Design Article Archive

Abstracts of articles published in the January through December 2010 issues

January 2010:

Increase Boost Regulator Efficiency With Synchronous Rectification

by Bob Bell and Kim Nielson, National Semiconductor, Phoenix, Ariz.

Abstract: Boost power converters are the most common topology used for applications where the required output voltage is larger than the input voltage. While this topology is inherently very efficient, there is an often unexplored opportunity to increase the efficiency further. Though more commonly used in buck converters, synchronous rectification techniques can also be applied to enhance the efficiency of boost converters. After a brief review of boost converter operation, this article presents a design example of a converter with 12-V input and 24-V 6-A output. A prototype of this converter is built and its efficiency is measured in two configurations—with synchronous and nonsynchronous rectification. The article discusses these results and notes the design factors that influence the efficiency of synchronous boost converters.

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

*Testing Military Grade Magnetics: Transformers, Inductors and Coils**

by Paul Vrabel, Sandia National Laboratories, Albuquerque, NM

Abstract: Engineers and designers are constantly searching for test methods to qualify or "prove-in" new designs. In the high-reliability world of military parts, design test, qualification tests, in-process tests and product characteristic tests, become even more important. The use of in-process and function tests has been adopted as a way of demonstrating that parts will operate correctly and survive their "use" environments. This article discusses various types of tests to qualify the magnetic components—the current-carrying capability of coils, a next-assembly "as used" test, a corona test and inductance at temperature test. Each of these tests addresses a different potential failure on a component. The entire process from design to implementation is described.

**This paper was originally presented at the 2009 Electrical Manufacturing & Coil Winding Expo in Nashville, Tenn.*

Notes: 9 pages, 5 figures. Read the full story...

PFC Efficiency Improvement Using SiC Power Schottky Rectifiers

by Frederic Gautier and Cyril Borchard, STMicroelectronics, Tours, France

Abstract: With the recent introduction of new energy-saving regulations, power-supply designers are now confronted with stringent requirements for power efficiency. These requirements are forcing designers to consider the use of new power converter topologies and more-efficient electronic components such as high-voltage silicon-carbide (SiC) Schottky rectifiers. Use of SiC Schottky rectifiers in place of comparable silicon rectifiers can improve the efficiency of the active power-factor correction circuitry that's found in many SMPS designs. But to maximize the effectiveness of SiC Schottkys, power supply designers should understand the underlying technology and the key device parameters that must be considered when designing SiC Schottky diodes into an SMPS.

Notes: 12 pages, 18 figures. Read the full story...

February 2010:

Reverse-Current Phenomenon In Synchronous Rectifiers

by Suresh Kariyadan, International Rectifier, El Segundo, Calif.

Abstract: When a diode is replaced with MOSFETs for rectification, one important difference between the diode and MOSFET is that the diode is a unidirectional device whereas the MOSFET is a bidirectional device. No matter how the converter operates, the diode can block the reverse current while the MOSFET cannot. Synchronous rectification can force continuous current in the output choke and current becomes negative under no-load and light-load conditions. In addition to reducing efficiency at light load, the reverse current can cause a hard failure in a power supply. This article discusses how converter operating conditions create reverse currents and presents techniques for controlling these currents to prevent hard failures in nonisolated buck converters as well as isolated dc-dc converters where synchronous rectification is employed on the secondary side.

Notes: 7 pages, 9 figures. Read the full story...

*An Overview and Simulation Of DC-DC-AC And Z-Source Grid Connected Inverters**

by Veda Prakash Galigekere, Dakshina Murthy Bellur, and Marian K. Kazimierczuk, Wright State University, Dayton, Ohio

Abstract: Energy sources such as batteries, fuel cells, capacitors, solar cells etc., produce dc power, and it is often necessary to interface these sources to the main power grid. The dc voltage generated is stepped up and inverted to the appropriate voltage and frequency for grid integration by power electronic (PE) interface modules employing dc-dc converters and dc-ac inverters. This paper presents an overview of two of the possible methods of inversion: dc-ac inversion with a dc-dc converter interface, or single-stage Z-source based dc-ac inversion. These two approaches are described and design examples are presented for a typical 1-kW application. The circuit designs are verified with the aid of Saber Sketch simulation software and first-cut design procedures are presented that help power supply designers reduce the design time.

