Design Article Archive

Abstracts of articles published in the January through December 2013 issues

January 2013:

Hardware-In-The-Loop System Eases Development And Testing Of Grid-Connected Power Electronics Applications

by Evgenije Adzic, Vlado Porobic and Nikola Celanovic, Typhoon HIL, Novi Sad, Serbia

Abstract: To support the production and delivery of clean electricity, there is a critical need to have a single development and test environment that will allow verification of standard technical requirements for grid-connected power electronics systems. Typhoon HIL addresses this need by providing a uniform environment for evaluation of requirements relevant to the performance, operation, and testing of the grid-connected converter's control system. This article demonstrates some of the ways in which the Typhoon's high-fidelity real-time HIL emulation hardware (with 1-microsecond time step) and related software tool-chain offer advanced development and testing capabilities to manufacturers of grid-connected converter systems. Along with enabling faster product development, this emulation platform eliminates the need for expensive hardware test equipment traditionally used for grid simulation. As their design example, the authors show how the HIL platform was used to evaluate the power electronics circuit and corresponding control strategy for a PV three-phase grid-inverter application.

Notes: 15 pages, 20 figures. Read the full story…

Rad Hard Processors And Power Converters Propel Intermediate Bus Architecture Into Space Applications

by Leonard Leslie, VPT, Blacksburg, Va.

Abstract: Until very recently, the efficient distributed power topology based on point-of-load converters (POLs), also referred to as the intermediate bus architecture, was not available to space designers due to the extreme environmental requirements of these applications. While designers could apply distributed power schemes using space-grade, isolated dc-dc converters and EMI filter modules, they were limited to using linear regulators for voltage stepdown at the point-of-load. However, with the introduction of high-efficiency, high-power-density POLs qualified for space, the use of the intermediate bus architecture in space systems became feasible, enabling designers to better optimize their power distribution systems for efficiency, size and weight. This article discusses the special design requirements and issues that must be considered when applying POLs and the intermediate bus architecture in space applications.

Notes: 5 pages, 3 figures. Read the full story…

Simple, Yet Versatile Flybacks Present Low-Cost Driver Solutions For LED Lighting

by Peter B. Green, International Rectifier, El Segundo, Calif.

Abstract: Most LED light fixtures continue to drive the LEDs with current-regulated dc by means of an LED driver circuit consisting of an ac-dc switching converter. The simple, single-stage flyback converter is a basic platform used in many LED drivers because of its simplicity and low component count. It meets many of the common application requirements for isolation, input voltage range, power factor, THD and operating life. And with the addition of a few components, the LED driver becomes dimmable using an analog control voltage. This article describes two isolated LED driver designs based on the one-stage flyback converter. The first design is non-dimmable; the second is dimmable. The operation of these circuits, their typical performance capabilities and ranges of operation, and important design considerations are explained.

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

February 2013:

Simplified Analysis Of A DCM Boost Converter Driving An LED String Part I: Theoretical Analysis

by Christophe Basso, ON Semiconductor, Toulouse, France and Alain Laprade, ON Semiconductor, East Greenwich, R.I.

Abstract: The design of a DCM boost converter involves certain challenges such as properly stabilizing the design. Although small-signal models exist for performing this type of analysis, some difficulty arises in trying to apply these models to LED driver applications. That's because the ac analysis of a boost converter driving LEDs differs from that using a standard resistive load. As the series diodes impose both dc and ac loading conditions, deriving the final transfer function is not a simple matter. Here in part I of this two-part article, the authors present an easier method for analysis. Rather than using the classical small-signal model of the DCM boost converter, they develop a simplified model based on the output current expression for the converter and then use this model for analysis.

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

Synchronous Buck Converter Enables Multiple Bias Rails And Input Voltage Sensing For Isolated Applications

by Vijay Choudhary, Applications Engineer, Texas Instruments, Phoenix, Ariz.

Abstract: A synchronous buck converter can be used in an isolated (Fly-Buck) configuration to create multiple power rails on both the primary and secondary sides. The isolated outputs do not need any optocoupler-based feedback for regulation. The primary output is controlled directly and the additional outputs are regulated based on the transformer turns ratio. Therefore, a Fly-Buck converter is simpler to design than the traditional flyback-based solutions and results in smaller and cheaper isolated bias power solutions. Additionally, a Fly-Buck-based design can be easily modified to transfer input voltage information to the secondary side, thereby providing a compact, relatively accurate, and cost-effective sensing and power solution.

