

Design Article Archive

Abstracts of articles published in the January through December 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.

[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.

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Notes: 6 pages, 2 figures.

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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

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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.

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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.

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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

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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.

[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

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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.

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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- μ F 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- μ F capacitor occupying just 5.5×10^{-5} cc! This

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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.

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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

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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...](#)

June 2025:

Measuring Loop Response Of Regulators With Inaccessible Feedback Resistor

by Adam Huff, Xu Zhang and George (Zhijun) Qian, Analog Devices, San Jose, Calif.

Abstract: For a power supply to be stable, a certain gain and phase margin is needed. The conventional approach of making Bode plot measurements is preferred for its simplicity, assuming the user has access to the top feedback resistor. But how can the loop response be measured when the top feedback resistor is inaccessible within a molded module? And how is the loop response measured when a device does not require a top feedback resistor and instead uses an output voltage sense pin? In this article, we present variations on the conventional loop response measurement method, which use the same instrument but with some changes in the connection to the regulator and (in one case) some simple additional circuitry.

Notes: 5 pages, 7 figures.

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Non-Inverting Integrators Are Not Really Integrators (Part 2)

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

Abstract: The first part of this series dedicated to different types of integrators described the standard inverting integrator circuit and a variant with phase correction. Through analysis, it was shown that inverting integrators (with or without phase correction) are real integrators because their amplitude-frequency characteristics are down sloping at a constant rate unlimitedly, assuming there are no parasitic parameters. Now, it is time to review non-inverting integrators, which are widely promoted as proposed integrator solutions and draw some conclusions about their integrating abilities.

Notes: 4 pages, 3 figures.

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Dickson Architecture And Novel Switching Techniques Enhance Charge Pump Benefits

by Soojin Chung and Jason Ngai, pSemi, San Jose, Calif.

Abstract: The charge pump or capacitor divider is increasing in popularity in high-efficiency power conversion, particularly for slim, low-profile, battery powered applications. This article explores the use of multiple capacitor division ratios on the same IC device. It also introduces a feature that allows dynamic and seamless transitions between the ratios, depending on the external circuit environment.

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By considering various battery-powered architectures, we show how the charge pump offers significant advantages and how the ability to dynamically transition between ratios extends the system run-time. This article focuses on specific technologies used in pSemi voltage regulators. As such, it analyzes operation of the Dickson charge pump architecture and the company's novel "adiabatic" or lossless switching of the charge pump.

Notes: 9 pages, 10 figures.

[Read the full story...](#)

July 2025:

Motor Control For Designers (Part 1): Basic Principles Of Motor Theory

by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

Abstract: With the rising popularity of electronically commutated motors such as brushless dc motors, permanent magnet synchronous motors and variable reluctance motors, requirements for motor control and motor drive design are growing. For electronics engineers seeking proficiency in these topics, it's necessary to learn not only how the controllers and inverters operate, but also how the motors themselves work. Likewise, motor designers may benefit from an understanding of how the circuits driving the motors function. This article kicks off a mini-course on motors and circuits that aims to inform both the circuit and the motor designers by covering the following topics: 1) motor theory, 2) motor design, 3) motor-drive design, and 4) motion control. The goal in publishing these four series is to convey a working design knowledge of electric machines and the electronics and software to control them.

Notes: 8 pages, 1 figure, 3 tables.

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Non-Inverting Integrators Are Not Really Integrators (Part 3): Impact On Rogowski Sensors

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

Abstract: In previous parts we considered general properties of inverting and non-inverting integrators and figured out that a non-inverting configuration is not an integrator at all. We have come to that conclusion by analyzing the amplitude-frequency characteristics of both configurations. However, we would also like to know the impact of these characteristics in a key integrator application—the Rogowski coil sensor. To do this, we'll analyze the responses of both the inverting and non-inverting integrator configurations to the derivatives of rectangular pulses. We are using rectangular pulses because they have a wide spectrum and thus represent the worst case. And while we've cast doubt on the value of non-inverting integrator configurations, we'll still include them in our analysis because of the frequency with which they appear in a plethora of publications.

Notes: 5 pages, 2 figures.