**This paper was originally presented at the 2009 Electrical Manufacturing & Coil Winding Expo in Nashville, Tenn.*

Notes: 14 pages, 9 figures. Read the full story...

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Small-signal Analysis, Modeling And Design Of A Synchronous Buck-Converter In Voltage-Mode Control

by Dr. Sunil Akre, Maxim Integrated Products, Sunnyvale, Calif.

Abstract: Non-isolated synchronous buck conversion is the topology of choice for point-of-load dc-dc converters. Although many buck converters use forms of current-mode control, voltage-mode control is gaining popularity in next-generation systems. Voltage-mode control is robust and easy to understand and while its control-loop compensation is more complex than that of peak-current-mode control, voltage-mode control allows better optimization of bandwidth. To help engineers understand and optimize converter design, this article provides a detailed derivation of the full-order small-signal analysis and modeling of a synchronous buck converter in voltage-mode control. After the transfer functions are derived, they are employed in a simple step-by-step design procedure. A prototype converter is developed and the results are compared with the analysis.

Notes: 20 pages, 13 figures. Read the full story...

Case Study: Flared Pin Fin Heat Sink Keeps LED Light Burning Brightly

by Barry Dagan, P.E., Cool Innovations, Concord, Ontario, Canada

Abstract: An inadequate cooling solution threatened to limit the performance of an LED lighting module. The aluminum extrusion heat sink that was used to cool the 65-W LED module allowed a temperature rise beyond the module's allowed temperature limit. To improve cooling, tests were conducted on the extrusion and two pin fin heat sinks. As described in this article, a flared pin fin heat sink of similar size to the extrusion offered significantly lower thermal resistance than the extrusion and met the temperature spec of the application. Results described here may be applied to power devices that, like the LED module, require natural convection cooling.

Notes: 3 pages, 1 table. Read the full story...

March 2010:

Digital Isolators: A Space-Saving Alternative to Gate-Drive Transformers in DC-DC Converters

by Bob Bell, National Semiconductor, Phoenix, Ariz. and Don Alfano, Silicon Labs, Austin, Texas

Abstract: Pulse transformers have long been the most commonly used method to isolate gate-drive signals in isolated dc-dc converters. These devices provide excellent isolation but have limitations when operating at the high duty cycles encountered when driving synchronous rectifier MOSFETs in half-bridge and full-bridge topologies. A new alternative to pulse transformers, fully integrated digital isolators employ RF coupling techniques to transmit digital information across an isolation barrier. In this article, the principles of operation and benefits of digital isolator technology will be discussed and a half-bridge dc-dc converter reference design employing digital isolators will be presented.

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

Design Article Archive

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*Modeling of Integrated Magnetics Components**

by Mark Christini, Ansoft Corporation, Pittsburgh, PA and Roberto Prieto, Universidad Politécnica de Madrid (UPM), Madrid, Spain

Abstract: Integrated magnetics, the building of transformers and inductors on the same magnetic core, allow designers to reduce component size, losses, and flux ripple. However, the design of integrated magnetic components is not a trivial task because the selection of the core, air gaps and winding setup is not obvious. Ansoft's PExprt software is capable of creating accurate models for these complex components, allowing the designer to select the appropriate winding strategy without time-consuming prototyping iterations. PExprt uses finite element analysis techniques to generate frequency-dependent models of integrated magnetic components, which include the materials and winding layout. In this article, we demonstrate how to use PExprt to model a push-pull forward converter with integrated magnetics for a 48-V Voltage Regulator Module with a 1.2-V and 70-A output.