Notes: 8 pages, 12 figures, 3 tables. Read the full story…

How To Choose Between Ferrite Or Powdered-Iron Cores: A Case Study

by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

Abstract: This case study explores the design of a 5-W dc-dc converter. The focus here is on determining which core material is optimal for a flyback converter that uses ripple-current steering in both primary and secondary circuits. Ripple-current steering makes it possible for even a continuous-conduction mode (CCM) flyback converter to have CCM primary and secondary currents with their benefits of higher efficiency and reduction in noise. Ripple steering is explained and the choice of ferrite or iron-powdered cores is then explored in detail.

Notes: 10 pages, 2 figures, 2 tables. Read the full story…

March 2013:

Simplified Analysis Of A DCM Boost Converter Driving An LED String Part II: Practical Considerations

by Christophe Basso, ON Semiconductor, Toulouse, France and Alain Laprade, ON Semiconductor, East Greenwich, R.I.

Abstract: Part I of this article was dedicated to the theoretical analysis of a boost converter driving an LED string. This study was motivated by the need to stabilize the loop of an LED backlight driver in an automotive application. As pulse width modulation (PWM) is implemented for dimming control, loop control represents an important design consideration that conditions the final performance of the driver. Here in Part II, the authors describe the implemented solution and verify the measured frequency response versus the theoretical derivation from Part I.

Notes: 8 pages, 6 figures, 1 table. Read the full story…

Better Than Class D: Predictive Energy Balancing Can Boost Efficiency And Fidelity Of Cell Phone Audio Amplifiers

by Tom Lawson, CogniPower, Malvern, Penn.

Abstract: The art of building a good class D audio amplifier revolves around removing unwanted harmonics, distortion, and noise from the audio output. However, those ends can be achieved more effectively using Predictive Energy Balancing (PEB), a method of control originally developed for switched-mode power supplies. Because PEB allows an output to be regulated precisely on a cycle-by-cycle basis, instead of on the average, PEB enables an entirely new form of switched-mode amplifier. This article describes the operation of a PEB audio amplifier, comparing its efficiency and fidelity

against class D audio amps. The discussion focuses on the types of amplifiers used in cell phones and other handheld devices where there are opportunities to improve audio performance and efficiency. But the techniques described here may benefit high-power and high-fidelity audio amplifiers as well.

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

Vertical Devices In Bulk GaN Drive Diode Performance To Near-Theoretical Limits

by Isik C. Kizilyalli, Andrew Edwards, David Bour, Hemal Shah, Hui Nie, and Don Disney, Avogy, San Jose, Calif.

Abstract: Alternative materials are enabling a new generation of power devices that can far exceed the performance of silicon (Si) based devices. Silicon carbide (SiC) diodes have already been commercialized and are increasing market share in applications that demand higher efficiency. However, there is also great interest in developing gallium nitride (GaN) based power devices because the fundamental material-based figure-of-merit (FOM) of GaN is at least five times better than SiC and nearly 1000 times that of Si. In this article, the authors explain how full advantage of the material properties of GaN is taken by fabricating vertical diodes on low-defect-density bulk GaN substrates. The 600-V to 1700-V rated devices described here demonstrate performance near theoretical limits as predicted by the GaN material properties. In addition, measurements reveal robust avalanche breakdown (demonstrated for the first time for a GaN device).

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

Tips For Applying POL Converters In Downhole And Other Harsh Environments

by Ramesh Khanna, Texas Instruments, Dallas, Texas

Abstract: The issues of component selection and PCB design are critical when designing power systems for harsh environments. Even when the power system design is developed using familiar devices such as LDOs and buck regulators, the application of these regulators quickly becomes complicated by environmental considerations such as extreme temperatures and shock and vibration. This article explores the various features of a buck-based point-of-load (POL) converter design pertaining to extreme environments. It also addresses the use of LDOs, which designers may be forced to use in light of low noise requirements in applications with temperatures up to 210°C. This article discusses the power requirements to meet system needs as well as low noise and system-level protection necessary for the end customer dealing in gas and oil exploration/production.

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

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April 2013:

Enhanced Web Tool Speeds IGBT Selection, Matching Device To The Application

by Steve Clemente, International Rectifier, El Segundo, Calif.

