier, driving high-side switches, passing communication signals, and using digital methods to encode analog signals such as a PWM signal. A variety of solutions exist in packaged form including optical, magnetic and even capacitive isolators. Each solution has some type of tradeoff in performance or key technology that differentiates it from its peers albeit at a cost. This article describes a simple digital isolation circuit based on a tiny toroidal pulse transformer. It achieves safety isolation by using triple-insulated wire and appropriate spacing between the terminals. Though comparable to a gate-drive transformer, the transformer developed for this digital isolation circuit is much simpler, smaller, and lower in cost.

Notes: 5 pages, 5 figures. Read the full story…

Failure Analysis On Power MOSFETs With Copper Wire Bonds

by Huixian Wu, Arthur Chiang, and David Le, Vishay Siliconix, Santa Clara, Calif.

Abstract: Copper wire bonds are being used increasingly in microelectronic components as a less expensive alternative to bonds made of gold. So far, the evidence indicates that copper is a viable alternative, but proving its reliability will require new failure analysis (FA) techniques that are specific to the copper wire-bonding process. In this article, the authors talk about new FA techniques and procedures that have been developed specifically for components using copper-wire technology. They

explain why copper wires need to be treated differently from gold and use case studies from power MOSFET devices to show a step-by-step example of an FA process designed to preserve all the evidence needed to perform an effective analysis on failed devices.

Notes: 16 pages, 17 figures. Read the full story…

Switch-Mode Rectifier Technology Reshapes Industrial Battery Charging

by Mike Kania, Eltek, Watchung, NJ

Abstract: Visit any electrical substation in the United States and chances are good that you will find switchgear powered from a battery system that uses silicon-controlled rectifier (SCR) or thyristor battery charger technology. These chargers are large and heavy relative to their power output, yet they have performed well for decades in applications where reliability and uptime are critical. Unfortunately, this record has resulted in a general perception that a battery charger must be built like a "battleship" to meet the needs of industrial sites. As a result many users are missing out on the significant benefits offered by modular power systems using switched-mode rectifier (SMR) technology. This article discusses those benefits.

Notes: 9 pages, 8 figures. Read the full story…

April 2012:

Utility Direct Technology Boosts Efficiency Of Fast Charging For Electric Vehicles

by Arindam Maitra, Electric Power Research Institute, Palo Alto, Calif.

Abstract: A team of engineers and scientists from the Electric Power Research Institute (EPRI) and Enertronics has developed a new type of fast battery charging technology for electric vehicles (EVs). Their medium-voltage fast charger technology is based on a solid-state transformer that will allow EV charging to interface directly with a utility's electric distribution delivery system. The Utility Direct Fast Charger technology uses fewer components than comparable dc fast charging technologies in use today, is expected to offer lower installation costs, and is significantly more efficient than existing systems. This article presents test results for a prototype of this fast charger technology, comparing its performance with that of conventional dc fast charging systems, which operate from lower input voltages. The article also discusses benefits of EPRI's Utility Direct Fast Charger technology and the underlying solid-state transformer concept that makes it possible.

Notes: 7 pages, 8 figures. Read the full story…

How To Correct Voltage Imbalance In Half-Bridge Converters Under Current-Mode Control

by John Bottrill, Texas Instruments, Dallas

Abstract: The half-bridge is a popular topology in today's power converter designs. However, a half-bridge converter operating under current-mode control has inherent issues that lead to oscillations. These issues are the result of slight imbalances in duty cycle and volt drops in the circuits, which cause the capacitors that terminate the primary winding to move slightly off the mid-point voltage into the converter. Current-mode control then leads to what can best be described as positive feedback to the current signal. This article examines the mechanism that leads to current imbalances in the primary winding of this converter, resulting in increased voltage imbalance. This article further explains how to overcome these imbalances while retaining current-signal integrity.