**This paper was originally presented at the 2009 Electrical Manufacturing & Coil Winding Expo in Nashville, Tenn.*

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

Software Speeds Transformer Design For AC-DC Power Supplies

by Sameer Kelkar, Power Integrations, San Jose, Calif.

Abstract: Spurred by energy-efficiency regulations, switch-mode power supplies (SMPSs) are rapidly replacing traditional linear power supplies even in relatively low-volume markets where the complexity of SMPSs has been a barrier to their adoption. This trend is aided by the development of integrated control ICs and powerful design software, which has simplified power supply design for many applications. To illustrate the impact of a controller IC with optimized design software, this article will present an ac-dc power supply design example based on the TopSwitch-HX controller IC. Using the vendor's PI Expert design software, an optimized design will be generated including a transformer design complete with detailed instructions on its mechanical construction.

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

Integrated Protection and Careful Layout Protect PoE Systems from EOS and ESD

by A. Bremond and C. Appere, STMicroelectronics, Tours, France

The IEEE-802.3af standard defines equipment for supplying power via an Ethernet cable. But as is usually the case when electrical devices are connected by cables, those devices are subject to interference from electrostatic discharge (ESD) and electrical over stresses (EOS). This article reviews the operating principles of Power over Ethernet (PoE) systems, describes the EOS and ESD standards that PoE systems must comply with, and presents a new, more cost-effective solution for PSE-side

protection that reduces pc board-space requirements, while also improving protection of the PSE controller. The importance of PCB layout in suppressing ESD is also discussed.

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

April 2010:

Why Struggle With Loop Compensation?

by Michael O'Loughlin, Texas Instruments, Dallas, TX

Abstract: In the power supply design industry, engineers sometimes have trouble compensating the control loop for their power supply. They try to get the loop to cross over at a very high switching frequency in an attempt to improve large-signal transient response, only to end up struggling with stability issues. One of the most popular control methods in power supply design is peak current-mode control. Even though this method is supposed to be easier to compensate than voltage-mode control, some power supply designers still struggle with compensating the voltage loop. This is because they are unaware of the double pole that occurs (at roughly half the switching frequency) in the control-to-output transfer function. This article describes a method for compensating the voltage loop using a network analyzer and following a few simple rules to ensure stability.

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

Scoping Out The Best DC-DC Converter Design

by Jeff Perry, National Semiconductor, Santa Clara, Calif.

Abstract: With today's proliferation of nonsolated, dc-dc converter solutions, there are a wide variety of options for fulfilling a power supply requirement. When considering embedded solutions, finding the optimum embedded dc-dc solution is not a simple matter even if you've narrowed your search to a single power IC vendor. For a given set of power supply input and output requirements, there may be 50 or more possible designs. To determine which design works best in the application, designers need to establish goals for their power supply such as low cost, small footprint or high efficiency. Unfortunately, these goals are frequently in conflict with each other, adding to the complexity of finding the right solution. To address these challenges, semiconductor vendors are developing more-sophisticated product selection tools, which go beyond simple parametric searches and look-up tables, crossing into the realm of power supply design. This article demonstrates how to use one such tool, National Semiconductor's WEBENCH Visualizer, which allows real-time comparison between a large number of power supply design options.

Notes: 8 pages, 6 figures. Read the full story...

May2010:

Power Supply Topology Selection – It's Not Just About Power

by Frank Cathell, ON Semiconductor, Phoenix, Ariz.

Abstract: When discussing power circuit topologies, most application notes, charts, and articles tend to imply that the selection of a given topology is dependent on the output-power level required by the application. Unfortunately, this criterion for topology selection is, by itself, generally insufficient and can lead to inadequate performance, low efficiency and unreliable power supply designs. This article will address the additional specification elements and/or circuit subtleties of the more-common topologies that must be considered when trying to select the optimum power supply topology.

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

Lost in Space:
Unpredictable Aging Can Send Resistor Accuracy Way Off Course

by Steve Sandler and Charles Hymowitz, AEi Systems, Los Angeles, Calif..