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Optimized Magnetics Winding Design (Part 2): Minimized Winding Resistance For Constant Layers Or Strands

by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

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Abstract: In the previous part of this article, the constant-frequency eddy-current resistance ratio F_r , which is usually plotted with constant M winding layers as a parameter, instead allows M to vary according to various geometric constraints on the winding window such as number of bundle strands or winding cross-sectional area. However, as we discovered in the earlier analysis, making winding area constant did not lead to a clear minimum for F_r and therefore provided no clarity on optimal wire size. In this article, we see how this problem can be overcome by solving for the constant-frequency eddy-current resistance ratio of a bundle (F_r/N_s), rather than that of the individual strands. We then delve further into how this resistance ratio varies for constant number of layers and strands, and in part 3, constant winding area.

Notes: 5 pages, 2 figures.

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August 2025:

Operational Transconductance Amplifiers In PWM ICs: Grounded And Negative Feedback Compensation Both Have Their Place

by Alain Laprade, Power Electronics Specialist, Saunderstown, R.I.

Abstract: Operational transconductance amplifiers (OTAs) are commonly used with grounded-feedback compensation networks in PWM IC designs. However, an alternative configuration—connecting the compensation network via negative feedback to the output voltage divider—has shown promising results. Despite its potential, this approach remains underutilized, likely due to misconceptions about its viability. When I first experimented with this technique years ago as a field applications engineer, the prevailing belief was that OTA negative feedback wouldn't work. This article aims to clarify that misunderstanding and explore the merits of both configurations. Using type-II feedback transfer function models, we'll compare grounded and negative-feedback implementations to highlight their respective tradeoffs and performance characteristics. All theoretical expressions are validated through SIMPLIS simulations to ensure practical relevance.

Notes: 13 pages, 13 figures, 4 tables.

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Motor Control For Designers (Part 2): Electromagnetic Force Production In Motors

by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

Abstract: This part continues the discussion of motor theory by explaining how electromagnetic force is generated. It begins by introducing the Lorentz Force equation to explain the generation of mechanical force in electrostatic and magnetic motors. Next, we use the example of a simple two-pole motor to explain how the motor components cause magnetic fields to interact to produce force and motion. The relationship between rotor field and stator field-current vectors is used to explain phase and magnitude control as the basis for motion control including torque generation. The next section extends the explanation of motor construction, describing an outer-rotor permanent-magnet (PM) motor including pole-pairs, winding configurations, and various aspects of its operation. Finally, the roles of pole-pairs and phase windings in the implementation of phase control and the regulation of torque angle for field-oriented control are explained.

Notes: 8 pages, 10 figures, 1 table.

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Better Core Geometry Is Why Planar Magnetics Win

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

Abstract: Sometimes it is said that planar magnetics perform better than wound magnetics. That's a curious statement. What does it mean "to perform better"? Essentially, it is to have lower loss at the same volume, core material, operating power and frequency. The loss in transformers is defined by the value of the magnetizing current. Therefore, to understand how transformer geometry influences losses, we must determine how the core geometry affects the magnetizing current. As we will see, a lower core height leads to lower losses. For inductors, the magnetizing current is the operating current, and we cannot adjust it. Inductors are intended for storing magnetic energy, and the higher S_{core}/I_{mag} ratio allows for storing more energy at the same current as we will see.

Notes: 3 pages.

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September 2025:

Leveraging Special Dead-Time Control Modes To Optimize GaN-Based Buck Converter Designs

by James R. Staley, Analog Devices, Durham, N.C.

Abstract: Synchronous converters operate by alternately toggling a control switch and a synchronous switch device on and off. If the delay (dead time) between turning one switch off and the other on is longer than necessary, efficiency suffers. If the delay is not long enough, shoot-through can cause massive amounts of current flow through the switch pair. This hurts efficiency and can damage components. While these considerations have been well understood, the dynamics change when silicon MOSFETs are replaced with GaN FETs. This article explores the switching dynamics at play when GaN FETs are used for the power stage in synchronous buck converters and how specialized dead-time adjustment modes in two buck controllers can be used to optimize dead time based on design goals for efficiency and reliability.

