Design Article Archive

Abstracts of articles published in the January through May 2025 issues

January 2025:

Assessing Performance Of A 10-kW String Inverter Based On GaN FETs

by Riccardo Ruffo and Vedatroyee Ghosh, Texas Instruments, Freising, Germany

Abstract: The implementation of wide-bandgap power devices based on gallium nitride (GaN) helps string inverters in photovoltaic systems achieve lower switching losses. At the same time, they enable use of much smaller magnetic components thanks to a significant increase in switching frequency compared to silicon-based power devices. In this article, we'll describe a low-cost 10-kW single-phase string inverter based on GaN power devices. The string inverter consists of two nonisolated power stages—a dc-dc converter comprised of two interleaved boost converters and a dc-ac converter. The design's high efficiency also enables you to connect a nonisolated dc-dc converter directly to an energy storage system (ESS), and to install it on the same heat sink with other power-conversion systems.

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

Designing An Open-Source Power Inverter (Part 23): Inverter Driver Design Refinement

by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

Abstract: Experienced design engineers can anticipate almost all of what needs to be considered in a design project. More involved projects, such as the design of an oscilloscope for instrument engineers, are straightforward for perhaps 95% of the project before anomalous behavior is encountered on the bench. The final 5% of the project becomes a research effort to find causes for unanticipated problems that can absorb 50% of the time of the project. This is why in the 1960s at Tektronix, planners would multiply the project time resulting from careful estimation by two to devise a more realistic project schedule. The Volksinverter design is no exception, and refinement of the earlier design work discussed in previous parts is necessary. In this latest installment in the Volksinverter series, some further attention is given to the design of the inverter stage.

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

The Importance Of Knowing Magnetic Core Saturation Field Strength For Accurate Hysteresis Loss Calculation

by Gregory Mirsky, Design Engineer, Deer Park, Ill.

Abstract: Magnetic cores manufacturers very seldom provide full hysteresis loops for their products. Although a previous work has shown how to calculate core power loss using an expression for the hysteresis loop derived from a core's data sheet specifications, it assumed values H_{sat} and $-H_{sat}$ based on B_{sat}/μ, without clearly defining how to determine the acceptable value of permeability. In this article, a method is proposed for defining H_{sat} based on an analytic expression for the core permeability dependence on the magnetizing field induced in the core. It assumes dependence of permeability on the applied magnetic field and a value of an *admissible permeability loss* due to the magnetization strength H rise. Using the new expression for H_{sat} derived here, we'll see how it can be applied to the previously derived expression for hysteresis loss in a design example.

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

February 2025:

Snapback TVSs Deliver More Accurate And Robust Circuit Protection

by Kevin Parmenter, Taiwan Semiconductor, Brea, Calif.

Abstract: In the rapidly advancing world of electronics, circuit protection is critical to ensuring equipment and system longevity, reliability, and safety. One of the latest innovations in this field is snapback TVS (transient voltage suppressor) technology. While no device is perfect for all applications, the advancement of snapback TVS technology brings the industry closer to the ideal solution for protecting many applications across various markets, including consumer electronics where warranty returns can consume entire profit margins. This article discusses the technology and market trends that are driving adoption of TVSs, the pros and cons of conventional TVS devices, and how snapback TVS device technology offers a groundbreaking approach to circuit protection.

Notes: 7 pages, 5 figures, 2 tables. Read the full story…

Designing An Open-Source Power Inverter (Part 24): Inverter Output Filter Conundrum

by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

Abstract: As we approach the end of this Volksinverter design series, we address an aspect of power inverter performance that will be critical to commercial implementations of this design for compliance reasons as well as for the proper operation of the equipment being powered. The issue at hand is EMI, and specifically the conducted EMI produced by the inverter. The Volksinverter output stage—the inverter itself—has an LC filter. Will it adequately attenuate EMI currents? In this part we analyze operation of the LC filter, and discuss different possible solutions to suppression of common-mode currents, but ultimately settle on a modified configuration of the filter. We also analyze how PWM switching sequences affect EMI performance and which sequences are optimal. In the last section, filter design equations are presented.

Notes: 8 pages, 3 figures, 1 table. Read the full story…

Current Mode-Controlled DC-DC Regulators (Part 3): CC-CV Regulation

by Timothy Hegarty, Texas Instruments, Phoenix, Ariz.

Abstract: This article examines a constant-current, constant-voltage (CC-CV) dual-loop architecture for a dc-dc regulator that provides a constant output voltage or constant output current, depending on the application requirement and operating condition. The author outlines incumbent designs for the CC circuit that work as an add-on to a conventional dc-dc regulator. He then details a CC-CV integrated circuit (IC) approach with low external component count, reduced cost, accurate current-setpoint performance and improved transient response. The IC implementation is unique in that it selects the minimum of the currents from the transconductance error amplifiers in the CV and CC loops. This error current then flows in a shared compensation component network, the resultant compensation

voltage becoming the reference command of the inner current loop of the current-mode architecture detailed in parts 1 and 2.