Abstract: Commercially available M55342 chip resistors specify tolerances as tight as 1% with aging on the order of 0.2% after 10,000 hours. Unfortunately, such specifications do not predict how resistors will age when subjected to the extreme temperatures encountered in space. So what is an appropriate aging tolerance for film resistors? To answer this question, designers may turn to the many specification and guideline documents that offer aging tolerances for resistors in space applications. Unfortunately, these specifications are often ambiguous, arbitrary or even contradictory. In this article, an attempt is made to analyze the aging tolerance of M55342 chip resistors from different perspectives, assess the validity of the different guidelines on resistor aging, dispel common myths, and suggest possible solutions for dealing with the unpredictability of resistor aging.

Notes: 12 pages, 3 figures. Read the full story...

*Effects Of Load Changes On The Control-to-Output Transfer Function Of A Buck-Boost Converter In CCM**

by Julie J. Lee and Marian K. Kazimierczuk, Wright State University, Dayton, Ohio

Abstract: A buck-boost converter reduces and increases dc voltage from one level to another. A buck-boost converter can operate in either continuous-conduction mode (CCM) or discontinuous-conduction mode (DCM), depending on the inductor current waveform. In CCM, the inductor current flows continuously for the entire period. In this paper, a small-signal model of a buck-boost converter in CCM is presented and the control-to-output transfer function is derived. The effects of load change on the control-to-output transfer function are then studied.

**This paper was originally presented at the 2009 Electrical Manufacturing & Coil Winding Expo in Nashville, Tenn.*

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

HOW2POWER TODAY

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June 2010:

How2 Get The Most Out Of GaN Power Transistors

by Johan Strydom, Efficient Power Conversion, El Segundo, Calif.

Abstract: Thirty years of silicon power-MOSFET development has taught us that one of the key variables controlling the adoption rate of a disruptive technology is how easy the new technology is to use. This principle has guided the design of EPC's enhancement-mode GaN (eGaN) transistors. This article explains why eGaN devices are easy to use, describing how they operate and their similarities and differences versus power MOSFETs. With that as background, the article explains the gate-drive requirements for eGaN transistors, and presents suitable discrete and IC-based gate-driver designs for use with eGaN devices.

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

How To Design A 250-W HID Electronic Ballast

by Tom Ribarich, International Rectifier, El Segundo, Calif.

Abstract: Typical outdoor lighting applications today use high-intensity discharge (HID) lighting technology. HID lamps are difficult to control and the design of the electronic HID ballast to drive them is complex. Some of the functions performed by the electronic HID ballast include ignition, warm-up, constant power control, power factor correction, and protection against all lamp and ballast fault conditions. This article describes an electronic ballast circuit for a 250-W HID lamp using the new IRS2573D HID control IC. Fundamental lamp requirements and control methods are presented, as well as complete circuit schematics and waveforms.

Notes: 7 pages, 5 figures Read the full story...

*Comprehensive Flux Estimator Implementation Procedures For Advanced Control Of Inverter-Fed Induction Machines**

by Ali M. Bazzi and Philip T. Krein, Grainger Center for Electric Machinery and Electromechanics, Department of Electrical and Computer Engineering, University of Illinois at Urbana-Champaign, Urbana, Ill.

Abstract: This paper presents the implementation of a flux estimator for induction machines. Both stator and rotor flux are estimated using the back-EMF method. A procedure for the implementation, calibration, and testing of this estimator on a digital signal processor is given. The procedure is intended for applications in which the estimator is essential but not a primary system development target. The work presented here can be extended to other estimators, especially for advanced inverter-fed motor control applications.

**This paper was originally presented at the 2009 Electrical Manufacturing & Coil Winding Expo in Nashville, Tenn.*

Notes: 18 pages, 19 figures. Read the full story...