Abstract: A vendor's device-selection tool enables the system designer to navigate through the various part numbers more easily, in order to locate the most suitable components. However, these tools are still evolving. This article discusses the recent enhancements made by International Rectifier in its IGBT selection tool. The first version of the tool permitted users to enter critical application parameters and then calculate a device's junction temperature under a set of representative operating conditions. But lately the functionality of this tool was expanded to account for heatsink thermal resistance as well the thermal resistance for surface-mounted parts. In addition to describing tool features, this article presents an example of how this tool can be used to compare alternative solutions in the design of a small motor drive. Tool limitations are also discussed as these are leading to the development of more-powerful, application-specific tools.

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

GaN Power Devices Slash Size, Raise Efficiency Of 4-kW Solar Inverter

by Carl Blake, Transphorm, Goletta, Calif.

Abstract: The promise of higher-efficiency power conversion using gallium nitride (GaN) high-electron-mobility transistors (HEMTs) and fast-switching diodes has been achieved with devices now in volume production. The technical challenges involved in attaining this important milestone at voltages above 200 V to 300 V were thought by some industry experts to be insurmountable. But today, a commercial 4-kW PV inverter using 600-V GaN technology establishes new benchmarks for size and performance. This article will describe the topology of a 4-kW, grid-tied, single-phase solar panel string inverter that replaces conventional silicon (Si) IGBTs with GaN HEMTs in the boost converter section—and in the bridge circuit—which results in a 50% reduction in losses, allowing overall efficiency to achieve a peak efficiency above 98%. Compared to the existing silicon inverter design that switched at 16 kHz, this new unit is almost 45% smaller because it is able to switch at 50 kHz while achieving higher efficiency.

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

May 2013:

IGBT With Intrinsic Body Diode Improves Performance Of Single-Ended-Resonant Inverters In Induction Heating Applications

by Jae-Eul Yeon and Min-Young Park, Consumer Power System Team, HVPCIA, Fairchild Korea Semiconductor, Bucheon, Korea

Abstract: The field-stop IGBT provides lower saturation voltage drop and lower switching losses than the conventional non-punch-through IGBT, making the field-stop IGBT well suited for induction heating (IH). The integration of an anti-parallel diode on the IGBT die through use of the shorted-anode technology made the field-stop IGBT even better for IH designs. Here, the authors introduce Fairchild's second-generation field-stop shorted-anode trench IGBT with intrinsic body diode. This latest generation IGBT is offered in voltage ratings ranging from 1100 V to 1400 V, which align closely with the requirements of induction heating. After discussing the requirements of IH applications, they describe the structure and characteristics of the new IGBT that make it most effective in single-ended-resonant inverters used in IH designs. This latest-generation IGBT enables designers to achieve better inverter performance at higher switching frequencies, which ultimately enables better heating efficiency. Experimental results confirm the advantages of the new IGBT in the intended applications.

Notes: 5 pages, 4 figures, 2 tables. Read the full story…

Video: Troubleshooting Distributed Power Systems (Part 1): Why Stability Matters

by Steve Sandler, AEi Systems and Picotest, Phoenix, Ariz.

Abstract: Control-loop stability impacts power supply performance in multiple ways. Even if the control loop is not oscillating, poor stability—as evidenced by low phase margin—in voltage regulator and reference circuits can lead to problems such as poor PSRR or reverse transfer performance. What's more, many system-level problems such as clock jitter, noise-induced degradation of circuit performance, and EMI can be traced back to poor control-loop stability in the power supply. In this 5-minute video presentation, Steve Sandler discusses how stability impacts circuit performance, offering examples that demonstrate the effects of stability problems on both power supply and system performance. This video is part one of an ongoing series.

Notes: 5-min. 31-sec. runtime. Watch the video…

How To Choose Magnetic Core Size

by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

Abstract: One of the basic decisions in the design of magnetic devices is how large of a core should be chosen for a given design. It would seem that such a basic question would have some well-established theoretical answers by now. The actual situation is not so simple, though in this article, a rationale is presented that hopefully can simplify this important part of the design. As the author explains, the problem of sizing the core revolves around the issue of how to relate a maximum design temperature to core power-loss density. An experienced magnetics designer has an intuition for core size, but that is hardly a basis for a design procedure. The author's analysis leads to a pair of equations and a simple procedure for selecting a core size from among the various catalog options.

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

June 2013:

Boost Power Converters Finally Get Some Respect!

by Bob Bell and Eric Lee, Texas Instruments, Phoenix, Ariz.