Notes: 5 pages, 6 figures. Read the full story…

Selecting A DSP Controller For Brushless Permanent Magnet Motor Drives

by Mala D. M., Varun Kumar H., Sudharshana, and Rakesh K. Dhawan, Strategic Technology Group, Ashburn, Va, U.S.A. and Pune, Maharashtra, India

Abstract: The selection of a proper controller for a motor drive application is one of the critical decisions that determines the success or failure of a project. There are numerous criteria to consider when choosing a controller and this article enumerates most of them. Specifically, this discussion focuses on the selection of a controller for applications employing brushless permanent magnet (PM) motors. Following a brief review of the operating principles of these motors and an overview of motor control requirements, the authors discuss controller selection criteria in depth while comparing the ability of MCUs and DSPs to meet these criteria. Ultimately, the authors make the case that DSP-based control is preferable to MCU-based control in brushless PM motor applications because of the special capabilities offered by digital signal controllers (DSCs.)

Notes: 13 pages, 3 figures, 3 tables. Read the full story…

May 2012:

More Boost With Less Stress: The SEPIC-Multiplied Boost Converter

by Bob Zwicker, Analog Devices, Olympia, Wash.

Abstract: The SEPIC-multiplied boost is a novel and tested topology for boost converters with moderately high boost ratios in the range of 10:1 to 50:1. This topology is suitable for applications with voltages ranging from as low as about 1.8 V on the input, up to perhaps 500 V on the output. The SEPIC-multiplied boost overcomes many of the disadvantages presented by other methods. For example, this topology significantly reduces the voltage stress on the main and rectifier switches without any accompanying significant increase in current stress. This widens and improves the choices in MOSFETs and Schottky rectifiers, where high voltage is often a problem. This article describes the origins and operation of the SEPIC-multiplied boost converter, compares this topology with other

boost topologies for obtaining high boost ratios, presents test results for an actual design example, and provides additional information about design variations and component considerations.

Notes: 19 pages, 20 figures, 6 tables. Read the full story…

Internal LDO Circuit Offers External Control Of Current Limiting

by Cornel Stanescu, Cristian Dinca, Radu Iacob and Ovidiu Profirescu, ON Semiconductor, Bucharest, Romania and Santa Clara, Calif.

Abstract: With low drop-out voltage regulators (LDOs), a key function that can be augmented is current limiting. In particular, giving designers external control of current limiting is useful as this enables them to limit power dissipation without resorting to overly complex methods. This article describes implementation of an control technique for LDO current limiting that offers a high degree of flexibility to design engineers. This approach allows designers to choose the optimum current for their specific circuit design simply by changing the value of an external resistor. Theoretical considerations, simulations and experimental results indicate the validity of the proposed technique, that it is fully functional, and that the LDO has a fast load-transient response.

Notes: 6 pages, 7 figures. Read the full story…

Why Use The Refined Model Of Current-Loop Converter Control?

by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

Abstract: If you've read through the author's seven-part series on modeling of current-loop control, but are still not sure how how to apply Feucht's refined model to your power supply designs, this "sequel" may help. In this piece, the author reviews the inadequecies of Spice-style circuit simulation and why math-based control-loop modeling such as that using waveform-based models can be advantageous when designing a power converter. The author reviews the similarities and differences between the existing models of current-loop control and his refined model, and concludes by noting the circumstances under which use of his refined model will more accurately predict converter performance.

Notes: 4 pages, 1 figure. Read the full story…

Troubleshooting EMI: Use Versatile Instrument And Preamp To Search For Embedded Noise

by Steve Sandler, Picotest, Phoenix, Ariz.

Abstract: Most engineers do not have convenient access to the equipment necessary for electromagnetic compliance (EMC) or electromagnetic interference (EMI) testing. Certified test labs, while readily available, and necessary for conformance testing, are a very expensive solution for troubleshooting EMI/EMC issues that ought to be addressed during product development. In this video, Steve Sandler demonstrates a test-setup that may be used to troubleshoot EMI during product design and development using readily accessible test equipment. While these same tests may be performed with various test instruments, two of the instruments selected for use in this demo—the

LeCroy Waverunner 610Zi oscilloscope with built-in spectrum analyzer and the Picotest J2180A preamp—offer a mix of performance, versatility, and cost that justifies their use in these measurements.

