HOW2POWER TODAY

Design Article Archive

Abstracts of articles published in the March 2024 issue

January 2024:

Prismatic-Cell Supercapacitors Enable Thinner Boost Circuits

by Ron Demcko, Ryan Messina, Ashley Stanziola and Daniel West, KYOCERA AVX Components, Fountain Inn, S.C.

Abstract: Continued advances in ultra-low power (ULP) ICs and the demand for smaller-size portable electronics have combined to create an opportunity for small, thin supercapacitors. Supercapacitors can help achieve extended battery life by supplementing peak power delivery from primary and secondary batteries. Moreover, depending upon the power budget, supercapacitors can even eliminate batteries altogether in some applications. When charged by an energy harvesting source, supercaps by themselves can power some circuits, enabling a near limitless number of charge and discharge cycles. Prismatic-cell supercapacitors offer an additional advantage as they reduce the height of the supercap versus what would normally be required with a conventional device packaged in a radial can. The PrizmaCap series supercapacitors can maximize this benefit as they offer the highest energy density of any prismatic electrochemical double layer capacitor.

Notes: 8 pages, 5 figures, 1 table. Read the full story…

Laplace Transform Simplifies Analysis Of Realistic SMPS Waveforms

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

Abstract: When making calculations with the rectangular waveforms present in switched-mode power supplies, designers try to avoid the difficulties associated with the real shape of these pulses. They ignore that these pulses are not actually *rectangular* as in the ideal case, but rather *trapezoidal*. Unfortunately, replacement of trapezoidal pulses with the ideal rectangular ones may adversely affect assessment of power loss since overlapping of turn-on and turn-off times of, for example, transistors in the same column of the bridge, is the main source of dynamic power loss. While there are "artificial" methods of including the on and off times in the analysis, these may produce false results or be very cumbersome. A simpler alternative method for performing analysis of realistic SMPS waveforms uses the Laplace transform, taking advantage of a previously published formula that represents a series of trapezoidal pulses.

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

Improving Durability Of Wire Bonds In EV Batteries

by Dodgie Calpito, Tanaka Kikinzoku International, San Jose, Calif.; and Shuichi Mitoma, Shizu Matsunaga, Kosuke Ono, and Tsukasa Ichikawa, Tanaka Denshi Kogyo, Tokyo, Japan

Abstract: Wire bonds are delicate with limited flexibility, and in semiconductors, they are usually encapsulated by buffer materials such as resin or mold compounds. These materials give them a measure of durability and strength to resist damage from vibration. But that measure of durability is lost in open-air applications in the majority of EV battery packs where there is no material to protect the wire bonds from the effects of vibration, leaving the wire bonds vulnerable to breakage. In this article, we look at ultrasonic wire bonding as it is used for the interconnection of cylindrical lithium-ion (Li-ion) cells in EV battery packs. Specifically, we present a series of vibration tests that were conducted on wire bonds used in EV battery packs to determine the degree to which different aspects of wire bond design affect their susceptibility to breakage.

Notes: 8 pages, 11 figures, 3 tables. Read the full story…

Inductor Turns For Maximum Energy Transfer With Core Saturation

by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

Abstract: In a previous article, an asymptotic semi-log model of core saturation was presented. It has three regions of core operation: unsaturated ($H < H_0$), saturated ($H_0 \leq H < H_T$), and fully-saturated ($H \geq H_T$). Power inductors are operated in the saturated region because it is in this region that maximum energy or flux can be stored. This article applies the asymptotic core saturation model to the main magnetics design goal of maximizing energy density in the core for power transfer. This basic performance goal optimizes inductor turns. To do this, we must determine the value of k_{sat} and H (representing average current) in the core saturation model where core transfer-energy density is maximized to achieve maximum power transfer in a power converter for a given core size. Since circuit design parameters determine average current and can affect the minimum allowable $k_{sat,}$, the finding of the optimum k_{sat} may lead the designer to select a larger or smaller core.

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

February 2024:

How Active EMI Filter ICs Reduce Common-Mode Emissions in Single- And Three-Phase Applications (Part 2): Modeling Ferrite Chokes

by Timothy Hegarty, Texas Instruments, Phoenix, Ariz.

Abstract: Part 1 of this article series included an overview of active EMI filter (AEF) techniques to diminish the reliance on bulky passive filter components. An AEF circuit can significantly reduce magnetic component and overall filter size versus an equivalent passive filter, enabling higher-density filter designs for size-constrained applications. However, accurate characterization and modeling of the choke impedance is an essential step and of paramount importance in EMI filter design, as the choke impedance directly impacts filter attenuation performance (as well as loop stability in active designs). Following a review of the impedance behavior of ferrite-cored magnetic components, this article describes a SPICE-compatible behavioral model for a ferrite choke using an intuitive circuit structure. This model facilitates easy and accurate system-level EMI simulations in the time and frequency domains for both passive and active filter designs.