Abstract: Over the years, IC vendors have continuously developed newer, faster, more-feature-rich buck controllers and regulators. Meanwhile, controller choices for boost power converters have remained limited. But lately, new boost applications such as automotive start-stop have emerged, requiring higher efficiency, higher power density, and novel protection features. In response, new boost controller ICs have been developed with features such as fully synchronous operation and interleaved multiphase capability along with robust protection. This article presents single- and dual-phase synchronous boost power converter designs based on a recently introduced boost controller, the LM5122. The operation of these converter circuits and the unique features of the controller are discussed here. Measured results for efficiency and simulated results for output current ripple are also presented, demonstrating the benefits of synchronous rectification and interleaved, multiphase operation in boost applications.

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

New Twist On The Half-Bridge Converter Solves Subtle Failure Mode

by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

Abstract: The half-bridge circuit is a familiar power circuit but it has a subtle transformer-related failure mode that can be avoided if understood. If you know what a half-bridge circuit is, it might not be the failure mode you think it is. The familiar problem arises from capacitors on the primary side of the circuit forming a resonance with the primary inductance, resulting in both flux and charge imbalance. A lesser-known difficulty arises from a resonance on the secondary side of the circuit where the secondary leakage inductance resonates with the diodes' parasitic capacitance, leading to excessive voltage overshoot and power dissipation. This article explains how this failure mode arises and how to avoid it through a reconfiguration of the secondary-side circuit.

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

Circuit And Packaging Innovations Plus Latest MOSFETs Optimize DC-DC Converters For Space-Constrained Designs

by Ramesh Balasubramaniam, International Rectifier, El Segundo, Calif.

Abstract: Developing the third-generation SupIRBuck point-of-load integrated voltage regulators required that designers pull together innovation in three areas: IC switching regulator circuit design, high-efficiency MOSFETs and IC packaging. This article describes how these innovations were leveraged in the development of the IR3847, a 25-A point-of-load buck converter that is the newest member of the Gen 3 SupIRBuck family. Benefits of the new PWM modulator design, a higher-voltage internal gate drive, and proprietary package design are discussed here along with other device features that enable the regulator to address requirements of thermally and space-constrained applications. To support the selection and design in of the IR3847 and other SupIRBuck family members, a free online design tool is offered at the vendor's website and a demonstration of this tool is presented here.

Notes: 12 pages, 19 figures, 1 table. Read the full story…

Video: Troubleshooting Distributed Power Systems (Part 2): Impedance Is The Critical Measurement

by Steve Sandler, AEi Systems and Picotest, Phoenix, Ariz.

Abstract: Whether your goal is to optimize system performance or to troubleshoot issues in distributed power systems, impedance measurement is an indispensable tool. That's because there is a direct correlation between impedance, which is a highly observable characteristic, and two key measures of system performance—noise and stability. In this 10-minute video, Sandler discusses the value of impedance measurements and demonstrates their usefulness with two examples: one using vendor-supplied data for a voltage reference and another using ADS-generated data for a second-order control loop. As Sandler explains, analysis based on impedance measurements can more thoroughly assess control-loop stability than Bode plot measurements, and can do so more conveniently for control loops that are hard-to-access in system, and for devices (like some voltage regulators) that do not allow access to the feedback path. This video is part two of an ongoing series.

Notes: 9-min. 57-sec. runtime. Watch the video…

July 2013:

Closed-Loop Sensors With Magnetic Probe Extend High-Precision Current Measurement To Higher Current Levels

by Klaus Reichert, VACUUMSCHMELZE (VAC), Hanau, Germany

Abstract: In performing current measurement in high-power applications, both precision and range of measurement are important. High-precision measurement is critical for many applications, such as measurement of motor torque in drive systems or, in the energy sector, of current fed into the power grid. Meanwhile, wide-range current measurement is useful in designing high-efficiency control circuits and ensures safe and accurate short-circuit current measurement. This article focuses on a class of current sensors well suited for high-power applications—closed-loop sensors with magnetic probe. The characteristics, benefits, and principles of operation of these sensors are discussed here. With that as background, a new family of sensors is introduced. Members of this family extend the range of closed-loop sensors with magnetic probe to much higher ratings (1000 A eff) and measurement ranges (±2500 A) than were previously possible.