Increasing Active-Mode Efficiency And Reducing Standby Power For Energy Star

by Majid Dadafshar, Fairchild Semiconductor, Carlsbad, Calif.

Abstract: As the need to meet green initiatives becomes more pressing, the International Energy Association will be mandating that suppliers of electronic equipment reduce the power consumption of their systems below 1 W, 0.5 W or even 0.25 W when operating in the standby mode. To reduce this wasted energy below the desired limits, we need to both improve consumer awareness of the problem and improve the available power supply technologies. This paper focuses on the technology side, discussing the main sources of loss in ac-dc power supplies and techniques for reducing these losses during active and standby modes of operation.

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

July 2010:

How To Control Phase Voltage Ringing In Synchronous Buck Converters

by Suresh Kariyadan, International Rectifier, El Segundo, Calif.

Abstract: In synchronous buck converters, fast switching of the MOSFETs can cause high-voltage spikes and ringing at the phase node. These effects are undesirable because they can cause increased power dissipation, higher voltage stress on the switching devices, higher EMI, and higher peak-to-peak output ripple and noise at higher bandwidth. In this article, an integrated buck converter is used to study the undesired voltage spikes and ringing at the phase node caused by fast switching. The focus here is mainly on the peak-to-peak output ripple voltage that occurs at higher bandwidth. Experiments are conducted to gauge the impact of different methods used to control this ringing, and the pros and cons of these methods are discussed.

Notes: 11 pages, 7 figures. Read the full story...

Integrating Statistics And Manufacturing Data Into Simulation of Permanent Magnet Motor Drives

by Rakesh Dhawan and Amitabh Mallik, Strategic Technology Group, Pune, India

Simulating motor drives using Spice, Simulink or other tools is a great way to verify a concept or basic system performance. And through the use of Monte Carlo (MC) and worst-case analysis (WCA), a reasonable estimate of the performance probability distribution can be made. However, MC and WCA techniques are based on assumptions of a normal probability distribution and linear correlations between various system parameters. These techniques are not sufficient in predicting realistic system performance. In this paper, we propose techniques to modify MC and WCA through the integration of manufacturing data to explain and predict abnormal correlations between various system parameters such as those that occur when a production ramp up takes place. These techniques are tested and verified on a permanent magnet brushless motor drive system.

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

Rediscovering The Integrated-Magnetics Isolated Ćuk Topology

by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

Although much has been written about Ćuk-derived converters, there are still many misconceptions regarding this class of topologies and the design considerations are generally not well understood. For instance, the claim that Ćuk-derived converters are free of ripple current on the converter's input and output is only conditionally true. Another point that designers should understand is that a flyback converter with primary and secondary ripple-current steering is equivalent to the isolated Ćuk converter. In addition, there are certain figures-of-merit that play an important role in optimizing the performance of Ćuk-derived converters. One of the most underutilized of these converters is the magnetically-integrated IsoĆuk (IMIC) converter. In this article, the design considerations for this variety of the optimal converter topology are discussed.

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

August 2010:

How To Submit A Device For Failure Analysis

by Paul L. Schimel PE, International Rectifier, El Segundo, Calif.

Abstract: As a field applications engineer, (FAE), the author receives at least one call a week from a customer who has submitted a semiconductor device for failure analysis (FA) and then received a report back that provided no real insights into why the part failed. It turns out there's much more to failure analysis than simply sending in a charred component. In this feature, the author describes a logical process for submitting failed devices to a semiconductor supplier that will give customers the greatest likelihood of obtaining meaningful results. He discusses issues such as when in the design process you should submitted failed devices for analysis, how the FA lab operates, what materials you should submit, and what you should expect to see in an FA report. The author also explains how the local FAE can support this process, and why you'll want to consult that person sooner rather than later when you're experiencing device failures.

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

SIMPLIS Simulation Tames Analysis Of Stability, Transient Response, And Startup For DC-DC Converters

by Timothy Hegarty, National Semiconductor, Tucson, Ariz.