Notes: 2 minutes. View the Video…

June 2012:

Simple Control Method Tames Flux Saturation In High-Frequency Transformer-Link Full-Bridge DC-DC Converters

by Girish R. Kamath, Hypertherm, Hanover, NH

Abstract: The high-frequency transformer-link dc-dc converter is the preferred topology for low- and medium-power plasma-cutting applications since it is compact, light and provides good dynamic response along with galvanic isolation. However, such systems suffer from transformer-core flux saturation, which leads to problems such as an increase in converter switch loss and noise, power supply shutdown or even a catastrophic failure in some cases. Several solutions have been proposed, but each has its drawbacks. The simple method of transformer-flux control proposed here overcomes many of those disadvantages. This method maintains tight control of the transformer flux by steering the PWM output signal to the appropriate converter switch without affecting the main control loop. This enables full utilization of the transformer core without compromising the system's dynamic response. Furthermore, it can be retrofitted into an existing power supply with minimal impact on its circuitry.

Notes: 5 pages, 6 figures, 1 table. Read the full story…

IGBT Devices And Modules Evolve To Address Inverter Design Challenges In Electric And Hybrid-Electric Vehicles

by Jack Marcinkowski, International Rectifier, El Segundo, Calif.

Abstract: The mass adoption of electric vehicles (EVs) and hybrid electric vehicles (HEVs) depends on automakers achieving reductions in the cost, size and weight of electric power train systems, while simultaneously increasing their reliability. The industry struggles with these issues due to the relative immaturity of the existing power electronics systems. Standardization is needed to lower the cost of these systems. But automotive OEMs and their suppliers are seeking differentiation and looking for better, more cost-effective solutions to be more competitive. Innovative solutions in the form of improved semiconductor devices and modules are needed to overcome these conflicting goals. This article will discuss the challenges faced in the design of traction inverters for EVs and HEVs, explain how these challenges necessitate changes in IGBT devices and modules, and discuss recent trends and advances in device and module development with a focus on International Rectifier's CooliR technology.

Notes: 6 pages, 2 figures, 2 tables. Read the full story…

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July 2012:

Use Worst-Case Analysis Tool To Efficiently Validate Your Designs

by Ed Walker, Design/Analysis Consultants, Tampa, Fla.

Abstract: When it's time to validate their electronic circuit designs, many engineers depend on testing of prototypes and running of Monte Carlo simulations, believing that these two methods are sufficient to ensure design reliability. However, bench measurements and Monte Carlo analysis will not catch all potential design problems and the potential field failures that they miss can prove to be very costly. To truly validate a design, worst-case analysis is required. Design Master software allows engineers to efficiently and thoroughly validate their designs, using an advanced form of worst-case analysis called WCA+. This program provides a fully integrated set of analysis tools, including a worst-case solver, probability estimates for out-of-spec results, sensitivities, and optimum values. This article demonstrates how to use Design Master by going step-by-step through a simple analysis example.

Notes: 9 pages, 18 figures. Read the full story…

Making Sense of Two-Wire Current-Sense Resistors

by Steven Sandler, Picotest, Phoenix, Ariz.

Abstract: Four-wire sense resistors provide two power connections and two sense wires in order to make a precision measurement. Newer two-wire devices are available in values as low as 250 micro-ohms (μΩ), with wide pads to minimize inductance. In the most simplistic case, we could assume that a device such as this can be represented as a single resistor with two connections. But in real applications that assumption could lead to incorrect measurements as demonstrated in this article. Using a simple, but precise test set up, measurements are taken on a 1-mΩ 5% metal-foil current-sense resistor mounted to a small PCB. These measurements enable development of a finite element analysis model, which provides insights into the PCB's influence over the resistor's actual value in an application and what steps designers can take to obtain the desired or specified value.