Notes: 10 pages, 11 figures, 3 tables.

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Stackable Buck Regulators Simplify Multiphase Design

by Min Chen, Infineon, El Segundo, Calif. and Vijay Viswanathan, Infineon, Morrisville, N.C.

Abstract: With the increasing power consumption required by modern POL power systems, more power rails need a maximum output current beyond the capability of a single-phase POL converter. Although multiphase converters can be used for these power rails, a discrete multiphase design increases component count, leading to a higher BOM cost and added design complexity. And there's extra PCB area and layout effort required to accommodate a multiphase PWM controller and power stages. However, the same multiphase design goals can be achieved using integrated stackable POL converters. These devices provide a more cost effective and compact solution when the total phase count is less than four. In this article, the benefits of analog stackable integrated dc-dc buck regulators in general and the TDA38540 in particular are discussed.

Notes: 8 pages, 7 figures, 5 tables.

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Energizing Output Filter Inductor Enables Instantaneous PSU Activation

by Viktor Vogman, Olympia, Wash.

Abstract: Using a cold redundancy technique to wake up a battery backup module allows for accelerated power supply wake-up. It is based on the concept of precharging output capacitors to their steady-state voltage levels. In this non-resonant transition case, a soft start is not required, as only the output filter inductor needs to be charged to the current matching the current consumed by the load. Although a full power stage activation in this case typically lasts only a few hundred microseconds, the usage of this technique still requires much larger dc bus capacitor values than would be needed in the “ideal” instantaneous wakeup case. To overcome this limitation, this article discusses the opportunity to “precharge” the output filter inductor along with the output capacitor, to further accelerate the backup module activation process.

Notes: 6 pages, 3 figures.

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Optimized Magnetics Winding Design (Part 3): Minimized Winding Resistance For Constant Winding Area

by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

Abstract: In the first two parts of this series, magnetics winding design optimization was explained for constant layers and constant strands per turn bundle and some design formulas were given. In this third part, the most useful formulas are presented based on a fixed allotment of window area in the core to the windings. A given winding thus has fraction k_{ww} of the total core window area A_w , and the goal is to determine the optimal wire size for minimum (primary-referred) winding resistance R_{wp} .

Notes: 4 pages, 1 figure.

[Read the full story...](#)

October 2025:

Current-Mode Controlled DC-DC Regulators (Part 4): Small-Signal Behavior Of The CC Loop

by Timothy Hegarty, Texas Instruments, Phoenix, Ariz.

Abstract: In part 3 of this series, the author defined a CC-CV regulator with a novel dual-loop architecture activating either the CC or CV error amplifier at a given time, thus minimizing loop interactions and yielding a seamless handoff from CC to CV and vice versa. He then described a synchronous buck controller with this CC-CV implementation that offers accurate current-regulation performance, a low external component count and reduced cost. This fourth installment builds on part 3 by pursuing the relevant small-signal transfer functions for the CC loop. Designing the CC and CV loops with similar small-signal dynamics enables the use of a shared compensation component network. Bode plot simulations of the loop response in CC mode, based on a commercially available CC-CV GaN synchronous buck converter (the LMG708B0), illustrate the small-signal characteristics of the dual-loop architecture.

Notes: 11 pages, 11 figures, 2 tables.

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Controlling Rogowski Sensor Frequency Response Through Integrator Design

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

Abstract: In a previous article series, the operation of the Rogowski coil was analyzed and equations were derived for designing both the coil and integrator to create a complete Rogowski sensor. The purpose in doing so was to allow designers to obtain some of the benefits of Rogowski sensors such as wide current range at a much lower cost than off-the-shelf instrument-grade Rogowski sensors, while only making small sacrifices in sensor accuracy. In this article, we carry the discussion design further by explaining how to tailor the frequency bandwidth of the Rogowski sensor to a particular application through adjustment of the integrator design. This part also draws on some of the analysis performed in the recent series on integrators.

Notes: 9 pages, 6 figures.