Notes: 16 pages, 15 figures, 3 tables. Read the full story…

CMOS Buffers Support Cold Sparing For Space ICs Without The Usual Power Penalty

by Mark Hamlyn, Kyle Schulmeyer, Anton Quiroz and Abhijeet Ghoshal, Apogee Semiconductor, Plano, Texas

Abstract: Satellites are designed with duplicate systems or components for critical functions. Where redundant components are used, the back-up systems are powered-off or "cold spared" when not in use. Cold-spare components are electrically isolated from the primary system in operation via separate power supplies. However, the presence of ESD clamping diodes in standard CMOS input and

output buffers creates difficulties in cold-sparing of logic circuits as the diodes create unwanted paths of current conduction via the cold-sparing power supply, wasting power. To address these issues, system designers may add isolation circuitry but that also increases system complexity. With these challenges in mind, Apogee Semiconductor has developed proprietary I/O structures that enable cold-sparing without the power penalty associated with use of COTS-based CMOS ICs, while also avoiding the drawbacks of isolation circuitry.

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

Load-Adaptive PSU Can Benefit Server Systems With Reduced Idle Power

by Viktor Vogman, Olympia, Wash.

Abstract: To promote the energy efficiency of server platforms under light loading conditions, the 80Plus program was established to certify computer and server system power supply units that at high cert levels have more than 80% energy efficiency even at 10% of rated loads. However, for systems with lower idle power consumption and PSUs with lower 80 Plus certification levels, there is still an opportunity for improvements. Such opportunity is associated with the use of a load-adaptive PSU architecture that can boost PSU efficiency at such power levels, bring additional energy savings, and be a better choice for such cases. This article studies an opportunity to use such an approach for server power supplies whose efficiency highly depends on the consumed power level.

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

Optimizing Winding Design For Low-Resistance Windings—Selecting Wire Or Bundle Size To Fill The Core Window

by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

Abstract: One of the main goals of winding design is to maximize current density in the core window. Then inductor transfer power—energy storage per cycle—is maximized as is converter power density. For transformers, a full window also transfers maximum power. Thus the goal is to put as much conductive area in wire into the window area as possible. This article analyzes how to optimize winding geometry when wire size is large and turns are few—through the selection of wire size, number of layers, and bundle size—to achieve this goal of maximizing conductor area within a given core window. By manipulating the wire and winding parameters, we are able to maximize the window boundary packing factor, a concept that brings us to maximum conductive area.

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

March 2024:

Designing An Open-Source Power Inverter (Part 15): Transformer Magnetic Design For the Battery Converter

by Dennis Feucht, Innovatia Laboratories, Cayo, Belize

Abstract: This and the next two parts of the Volksinverter design series present an example procedure—a design template—for optimizing the design of converter transformers for boost push-pull

power-transfer circuits. Optimizations include core selection, maximized primary-to-secondary power transfer, optimal winding area allocation, and minimized winding loss. The template is based heavily on previous derivations in other magnetics and Volksinverter series articles published in How2Power Today. Magnetic design, which is the focus of this part, concerns determination of core material and size. The magnetic design is first because a core is needed to determine the parameters of the windings. Winding area allocation is considered under magnetic design because it affects *winding turns* N_p. N_p is an output parameter of magnetic (core) design and an important input to electrical (winding) design. Core choice is affected by winding currents and voltages from the circuit design.

Notes: 11 pages, 4 figures, 2 tables. Read the full story…

The Laplace Transform Applies To Nonlinear, Time-Variant Functions Too

by Gregory Mirsky, Design Engineer, Deer Park, Ill

Abstract: In previous articles, the dependence of inductance on time was analyzed using the Laplace transform for simplicity within MathCAD-15. The results were reasonable and caused no problems with the integrals' convergence. However, some readers objected to my methodology, arguing that the Laplace transform is usable only for linear time-invariant systems. To address this concern, in this article I will give some examples that confirm the validity of the Laplace transform for solving equations having time-variant parameters of power electronics components. It is worth recalling that time-variant functions or parameters are those whose values change within the time of the process. The most evident example is the amplitude-modulated signal, which we will review below. It is necessary to emphasize that this method holds true even if the function in question is nonlinear.

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

How Active EMI Filter ICs Reduce Common-Mode Emissions In Single- And Three-Phase Applications (Part 3): Modeling Nanocrystalline Chokes

by Timothy Hegarty, Texas Instruments, Phoenix, Ariz.

Abstract: Part 1 of this article series provided an overview of active EMI filter (AEF) techniques to diminish the reliance on bulky passive filter components. Part 2 discussed impedance characterization for a ferrite choke over a required frequency range using a behavioral model, which is an essential step and of paramount importance in EMI filter design, as the choke impedance directly impacts filter attenuation performance (as well as loop stability in active designs). More challenging to model than ferrite, however, is a choke with nanocrystalline core material, given its frequency-dependent and nonlinear magnetic permeability. It is for this reason that this article examines comprehensive simulation models for nanocrystalline-cored chokes, with the objective to design and use these magnetic components in both passive and active filter circuits.

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

Why Is Cooling So Important For Magnetics?

by Jim Marinos, Payton America, Deerfield Beach, Fla.

Abstract: Cooling is crucial for magnetics and electronic components in general because it directly impacts their reliability and lifespan. In this article, we'll discuss the mean time between failure

(MTBF) calculation, which is a key metric in assessing the reliability of electronic components, and explain how it can be applied to a magnetic component. The mil standard MIL-HDBK-217F has been used for decades to calculate MTBF for different environments. For this example, I will use the Ground, Mobile (G_M) environment for demonstration purposes.

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