Notes: 9 pages, 10 figures, 1 table. Read the full story…

Steering Through The Confusion: A Guide To IGBT Technologies, Terminology, And Operation

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

Abstract: For those who are new to the arena of motor drive design, or are considering IGBTs for use in other applications, or are possibly confused by all of the different IGBT buzz words, this brief tour of the available technologies may offer reasonable guidance. This information can be particularly helpful when selecting IGBTs for a new design, as much of what you need to know about different IGBT device types will not be spelled out on data sheets. And device selection guides are not equipped to ask and answer some questions that relate to IGBT process technology. Understanding the differences among the different IGBT technologies may also come in handy if you're ever tasked with finding modern replacements for IGBT devices used in an older product design.

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

How To Match The DDR Memory Power Solution To The Application

by Jim Aliberti, Texas Instruments, Dallas, Texas

Abstract: Double data rate (DDR) memory doubles the data transfer rate by transferring data at both the leading and falling edges of each clock cycle. DDR2 does this four times per clock cycle, while DDR3 and DDR4 do this eight and 16 times, respectively. Powering DDR memory chips requires the generation of two power rail rails—VDDQ and VTT. Suppliers of power management ICs have developed application-specific voltage regulators to generate these rails. Among the different DDR-specific power solutions, there are several different approaches to generating the power rails. These variations enable tradeoffs in pursuing design goals such as those concerning board space, efficiency, and cost. This article explains the various options for powering DDR memory and the advantages offered by each approach. Specific Texas Instrument devices are cited here as examples. However, similar types of devices are available from other vendors.

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

How Not To Observe Magnetic Saturation

by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

Abstract: On the bench, it is not only the circuit under test but also the measurement equipment that can lead to a misunderstanding of what is happening, thinking that the data is saying something it is not. This article provides a brief example of what to watch out for in power-circuit testing involving magnetics. Specifically, the influence of oscilloscope measurement scale on current measurements for a transformer or coupled inductor will be depicted and explained. With the wrong scope settings for amplitude, it is easy to drive the transductor being measured into saturation by providing too high a level of excitation current. In the example measurement, which is configured to measure primary inductance of a transformer, incorrect setting of amplitude scale leads to misleading current measurements, which then lead to erroneous calculations for primary inductance. Guidance is given on how to avoid this problem. The article also describes a technique for accurately measuring leakage inductance of a transductor.

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

August 2013:

Web-Based Toolset Accelerates Power Supply Design For Both Power Electronics Experts And Non-Experts

by Franki Poon, PowerELab, Shatin, N.T., Hong Kong

Abstract: Functionality, ease of use, and simulation speed have been optimized in a free online, power supply design and simulation toolset called PowerEsim. Within PowerEsim, there are several tools including ones for circuit simulation, loss analysis, thermal simulation, input harmonic analysis, and Monte Carlo analysis. There's also a very popular Magnetic Builder tool, among others. These individual tools are seamlessly integrated so that the users feel as if they are using a single tool. Furthermore, PowerESim has been optimized to perform very fast simulations. With some topologies, it can run hundreds of simulations per second. These simulations include accurate models of magnetic components that have been designed using Magnetic Builder. And by offering three different options for starting a power converter design, PowerESim accommodates the varying skill levels and requirements of both power supply and non-power supply designers. After briefly describing these options, this article demonstrates how a power supply designer could use this tool to design a power factor correction (PFC) stage.

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

A Guide To The Operation And Use Of Input EMI Filters For Switching Power Supplies

by Anastasios Simopolous, Beta Dyne, Bridgewater, Mass.

Abstract: The noise generated by power supply switching is a problem in electrical and electronic systems. But at least in terms of conducted EMI, the switching noise can be controlled with an input filter placed between the power lines, neutral and chassis. Despite the widespread use of switching power supplies, many engineers are not clear on how input filters operate, their capabilities and their limitations, how to specify them, and how to apply them. This article aims to address all of these issues, primarily with the non-power supply designer in mind, but in a way that will also inform new power supply designers about key aspects of filter design and application. Understanding input filters is not only about knowing when and how to specify them, but also when not to use them. For example, some power supplies have built-in input filters, making it unnecessary to add input filtering to the customer's board. But to begin the filter discussion, this article looks at regulatory requirements for emissions, which will dictate the minimum required filter performance.

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

Video: Troubleshooting Distributed Power Systems (Part 3): Measuring Impedance Using Vector Network Analyzers (One-Port Tests)

by Steve Sandler, AEi Systems and Picotest, Phoenix, Ariz.