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Motor Control For Designers (Part 3): Torque-Current Relationship

by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

Abstract: With the definition of terms and key relationships established in the first parts of this series, we can now proceed to develop a motor model in the next three parts. As an electromechanical device, it will have certain relationships between electrical and mechanical quantities. This part relates electrical and mechanical quantities in two simple equations for torque T and induced voltage v_{ω} . We begin by deriving these expressions, and then describe how motor geometry influences the induced-voltage waveform. This relationship is further illustrated by presenting the flux and induced-voltage waveforms for a simple PMS motor example.

Notes: 6 pages, 4 figures.

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The Ćuk Integrated Magnetics Converter With Current Ripple Cancellation: The Optimal Power Conversion Topology?

by Isaac Cohen, Huntington Station, N.Y.

Abstract: It's claimed that the Ćuk converter is superior to other topologies (operating at the same frequency) because it offers zero (very low) current ripple at both input and output; inductive energy storage replaced by capacitive energy storage, leading to lower cost and smaller volume; dc current in the inductor, eliminating ac copper loss; and higher efficiency. However, to the best of the author's knowledge, no rigorous quantitative comparison was ever done to validate the narrative and quantify the advantage in power density and efficiency. In this presentation, a simple model is developed for easy simulation of the Ćuk converter. The Ćuk converter with integrated magnetics is then analyzed and compared to an equivalent flyback converter operating at the same frequency. Some conclusions are drawn about the claimed benefits of the Ćuk converter.

Notes: 87 slides.

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November 2025:

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SPICE Simulation Of A Digitally-Compensated Buck Converter

by Christophe Basso, Future Electronics, Toulouse, France

Abstract: The digital control of a switching converter offers many advantages over its analog counterpart. For instance, poles and zeros placed in the compensator no longer depend on passive components whose variability will affect the compensation strategy. There's also the option of dynamically changing the positions of these poles and zeroes based on operating conditions. For those of us coming from the analog world, the compensation can be thought out in the frequency-domain first, then translated into the discrete-time domain via an appropriate mapping process. Once the translation is done, it is worth validating the calculated coefficients and confirming the compensated converter delivers the expected transient response. To that end, LTspice offers a simple and efficient way to verify these calculations are correct before coding the compensator using a macro the author wrote to generate the filter coefficients.

Notes: 12 pages, 12 figures.

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Motor Control For Designers (Part 4): PMS Motor Electrical Model

by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

Abstract: Previous articles have developed the design equations needed to create an electrical motor model. The resulting model, which will be presented here, is simplified as a magnitude-only model in that it assumes that the torque angle $\delta = \pi/2 = 90^\circ$ —that phase control is field-oriented. This is not a major limitation from a design standpoint because magnitude and phase control are usually separate subsystems. (Later, this mini-course will cover phase control.) As noted in Motor Control For Designers (Part 1), the book cited by Krause and Wasynczuk develops a complete model that is taken apart in design for separate magnitude and phase control. This discussion begins with the introduction of a basic PMS motor model that represents the electrical and mechanical reference frames of the motor.

Notes: 5 pages, 4 figures, 2 tables.

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Integrator Feedback Resistor—Adverse Or Friendly? How To DC Stabilize An Integrator Output

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

Abstract: The integrator design in a recent article was incomplete as it did not correct for the “walkaway” of the integrator output caused by thermal and noise effects at the amplifier’s inputs, which include input voltage offsets and leakage current. These stray parameters make the integrator inoperable if specific measures are not taken. Very often designers use a feedback resistor of a few megohms, establishing negative feedback to eliminate the integrator output walkaway. But does this method work and if so, what effects might it have on integrator operation? In this article, we analyze the impact of the dc feedback resistor on integrator design—both inverting and non-inverting. We also discuss another method of stabilizing integrator operation in the Rogowski sensor application with servo feedback.

Notes: 4 pages, 3 figures.

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Why Couple The Windings In A SEPIC?