Notes: 7 pages, 7 figures, 2 tables. Read the full story…

How To Model Coupled Inductors In A SEPIC Converter

by Wei Gu, Analog Devices, San Jose, Calif.

Abstract: Converter designs based on the single-ended primary inductance converter (SEPIC) topology often opt to use a coupled inductor both to reduce the number of components and overall converter size, and to simplify control. However, this design choice complicates simulation: If the coupled inductor is not modeled correctly, the simulated result can be quite different from the bench result. Unfortunately, there is not much guidance on this topic in the literature, particularly with regard to the SEPIC. This article discusses how to best model coupled inductors in a SEPIC design. Methods to build a proper model are introduced and the equations are included.

Notes: 4 pages, 8 figures. Read the full story…

March 2025:

Protect And Enhance High-Power Designs With Integrated Solid-State Isolators

by Davide Giacomini, Infineon Technologies, Pavia, Italy and Sameh Snene, Infineon Technologies, Munich, Germany

Abstract: In high-power designs, an isolation technique with several integrated features can mean the difference between a product that meets and even exceeds customer expectations and one that generates numerous customer complaints. To achieve this isolation, an integrated solid-state isolator (SSI) based on coreless transformer galvanic isolation provides many design benefits. Unlike optical-based solid-state relays (SSRs), an integrated SSI driver can provide the required isolation and energy transfer to ensure proper operation and extended life for high-power systems as well as several integrated protection features. In this article, we'll describe the features and characteristics of Infineon's integrated SSI drivers and then present a series of examples demonstrating how these devices can be combined with power MOSFETs and other supporting components to replace conventional DIN-rail and panel-mount SSRs.

Notes: 16 pages, 9 figures, 9 tables. Read the full story…

Improving Validation Of Power Supply Re-Rush Performance Through More Accurate Sensing Of AC Line Peaks

by Viktor Vogman, Olympia, Wash.

Abstract: Switch-mode power supplies that support a wide range of input voltages (up to 277 Vac) in real applications can operate in various ac transient conditions such as voltage sags and surges, dropouts, line frequency deviations, etc. Although these conditions are detailed in power supply specs and replicated with conventional programmable ac sources during qualification, some power supplies that pass extensive qualification tests may still have a significant failure rate in the field due to ac transients associated with the so-called re-rush event. This article examines the impact of the ac peak voltage detection accuracy on replicating the worst-case re-rush condition and discusses shortcomings of the direct input voltage sensing technique. It then presents a simple technique based on voltage derivative sensing for improving the accuracy of such detection.

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

Coupled Inductor Design For A Flyback With Very Wide Input Voltage Range

by Gregory Mirsky, Design Engineer, Deer Park, Ill.

Abstract: There is an automotive and railroad class of flyback converters that demands operability over a very wide input voltage range—from 30 V to 800 V. These are backup power supplies that should operate when the traction battery decays. With such a wide input range, duty cycle will vary widely. Yet rather than assuming a duty cycle range, most flyback designs assume some average value for duty cycle. This can have serious implications for the performance of the coupled inductor, particularly in a flyback design with a very wide input voltage range. This article offers a procedure for designing the coupled inductor that takes into account the full duty-cycle range of the flyback. The procedure is demonstrated in a design example using the 30-V to 800-V input range.

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

April 2025:

Designing An Open-Source Power Inverter (Part 25): Boost Or Buck For Converters That Increase Voltage?

by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

Abstract: As this long and winding articles series comes to a conclusion, we have one more point to ponder. In retrospect, was the Volksinverter choice of the CA (boost) power transfer circuit optimal in view of residential inverter convergence to a CP (buck) configuration instead? If we look back at the previous comparisons of the buck and boost circuits, we'll see that there were some differences between these circuits that complicate the comparisons. The CP-PP circuit we are about to examine is slightly different from the PP and CP-BRG buck circuits previously examined, and is more structurally similar to the CA-PP to allow a more direct comparison of buck versus boost.

Notes: 8 pages, 3 figures, 1 table. Read the full story…

Exploring Advanced Configurable Logic For Current, Voltage And Power Measurement

by Ruslan Tykhovetskyi, Renesas Electronics, Lviv, Ukraine

Abstract: The increasing complexity of electronic devices often demands precise and reliable monitoring of current, voltage, and power. Beyond capturing instantaneous readings, analyzing how these parameters change over time is crucial for optimizing performance and efficiency. A highly effective approach to this challenge is leveraging configurable logic, which enables the creation of

flexible measurement systems tailored to specific applications. The SLG47011V programmable logic chip provides an ideal solution by combining high-speed data processing with functional adaptability, making it a powerful tool for modern engineering applications. In this article, we will explore the advanced capabilities of the SLG47011V for measuring current, voltage, and power, highlighting the importance of leveraging its configurable logic and specialized features to meet the specific requirements of modern monitoring applications.