Abstract: Vector network analyzers (VNAs) have always had measurement capabilities that looked like they would be particularly useful in assessing the performance of analog and power components and circuits. Unfortunately, the input range of these instruments did not extend low enough in frequency for many power and analog applications. However, two of the more recently introduced VNAs—Omicron Lab's Bode 100 and Agilent's E5061B—have changed this situation, making it possible to measure the impedance of many types of power components and circuits as Steve Sandler explains in this 10-minute video. This video focuses on single-port measurements, describing how they can be applied to low power circuits such as linear regulators, voltage references and op amps as well as semiconductors, capacitors, and inductors. Test set up requirements are discussed and example measurements are presented. This video is part three of an ongoing series.

Notes: 9-min. 31-sec. runtime. Watch the video…

September 2013:

Understanding The Breakdown Characteristics Of Lateral GaN-Based HEMTs

by Michael A. Briere, ACOO Enterprises under contract to International Rectifier, El Segundo, Calif.

Abstract: For lateral GaN-based HEMTs formed on silicon substrates, it has been suggested that the breakdown of these devices through catastrophic, non-recoverable, dielectric failure is both unexpected and undesirable. However, this behavior is neither unexpected nor essentially undesirable. Lacking a spatially resolved PN junction, lateral GaN-based HEMTs do not exhibit recoverable breakdown behavior and have no avalanche capability. Their primary breakdown mechanism is dielectric breakdown of the overlying insulating layers in the device. In that regard, they resemble ceramic capacitors more so than silicon power semiconductor devices. This major difference in breakdown behavior affects how the new GaN-based devices should be designed, rated, and specified

in power electronics applications. In addition, there are secondary breakdown mechanisms such as leakage that will influence device design and ratings. All of these issues will be discussed in this article with an eye toward giving the power system designer a clearer understanding of how to compare the new lateral GaN-based HEMTs with existing silicon and silicon carbide-based devices.

Notes: 5 pages, 2 figures. Read the full story…

Primary-Side Regulation Enables Two-Stage Constant-Voltage LED Driver With High-Performance And Low Cost

by Jin Zhu, Fairchild Semiconductor, Zhejiang, China and Yupu Tao, Fairchild Semiconductor, Shanghai, China

Abstract: A new two-stage LED driver solution based on primary-side regulation and constant voltage output (PSR-CV) in the first stage is proposed in this article. This LED driver design eliminates low-frequency current ripple yet maintains high power factor (PF) and low cost compared with currently available single-stage and three-stage solutions applied in analog LED dimming or non-dimming applications. PSR-CV regulation is employed on the primary side to achieve high PF and simple circuitry in one stage, which is then combined with a secondary dc-dc stage to eliminate low-frequency current ripple and implement the dimming function. While this article focuses on the two-stage LED driver solution based on PSR-CV, there is also another PSR-based, two-stage LED driver solution—one that employs constant-current regulation (PSR-CC). Both of these driver designs are described and contrasted in this article with the operation of the PSR-CV solution explained in detail. Finally, this article describes a prototype based on the PSR-CV two-stage LED driver design and presents test results for this prototype.

Notes: 10 pages, 11 figures, 1 table. Read the full story…

Video: Troubleshooting Distributed Power Systems (Part 4): Measuring Impedance Using Vector Network Analyzers (Two-Port Tests)

by Steve Sandler, AEi Systems and Picotest, Phoenix, Ariz.

Abstract: In the previous installment in this video series, Sandler discussed the benefits of using VNAs to measure the impedance of devices encountered in distributed power systems, providing details on how to perform and interpret one-port measurements. In this video, the focus shifts to making and interpreting two-port impedance measurements, particularly those in which the device under test is connected "in shunt through" with the VNA ports. Shunt through, wideband measurements can be made from approximately 100 microohms to a few ohms. This is the measurement performed by designers for the power distribution network (PDN) assessment of VRMs and POLs. This technique may also be used to measure the impedances of batteries, dc-dc converters, EMI filters, and other functions. Setup requirements such as 4-wire connections, a common-mode transformer, dc blockers, and ac versus dc coupling are explained in this video. Also discussed is the use of a preamp to measure impedances below 1 milliohm. In addition, the video presents impedance measurement examples such as a POL output, a motherboard PDN and a 250-microohm resistor. This video is part four of an ongoing series.