Notes: 4 pages, 6 figures. Read the full story…

August 2012:

Silicon Carbide Power Solutions Are Ready To Revolutionize Motor Drives

by Paul Kierstead, Cree, Durham, N.C.

Abstract: SiC material refinements and new power device availability are enabling a revolution in the power conversion market. Nowhere will SiC advantages be more impactful than in motor-drive applications. In many cases, SiC power MOSFETs and Schottky diodes can replace silicon components such as IGBTs and fast-recovery diodes, offering significant improvement in energy efficiency and enabling system refinements that reduce overall system cost. In this article, the author illustrates these benefits by analyzing the impact of SiC power devices on a standard variable-frequency motor drive. This analysis covers all three power conversion sections within the motor drive—the dc-ac

power inverter responsible for driving the motor at variable speeds and torques; the ac-dc rectifier section, which frequently includes regen circuitry; and the auxiliary power supply, which is responsible for powering the digital control and other functions.

Notes: 8 pages, 9 figures. Read the full story…

Non-Dissipative Control Saves Power And Cost In Stepper Motor Applications

by Enrico Poli and Jean-Jacques Meneu, STMicroelectronics, Agrate, Italy

Abstract: A stepper motor needs to control the current in the coils in order to control the torque and speed of the motor. To obtain the desired current, the traditional method senses the current flowing through the motor and provides feedback to the controller chip, which then decides whether to increase or decrease the current in the coil. In general, this method has required the use of expensive, large and highly dissipative shunt resistors. However, this article will present two new innovative control techniques that avoid using these shunts resistors, and hence, decrease the cost, complexity and power loss of the application. The new, non-dissipative current-control solutions—which employ either current-mode control or voltage-mode control—are more elegant from a technical point of view. But on top of that, these solutions do not increase the cost of the application nor require extra room on the PCB as the power level increases.

Notes: 4 pages, 5 figures. Read the full story…

Testing Power Supply Compliance To Energy Efficiency Standards

by Silvestro Fimiani, Power Integrations, San Jose, Calif.

Abstract: Over the last several years, leading worldwide standards organizations including the Environmental Protection Agency's Energy Star program, the European Commission's Code of Conduct and the California Energy Commission (CEC) have defined new efficiency requirements for external power supplies. These standards demand that designers test their products for active-mode efficiency and no-load power consumption to high levels of accuracy. To help simplify that process and accelerate product development, this article will describe a relatively straightforward way to measure compliance to these evolving energy efficiency standards and offer a few testing tips.

Notes: 6 pages, 4 figures. Read the full story…

September 2012:

Maximize The Efficiency Of Induction Heating By Minimizing IGBT Losses

by Alan Ball, ON Semiconductor, Phoenix, Ariz.

Abstract: Induction cookers, which use electro-magnetically generated heat energy for cooking, are considerably more energy efficient than the standard household electric cookers. Within the typical induction cooker, a switched-mode power converter employing an IGBT power switch produces a

magnetic field, which is then converted to heat by the cooking vessel. Through proper selection and use of the IGBT, designers can minimize its losses in the induction cooker and thereby maximize the overall efficiency of the application. This article explains the principles of operation behind induction cooking and gives an overview of the various sources of loss in the application including those of the IGBT for the case where soft switching is employed. The two dominant losses in the IGBT—conduction and turn-off losses—are discussed in detail, providing designers with tips on how to accurately measure these losses so that IGBT performance in the application can be properly assessed and optimized.

Notes: 4 pages, 3 figures. Read the full story…

Automotive Battery And Component Technologies Address Start-Stop Design Challenges

by David Jacquinod, International Rectifier, El Segundo, Calif.