Abstract: This article demonstrates a circuit simulation of a non-isolated dc-dc converter that allows us to explore the converter's load-transient behavior, control-loop stability and output-voltage startup characteristic (all of which are interrelated). The simulation, which is based on a full time-domain, non-linear, switching model of the converter, is essentially a "virtual prototyping" tool that gives the designer several well-known benefits. Among these are fewer PCB spins, early identification of design errors, shortened design time, and ultimately, reduced engineering cost. Aside from the simplicity and flexibility of the simulation process described here, its convenience renders it viable for everyday use

by the practicing power electronics engineer. With this approach, there's no need to derive averaged models of the converter or identify the current-loop sampling gain contribution.

Notes: 11 pages, 10 figures. Read the full story...

September 2010:

Powering RF Systems: Why So Many Power Supply Designs Have Problems And What IC Suppliers Should Do About It

by Steve Sandler and Charles Hymowitz, AEi Systems, Los Angeles, Calif.

Abstract: Many power supply designs used to power microwave and RF applications simply don't work as well as they need to. From the simplest linear regulators, to the switching converters, all the way up to the complete distributed power systems, these designs often fail to meet key specifications such as stability, regulation, ripple, and headroom. This feature examines the variety of technical reasons why these power supply designs perform poorly. It also demonstrates that, in many cases, the problems can be traced back to a lack of adequate information from the power component vendors. Their datasheets simply don't tell RF system designers what they need to know to develop power conversion circuitry. Nevertheless, this problem presents a great opportunity. And as the authors comment, power IC developers and FAEs—if they are willing—can do a lot to help. The article concludes with an intriguing list of "The Top Ten Things RF Engineers Should Know About Voltage Regulators."

Notes: 8 pages, 5 figures. Read the full story...

Debunking An Old Myth: Those New Devices Will Fall Off The Board

by Paul L. Schimel PE, International Rectifier, El Segundo, Calif.

Abstract: In the past, leadless semiconductor packages (those with no protruding pins) were something to avoid in the power electronics world. The "forbidden" leadless packages were the BGAs, flip chips, and what we now know as the PQFN packages. Back then, you needed the leads protruding from the package for a little compliance. The coefficient of thermal expansion (CTE) for the plastic package was fairly different from that of the system consisting of the printed circuit board (PCB), traces and solder. Without leads that could flex a little bit, eventually the solder would fracture and failure would ensue. But times have advanced as have the materials. The issue of CTE mismatch is no longer a reason to forego using leadless packages. Nevertheless, when semiconductor FAEs like the author recommend these packages to customers, they still hear this response: "We can't use those devices—they will fall off the board." To assure customers that the leadless devices are safe, the author investigated the CTEs of packaging and board materials. His findings are presented here.

Notes: 3 pages 1 table. Read the full story...

Embed Your Planar Magnetics To Maximize DC-DC Converter Performance (Part 1)

by Harold Eicher, Champs Technologies, East Setauket, NY

Abstract: Compared with wire-wound magnetic devices, planar magnetics offer advantages such as low profile, improved efficiency, and easier thermal management. However, the time is now for many design engineers to contemplate the switch from the discrete planar magnetic devices to embedded magnetics structures. With embedded planar magnetics, the copper windings for inductors or transformers are formed directly on the user's PCB and magnetic cores are then assembled over these windings. This approach enables a higher level of design optimization than the discrete planar approach. In this article, the author demonstrates how embedded planar magnetics can be applied to achieve enhanced performance in a digitally controlled dc-dc converter design. The magnetics design described here was originally developed as part of Microchip Technology's reference design for a dc-dc converter based on the dsPIC33F digital signal controller. In part 1 of this article, procedures are described for designing the main transformer.

Notes: 10 pages, 5 figures, 1 table. Read the full story...

October 2010:

How2 Understand eGaN Transistor Reliability

by Yanping Ma, PhD, Efficient Power Conversion, El Segundo, Calif.