Notes: 13-min. 12-sec. runtime. Watch the video…

How To Calculate Toroid Winding Length

by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

Abstract: The toroid or ring core shape has some significant advantages over round and square winding-window cores. Toroids contain the magnetic field better, reducing radiated circuit noise. They also dissipate heat more effectively. Yet when it comes to winding toroids, the winding length must be determined beforehand. It takes some algebraic work to derive winding length and the working equations will be given in this article. For the better engineers who do not like to use equations without knowing where they came from, the outline of their derivation is also given. According to the author, the winding lengths found using these equations are typically accurate to within 2% of the actual lengths.

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

October 2013:

Demystifying PSRR Specifications For LDOs

by Kern Wong, Texas Instruments, Dallas, Texas

Abstract: The quest for lower-noise feedthrough over frequency in low-dropout regulator (LDO) circuits is driving designers of mobile devices, tablets, and portable instruments to seek LDOs specifying ever-higher levels of power supply ripple rejection ratio (PSRR). While an LDO PSRR figure at higher frequencies often relates to improved system performance due to increased bandwidth in noise rejection, its popularity has overshadowed the device's native performance. A PSRR specification of ~10 MHz is often confusing, distorted, and unqualified. This article aims to clarify the LDO PSRR specification across the application's frequency range of interest and dislodge common myths to help designers make intelligent LDO selections. In addition, proven solutions in the form of circuit recommendations and LDO device options are provided to help engineers achieve their design goals.

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

Hold-Up Modules Reduce Capacitance Requirements For High-Rel Power Supplies

by Christophe Massenet, Gaia Converter, Summit, N.J.

Abstract: When a power supply designer needs to comply with military standards, he may need to take into account the transparency or hold-up requirement. The transparency requirement is the minimum amount of time during which input power can go away but the equipment is expected to remain operational. This power interruption duration may range from 50 ms all the way to 1000 ms. The simplest way to achieve such a hold up function is to connect the input bus to a huge tank capacitor. Unfortunately, when typical hold-up circuitry is employed, the actual capacitors required to achieve the specified hold-up time can be quite large. However, an integrated hold-up module offers a space-saving alternative. By increasing the voltage to which the hold-up capacitor is charged, the module increases the stored energy for a given capacitance value, reducing the amount of capacitance needed to achieve a given hold-up time. This article assesses the impact of hold-up modules on

mil/aerospace applications employing 28-V input dc-dc converters operating at different power levels.

Notes: 6 pages, 5 figures, 4 tables. Read the full story…

Video: Troubleshooting Distributed Power Systems (Part 5): Using Current Injectors

by Steve Sandler, AEi Systems and Picotest, Phoenix, Ariz.

Abstract: Previous videos in this series discussed the use of vector network analyzers (VNAs) to measure impedance using one- or two-port configurations. This video discusses another method of measuring impedance—the current injector method. Although not quite as accurate as the two-port VNA impedance measurement, the current injection technique has advantages including wide range (approx. 1 milliohm to thousands of ohms), the ability to measure in-system, and a suitability for measuring low-power devices such as op amps, voltage references, and voltage regulators. In addition, current injectors can be used to carry out other types of tests such as non-invasively measuring PSRR, determining power integrity and signal integrity sensitivity, and in generating high-speed load steps. In this video, Steve Sandler discusses each of these current injector measurement capabilities and presents test examples that illustrate how designers can perform and interpret these measurements. Along the way, Sandler offers many test tips to help the engineer obtain the most accurate results.

Notes: 11-min. 23-sec. runtime. Watch the video…

November 2013:

Video: Troubleshooting Distributed Power Systems (Part 6): The Switch

by Steve Sandler, AEi Systems and Picotest, Phoenix, Ariz.

Abstract: System and power converter issues are frequently related to a converter's switching characteristics, which are most easily observed at the switching node. In this video, Steve Sandler discusses the measurement and interpretation of switch-node waveforms as observed in point-of-load regulators (POLs). He discusses the instrumentation requirements for measuring switch-node waveforms, why these waveforms should be viewed using different time scales, and the impact of scope probes on these measurements. With those measurement requirements as background, Sandler examines how switching frequency and duty cycle affect power supply stability as well as EMI.

Notes: 9-min. 36-sec. runtime. Watch the video…

Design Article Archive

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Inductor DCR Current Sensing With Temperature Compensation: An Accurate, Lossless Approach For POL Regulators

by Timothy Hegarty, Texas Instruments, Tucson, Ariz.