Abstract: Start-stop systems have become one of the most rapidly adopted "hybrid" technologies as vehicle manufacturers look to meet targets for improved fuel efficiency and lower pollutant emissions while keeping costs down. However, effective implementation of these systems poses a number of challenges for the designer, ranging from how to maintain a stable electricity supply to key systems during shut-off and restart operation to selecting components that will cope with the harsh automotive environment. At a system level, issues such as starter-motor technology and limitations on lead-acid batteries also need to be considered. This article looks at some of the key challenges facing automotive designers when implementing start-stop systems and introduces new and emerging technologies designed to address these challenges. These technologies include a replacement for the conventional lead-acid battery, and automotive-qualified power MOSFETs and gate-driver ICs.

Notes: 4 pages, 3 figures. Read the full story…

A More-Efficient Half-Bridge LLC Resonant Converter: Four Methods For Controlling The MOSFET

by Gordon Wang and Alex Lin, Fairchild Semiconductor, Taipei, Taiwan

Abstract: Using a half-bridge LLC resonant converter in a power application can deliver higher efficiency and a more-compact design. The primary MOSFET of the LLC resonant converter can easily reach zero voltage switching (ZVS) and zero current switching (ZCS), and that saves energy. Also, because the circuitry of the LLC resonant converter works without a storage inductor on the secondary side, the PCB is smaller. LLC resonant converters typically use a secondary-side synchronous rectifier (SR) that operates in boundary conduction mode (BCM) or discontinuous conduction mode (DCM). But, regardless of the operating mode, current in the secondary-side SR can introduce power losses and reduce the overall efficiency of the design. One way to reduce these losses is to use detection signals to control the turn-on and turn-off of the MOSFETs. This article describes four different methods for doing so.

Notes: 8 pages, 10 figures, 1 table. Read the full story…

Design Article Archive

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October 2012:

Frequency-Foldback Technique Optimizes PFC Efficiency Over The Full Load Range

by Joel Turchi, ON Semiconductor, Toulouse, France

Abstract: "Green requirements" such as 80 PLUS aim to maximize power supply efficiency across a range of load conditions. So it has become critical that power supply designers address medium- and light-load efficiency in the PFC power stage. A popular approach to lowering losses under lighter load conditions is to reduce the switching frequency (frequency foldback.) While extremely efficient at very low power, this solution must be carefully implemented at intermediate power levels. This article clarifies how the switching frequency should be managed in a PFC boost converter to maximize efficiency across the load range. The converter's MOSFET losses are analyzed under critical-conduction and discontinuous-conduction modes of operation. Then the operating principles for a relatively new method of frequency reduction, known as current-controlled frequency foldback (CCFF), are explained. This article also discusses the operation of controllers using CCFF and presents experimental results.

Notes: 11 pages, 8 figures. Read the full story…

Techniques For Implementing A Positive And Negative Output Voltage For Industrial And Medical Equipment

by Rich Nowakowski, Texas Instruments, Dallas, Texas

Abstract: Many analog circuits in industrial and medical applications require both positive and negative supply voltages. A discrete switching regulator is often used to derive both positive and negative output voltages, but implementing an inverting buck-boost topology with a coupled inductor can be burdensome. However, recent advancements in dc-dc modules allow straightforward implementation of a split-rail power solution. This article surveys several discrete and module-based negative output and split-rail positive and negative output solutions for powering split-rail amplifiers, analog sensors, data converters, and audio amplifiers. Key factors such as complexity, component count, relative cost, and performance are explored.

Notes: 6 pages, 6 figures, 1 table. Read the full story…

Process, Packaging Combine To Advance High-Voltage Power MOSFETs

by Vipin Bothra, STMicroelectronics, Schaumburg, Ill.

Abstract: There's a significant amount of design activity today in power management involving voltages between 400 V and 1700 V, with the bulk of interest around 600 V at 2 kW. Applications include switched-mode power supplies, motor control, industrial machines, hybrid electric vehicles, and many others. Market pressures to make these end products smaller and more efficient place tremendous demands on the power components, especially the power MOSFETS. In response MOSFET vendors are improving the performance of their devices through advances in their process technology and packaging. This article discusses two examples of recent advances by STMicroelectronics—the

MDmeshV process and the HV PowerFLAT 8×8 package. Data is presented to illustrate the improvements in device performance made possible by these innovations.