Abstract: In June 2009, Efficient Power Conversion introduced the first enhancement-mode gallium nitride-on-silicon power transistors designed specifically as replacements for power MOSEFTs. These high electron mobility transistors were subjected to a wide variety of stress tests under conditions that are typical for power MOSFETs used in switch-mode power conversion. These tests included numerous tests to assess device stability under various bias, temperature, and humidity conditions as well as operational life under dc-dc converter operating conditions, and ESD testing. This article explains how these tests were conducted, what the results mean to power supply designers, and how they validate the readiness of the new GaN devices for use in commercial applications. In addition, the article discusses various mechanisms for device degradation and how they were addressed by EPC in their device designs. Areas targeted by EPC for improvement in future device designs are also discussed.

Notes: 12 pages, 9 figures, 2 tables. Read the full story...

The Over-Power Phenomenon In DCM/CCM-Operated Flyback Converters (Part 1)

by Christophe Basso, ON Semiconductor, Toulouse, France

Abstract: A flyback converter is typically designed to operate over an input-voltage range, characterized by low-line and high-line levels. Between these two input voltages, the converter must deliver its nominal power output. This requires that the designer include margin in calculations to account for production tolerances and ensure the delivery of nominal power under worst-case situations. But, this design margin, which benefits the converter at low line, may double the output-power capability of the converter under high-line conditions. This multi-part article series explore the origins of this excess power and how it can be controlled so that output power remains within a reasonable range. Part 1 focuses on flyback converters operating in discontinuous-conduction mode (DCM). As the article series continues, it will explore what happens when the converter transitions from continuous-conduction mode (CCM) to DCM, the case of quasi-resonant operation, and the influence of leakage inductance on power transfer.

Notes: 13 pages, 10 figures. Read the full story...

Embed Your Planar Magnetics To Maximize DC-DC Converter Performance (Part 2)

by Harold Eicher, Champs Technologies, East Setauket, NY

Abstract: In this article series, the author argues that the time is now for many design engineers to switch from discrete planar magnetic devices to *embedded* magnetics structures. With embedded planar magnetics, the copper windings for inductors or transformers are formed directly on the user's PCB and magnetic cores are then assembled over these windings. This approach enables a higher level of design optimization than the discrete planar approach. Here in Part 2, the author continues to explain the procedures used to design the main transformer TX1 that was developed for use in a digitally controlled dc-dc converter. This part of the article focuses on estimating ac copper losses in the PCB windings for TX1.

Notes: 10 pages, 2 figures, 1 table. Read the full story...

November 2010:

High Step-Down Ratio Buck Converters With eGaN Devices

by Johan Strydom, Efficient Power Conversion, El Segundo, Calif. and Bob White, Embedded Power Labs, Highlands Ranch, Colo.

Abstract: The intermediate bus architecture (IBA) is currently the most popular power system architecture in computing and telecommunications equipment. However, it is coming under scrutiny. Some companies using a +48 V system power distribution bus with on-board bus converters and point-of-load regulators (POLs) are wondering if they can simplify their systems. For them, a single "POL" that converts the +48 V system bus directly to the load voltages is a very intriguing idea. Until now, the limitations of silicon MOSFET technology have made it impractical to design such a POL and produce it commercially. This article discusses how recently introduced gallium-nitride (GaN) power devices have overcome these hurdles, making it feasible to build POLs with the high stepdown ratios needed to generate 1 V or less directly from a 48 V bus. Experimental results are presented for two high-stepdown-ratio buck converters—one built with state-of-the-art 60 V silicon devices and another built with eGaN devices.

Notes: 15 pages, 15 figures, 3 tables. Read the full story...