Abstract: In one popular version of inductor dc resistance (DCR sensing), a passive filter network is connected in parallel with the inductor. By emulating the inductor admittance with a low-pass sense network, a proportional voltage image of the inductor current is derived. A flat frequency response is achieved when the inductor time constant matches that of the RC sense network. With this method, time-constant matching and DCR temperature dependence must be addressed to achieve accurate current sensing across variations in load and temperature. This article explains the requirements for time-constant matching and DCR temperature compensation, looks at the conventional approach to temperature compensation, and then describes an alternative approach that leverages capabilities within newer PWM controllers to perform remote temperature sensing close to the inductor and temperature compensation of the inductor DCR. An implementation of a POL regulator using this current-sensing and temperature-compensation scheme is then presented along with experimental results.

Notes: 9 pages, 10 figures. Read the full story…

Everything You Wanted To Know About Copper Wire But Didn't Know To Ask

by Martin Kanner, KEMCO, Power Controls Div., Plainview, N.Y.

Abstract: Many of you reading this article have had formal training and or experience in the field of electrical engineering. Yet if you had to select the wire size for an electrical cable, it might be a mystery to you or you might have to guess at it. Selecting wire for a transformer or an inductor might be a more formidable task too. Or, how would you answer a question on how wide a copper run should be on a printed circuit board? It is the purpose of this article to make these simple tasks, just that.

Notes: 2 pages. Read the full story…

December 2013:

Single-Stage PFC Topology Employs Two-Transformer Approach For Improved Efficiency, Reliability, And Cost

by Fuxiang Lin, Independent Researcher, Sydney, Australia and Fuyong Lin, Hua Qiao University, Mechanical Department, Xiamem, Fujian, China

Abstract: A new single-stage power factor correction (PFC) power supply topology uses two transformers. The main transformer transfers energy from the primary circuit to the secondary circuit, while the auxiliary or forward transformer provides energy to correct the power factor (PF) of the input current waveform. The primary windings of these two transformers are connected in series. This topology can be used in all power supply topologies including single-switch types such as forward and flyback converters, and in half-bridge, full-bridge and LLC-resonant converters. Within a flyback

design, this circuit can operate from a universal input. With forward and half-bridge implementations, this circuit can operate from an input range of either 180 to 260 V ac or 90 to 150 V ac. This new topology promises high efficiency, high reliability and lower cost versus existing designs. In this article, the operating principles, inductor design, and forward transformer design for this topology are explained and experimental results are presented.

Notes: 10 pages, 12 figures. Read the full story…

Video: Troubleshooting Distributed Power Systems (Part 7): Measuring Ripple

by Steve Sandler, AEi Systems and Picotest, Phoenix, Ariz.

Abstract: Circuit designers, particularly power supply designers, are frequently required to measure power supply ripple. Nevertheless, many engineers struggle with this measurement as sensitivity, selectivity, and bandwidth limitations degrade the accuracy of oscilloscope results. But as Steve Sandler explains in this 7-minute video, specialized probes and adapters can improve the results obtained from the conventional time-domain approach to measuring ripple, while other approaches to measuring ripple—involving the spectrum and impedance domains—can yield more-accurate and more-insightful results. Various test setups and measurement techniques are described in this video and example results obtained from testing different point of load regulators are discussed. Sandler also provides tips to help designers avoid common measurement pitfalls.

Notes: 6-min. 42-sec. runtime. Watch the video…

Testing What You Know About Copper Wire

by Martin Kanner, KEMCO, Power Controls Div., Plainview, N.Y.

Abstract: For those who enjoyed Martin Kanner's article, "Everything You Wanted To Know About Copper Wire But Didn't Know To Ask" in the December 2013 issue, and want to test their understanding of the material, take this short exam.

Notes: 2 pages. Read the full story…

Matrix Transformers May Find New Life In the SiC and GaN Era

by Edward Herbert, Power Sources Manufacturers Association (PSMA) Magnetics Committee

Abstract: Many said that the matrix transformer was before its time, which may be true. It is particularly well suited for high frequencies, 300 kHz and above. In 1989, when it was introduced, few power converters operated there. Now, with switching frequencies commonly in that frequency range and higher, and with GaN and SiC devices promising higher switching frequencies yet, it may be time to take another look at the matrix transformer and its derivatives. Previously, the matrix transformer was licensed exclusively to one company, but the now patents have all expired, so anyone can use the technology.

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