Notes: 8 pages, 7 figures, 2 tables. Read the full story…

How eFuses Strengthen Power-Path Protection For Cooling Fans In AI Servers

by Kshitiz Khatri, Texas Instruments, Karnataka, India

Abstract: Over the past decade, power levels per rack server have surged from 10 kW or 15 kW to as high as 100 kW, increasing demand for more effective power dissipation. Consequently, fans are transitioning to higher voltage rails (48 V) to accommodate increased power requirements. Historically, eFuses such as the TPS25981 (12 V, 10 A) were used for power-path protection for the 120-W power range. However, the rising power demands of contemporary fans necessitate higher-rated eFuses, such as the TPS1685 (48 V, 20 A), which supports approximately 960 W. This enhancement is crucial for maximizing thermal performance in servers. This article will discuss the application requirements for fan-based cooling in AI server racks and the role of eFuses in protecting the fans against both overcurrent, overvoltage and overtemperature events.

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

Mythology In Power Magnetics

by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

Abstract: Magnetic components appear to be so simple—just two parts, a core and some wire wrapped around it. How could that be very complicated? If you ask this question of yourself seriously enough, you begin your own descent into the abyss of magnetics design. As a "recovering magnetaholic," I have learned that magnetics really is simple, but the path to simplicity is fraught with misleading ideas. Some of these ideas are partially true, but misleading in the ways they are usually expressed; while others are not true at all, though they may be widespread. More importantly, some basic concepts that should be widely known are not. This article is a chat about some of them.

Notes: 6 pages, 4 figures, 1 table. Read the full story…

May 2025:

MLCCs Are At The Forefront Of Capacitor Miniaturization

by Ron Demcko, KYOCERA AVX, Fountain Inn, S.C.

Abstract: Capacitors have been evolving for 100 years or more. In the pre-transistor era of point-to-point wiring, capacitors were large. For example, a 0.1-μF capacitor could occupy 3 cc of volume. That shrank to about 1 cc in the transistor era. Those days now seem like the stone age given the availability of tiny MLCCs such as an 0201-sized 10-μF capacitor occupying just 5.5 x 10^{-5} cc! This

article discusses the market and technology trends that have been driving down the size of MLCCs, including their package heights. These low-profile MLCCs are being embedded in IC substrates and pc boards. This article also touches on other capacitor types such as silicon and MOS, and single-layer ceramics, which are supporting further integration and embedding of capacitors in power circuits and other applications.

Notes: 4 pages, 2 figures, 1 table. Read the full story…

How Active EMI Filter ICs Reduce Common-Mode Emissions in Single- And Three-Phase Applications (Part 5): Improving Immunity To Low-Frequency Disturbances

by Timothy Hegarty, Texas Instruments, Phoenix, Ariz.

Abstract: A compact design of the EMI filter is vital to meeting packaging specifications in high-density ac-dc applications, such as server-rack power supplies and onboard chargers for EVs. Fortunately, an active EMI filter (AEF) circuit for common-mode (CM) noise attenuation, through miniaturization of the toroidal-cored CM chokes in the equivalent passive filter, can considerably reduce the size, weight and cost of the overall power-circuit implementation. Previous parts of this series provided an overview of AEF techniques, discussed behavioral models to characterize the chokes and derived loop-gain expressions for a feedback-type voltage-sense current-inject AEF circuit. This new installment in the series addresses the problem of AEF amplifier saturation, which can result from low-frequency CM disturbances at the filter's input port.

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

Non-Inverting Integrators Are Not Really Integrators (Part 1)

by Gregory Mirsky, Design Engineer, Deer Park, Ill.

Abstract: Integrators find use in a huge variety of electronic devices. Some of them use integrators to perform a mathematical operation of integrating analog signals. An example of such an application is a Rogowski current sensor where the output of the coil is a voltage proportional to the differentiated current in the bus. To restore the current waveform, an integrator is used. Many authors have presented non-inverting schemes for the integrator. However, these circuits produce erroneous results. Because of the non-inverting input, the transfer function of a non-inverting integrator obtains a zero at the pole frequency, thus destroying the integration function. In this article series, we'll analyze various forms of inverting and non-inverting integrators to confirm this problem and then present examples that illustrate the differences in performance.

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

Optimized Magnetics Winding Design (Part 1): A Discovery Over Fifty Years Late

by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

Abstract: Dowell derived a 1D field solution for a pair of parallel plates conducting current, much like the layers of windings in a transformer. Magnetics textbooks routinely derive and explain it, and how it can be applied to magnetic component *analysis*, which is to say the

calculation of winding resistance and therefore power losses for a given transformer design. Yet there is also an obvious way to apply it for magnetics design *optimization*, which minimizes winding resistance while applying constraints on certain winding parameters. The concepts presented in this new series may be familiar to those who have read my previous works on winding design such as references 1 and 2. However, the material is presented here in more of a tutorial format with further explanation of key points.

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