Notes: 5 pages, 6 figures. Read the full story…

November 2012:

Understanding Industrial System Structures Is Key To Powering Them

by Paul Greenland, MagnaChip, Cupertino, Calif.

Abstract: An efficient, compliant power conversion solution solves many of the problems endemic in the industrial environment. Decoupling complex loads from conducted interference, power spikes, surges and dropouts are just some of the many benefits of a well-specified power conversion system. This article aims to describe the fundamental elements of industrial control and monitoring systems and explain how these elements dictate requirements for power conversion. It discusses the basic structure and operation of SCADA systems, the importance of sensors and related functions, and the significance of EMI. In describing the impact of industrial system requirements on power conversion, the focus here will be on the dc-dc converters used in these systems.

Notes: 5 pages, 4 figures, 1 table. Read the full story…

How To Minimize Core Saturation

by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

Abstract: Saturation can be a limiting factor in the design of many magnetic components. Multiple component parameters such as core type (including material and geometry) and number of turns, as well as circuit parameters such as winding current and field current influence the degree of saturation seen in the application. Because the relationships among these parameters are not always obvious, determining the conditions required to minimize saturation can be challenging. In this article, the author provides an analysis of saturation that determines the optimum current waveform characteristics and number of turns required to minimize peak saturation for a given core type.

Notes: 4 pages, 1 figure. Read the full story…

Beyond Power Management: Power Engineers Must Also Solve ESD, EMI, and RFI Problems

by Bill Laumeister, Maxim Integrated Products, San Jose, Calif.

Abstract: The label "one size fits all" is rarely true when used to describe clothing and it most certainly does not apply to power management in ICs. Knowing that, we can focus attention on the 20%/80% rule to produce a well-designed power-management circuit. Following this principle, the power designer must consider all the potential disruptions to a steady flow of power and the various

ways to mitigate them. These disruptions include overvoltage, overcurrent, and interference conditions due to RFI, EMI, EMS, and ESD. This article, suggests voltage- and current-limiting devices and risetime reducers to manage the power. It also points to free and low-cost software tools to help design lowpass filters, check capacitor self-resonance, and simulate circuits.

Notes: 3 pages, 2 figures. Read the full story…

December 2012:

Hardware-Software Architecture Improves Performance Of Large, Battery-Powered Systems

by Eric Macris and John Bendel, Element Energy, Los Altos, Calif.

Abstract: The development of hybrid/electric vehicles and the proliferation of renewable, highly efficient grid-tied energy promise a cleaner environment and more-stable energy future. Central to these transformations, the adoption of large, multi-cell battery packs has accelerated rapidly. Yet, even with today's most-advanced designs, these large battery packs pose fundamental limitations. This article explores the development of a new, integrated hardware and software technology for managing battery-powered systems. This new approach enables cost-effective, continuously variable control of each individual cell in a battery pack, while integrating the functions of voltage stabilization, voltage up-conversion, and battery management. Prototype testing has confirmed that this approach to battery management enables battery pack designers to expand the performance envelope to achieve multiple benefits including an extension of battery cycle life, an increase in run time, a reduction in charging time with no penalty, and even reduced system cost.

Notes: 13 pages, 12 figures. Read the full story…

Impact Of High-Performance Computing Technology On Power Conversion

by Paul Greenland, MagnaChip, Cupertino, Calif.

Abstract: The evolutions of computers and power supplies are inextricably linked. In fact, the first PC manufacturers had captive power supply design groups to satisfy management concerns that the power supply was the weak link in the reliability chain. Historically, that may have been the case as the power supply technology was "pulled" by the computer technology. Nowadays, the evolution of power supplies and the evolution of computing load architectures are in lockstep, a critical requirement for the successful development of a high-performance computing system. In this article, the author traces the development of power system architectures for computing systems, detailing the influence of microprocessor development and other application trends on power conversion requirements.

Notes: 5 pages, 4 figures. Read the full story…