The Over-Power Phenomenon In DCM/CCM-Operated Flyback Converters (Part 2): Fixed-Frequency CCM Operation

by Christophe Basso, ON Semiconductor, Toulouse, France

Abstract: In part 1, this article explained how a flyback converter operating in discontinuous-conduction mode (DCM) can deliver more power under a high-line input condition than in a low-line situation. In the example discussed in that article, the converter did not exhibit mode transition, i.e., the converter stayed in DCM over the whole input range. However, in high-power adapters, it's standard practice to make the converter operate in deep CCM at low line and then transition to light continuous-conduction mode (CCM) or even DCM at high line. Operating in CCM at low line ensures lower conduction losses, while DCM at high line reduces the stress on the secondary-side diode. Nevertheless as with the DCM-only case, the power delivered at high line is again higher than that delivered at low line. Here in part 2, the author explains why this is the case.

Notes: 9 pages, 5 figures. Read the full story...

Five "Must-Have Ingredients" For Power Management In Hybrid Electric Vehicles

by Henning Hauenstein, International Rectifier, El Segundo, Calif.

Abstract: The high-voltage and high-power requirements of electric and hybrid electric vehicles (HEVs) are driving the introduction of new automotive electrical systems. These systems require special electronic devices, semiconductor solutions and advanced packaging options that are very different from those found in the state-of-the-art 12-V electrical systems in combustion-engine cars. In this product technology feature, the author discusses the challenges faced by semiconductor suppliers in addressing the needs of these new high-power electrical systems. He also describes the semiconductor and packaging technologies his company has developed to address these challenges, and presents examples of power devices that use these technologies to support automotive system design.

Notes: 7 pages, 4 figures. Read the full story...

December 2010:

Current Flow Analysis in Permanent Magnet Brushless DC Motor Control Using PSpice

by Amitabh Mallik and Rakesh Dhawan, Strategic Technology Group, Pune, India

Abstract: A brushless dc motor has a permanent magnet rotor and a wound stator. The windings are connected to an inverter and the inverter energizes the windings in a pattern that rotates the magnetic field around the stator. The energized stator winding causes the PM rotor to rotate in a synchronous fashion around the stator. So it is important to know the perfect sequence to energize the stator windings. Simulation could offer a convenient means for determining the optimum sequence

for energizing the windings. However, methods for performing this type of simulation using popular tools such as Spice are not widely known in the industry. In this article, we describe a step-by-step procedure for simulating a BLDC motor control system using PSpice.

Notes: 15 pages, 10 figures. Read the full story...

The Over-Power Phenomenon in DCM/CCM-Operated Flyback Converters (Part 3): Quasi Square-Wave Resonant Mode

by Christophe Basso, ON Semiconductor, Toulouse, France

Abstract: In parts 1 and 2 of this article series, we derived the equations that explain why flyback converters can deliver greater power under high input-line conditions versus low-line conditions. These previous articles focused on flyback converters operating at a fixed switching frequency and in continuous-conduction mode (CCM) or discontinuous-conduction mode (DCM). But despite its simplicity of design, the CCM flyback converter does not lend itself very well to synchronous rectification (SR) on the secondary side. Therefore, to achieve the higher efficiency associated with synchronous rectification, many designers are considering a change from CCM to a quasi square-wave resonant (QR) mode of operation where secondary-side shoot-through currents are eliminated. This article explains why over-power protection (OPP) is mandatory for QR-mode flyback designs to avoid the need for overdesign of components or risk component destruction.

Notes: 10 pages, 5 figures. Read the full story...

Embed Your Planar Magnetics To Maximize DC-DC Converter Performance (Part 3): The Bias Supply

by Harold Eicher, Champs Technologies, East Setauket, NY

Abstract: This article continues the discussion on embedded planar magnetics and how its use enhances the performance of a digitally controlled dc-dc converter design. Here in part 3, the focus is on the design issues faced when implementing a bias supply as part of the embedded dc-dc design. At the center of this bias supply design is embedded planar transformer TX3. This article also considers alternative magnetic solutions based on wound components and discusses the tradeoffs between the embedded-planar and wound-component approaches.

Notes: 11 pages, 5 figures, 1 table. Read the full story...