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Abstracts of articles published in the January through December 2025 issues

by Eleazar Falco, Würth Elektronik, Waldenburg, Germany

Abstract: The SEPIC (single-ended primary-inductor converter) is a nonisolated, switching power supply topology that provides an output voltage that can be higher, equal or lower than the input voltage. The SEPIC power stage is built with two inductors, which could also share the same magnetic core as the two windings of a coupled inductor. This approach provides some advantages compared to an uncoupled design, like a lower ripple current amplitude on each winding, and it is common to hear that either the required inductance or the ripple current can be “halved” thanks to the magnetic coupling. This article explains why the ripple current amplitude is reduced when magnetically coupling the windings in a SEPIC, as well as how the leakage inductance affects the maximum ripple current reduction. In addition, real measurements show that using a coupled inductor offers higher efficiency.

Notes: 8 pages, 10 figures.

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December 2025:

Design Of Dual Active Bridge Converters For Electric Vehicles—Evaluating Modulation Schemes And Operating Frequencies

by Silpashree Sahu, Abinash Dash, Dipankar De, Harikrishnan A, and Varri Chandra Sekhar Pavan Kumar, IIT Bhubaneswar, Jatni, India and Alberto Castellazzi, Kyoto University of Advanced Sciences, Kyoto, Japan

Abstract: The dual active bridge (DAB) converter is commonly used to interface different voltage levels in hybrid electric vehicle (HEV) and electric vehicle (EV) systems, while enabling bidirectional operation. The control of this power supply topology can be implemented with different modulation methods—single-phase-shift, triple-phase-shift and extended-phase-shift control. The choice of modulation method will affect component selection, converter efficiency and reliability. In this article, the authors present the results of a study comparing DAB converter losses for the three modulation methods and at different switching frequencies, with detailed design steps. This is mainly accomplished through an analysis and simulation of power switch and magnetics losses. This discussion includes an explanation of how the different modulation techniques control switching of the DAB’s two H-bridges, and how to determine the losses. Converter operation and thermal performance are verified experimentally.

Notes: 14 pages, 10 figures, 5 tables.

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Modified DCR Current Sensing Expands Inductor Choices For Peak-Current-Mode Buck Regulators

by David Baba, Texas Instruments, Chandler, Ariz.

Abstract: Buck regulators that employ output current sensing with internal slope compensation introduce specific considerations for inductor and current-sense resistor selection. At first glance, internal slope compensation may seem to restrict your design choices. With careful design, however, DCR current sensing can provide significant flexibility, even when the inductor selected has a low inductance value and a relatively high DCR. In this article, the author presents a method for designing and tuning a DCR current-sensing network to accurately replicate the inductor current in peak-current-mode buck converters. By matching the RC network’s time constant to the ratio of inductance and its DCR, you can align the sensed waveform with the actual inductor current for both dc scaling

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and ac ripple attenuation. This enables current-limit control and stable loop operation under different inductor values.

Notes: 9 pages, 5 figures.

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Accurately Measuring High Currents With A Precision Current Sense Amplifier

by Simon Bramble, Analog Devices, Hayes, U.K.

Abstract: Many digital multimeters can measure up to 10 A with a high degree of precision. However, if higher currents need to be measured, other methods must be used. While it is a simple matter to insert a current sensing resistor in series with the load and measure the voltage drop across it, there is a tradeoff. The voltage across the sense resistor should be small enough to provide the maximum voltage to the load and to minimize the heat dissipation in the resistor, but large enough to enable the voltage to be measured with a high degree of accuracy. An IC described in this article—the LTC6102—facilitates the measurement of a low voltage across the sense resistor and produces an amplified, ground-referenced output voltage with a high level of accuracy.

Notes: 8 pages, 10 figures, 1 table.

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Average Value Extractor Is More Precise Than Low Pass Filters

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

Abstract: When designing ac current sensors, we use the current's average value to create a voltage that mitigates the error due to dc offset in the system of integrator and amplifiers. While it's possible to obtain the average value of an analyzed signal through usage of a low-pass filter, the filter significantly narrows its operating frequency range, which is not always acceptable. However, with an op amp, we can subtract an ac component from a signal composed of this ac component and a dc offset delivered by the high-gain amplifiers employed in the system. In this article, we'll derive the equations for an average value extractor circuit built from an op amp-based circuit—specifically a differential amplifier. Then we'll demonstrate how this average value extractor can be used to perform dc stabilization of a Rogowski integrator circuit.

Notes: 5 pages, 3 figures.

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