

ECCE 2026 Presents Extensive Research On Magnetics Design For Power Conversion, Wireless Power Transfer And Other Areas

by David G. Morrison, Editor, How2Power.com

At the upcoming [IEEE Energy Conversion Congress & Expo \(ECCE 2026\)](#), October 4-8 in Vancouver, B.C., Canada, attendees will encounter a four-day program that features approximately 100 lecture (oral) sessions and 60 poster sessions, each featuring multiple papers. These sessions span a variety of subjects in power electronics, electric machines, energy sources and energy storage, and power systems. Within the power electronics area, there are numerous papers related to magnetics design.

While some magnetics papers are presented in dedicated magnetics sessions, many others are found in sessions on other topics in power converter design or application-themed sessions. Planar designs are very common. There are also numerous papers addressing magnetics design in the multiple sessions on wireless power transfer. Here the topic often shifts from the inductor or transformer design in power supplies to design of transmit and receive coils for wireless charging.

EMI sessions also inspire various papers with magnetics design elements. Additionally, inductor design rears its head in works on more niche topics such as machine protection, current sensing, and battery cell balancing.

In keeping with the broad popularity of the AI subject everywhere, this year's program features sessions on use of AI in power electronics, and naturally these include papers discussing the use of AI in magnetics design. Some of these reference the MagNet Challenge.

This article presents highlights of the magnetics-related talks at ECCE 2026 bringing together the abstracts for papers with relevance to power electronics. Though not covered here, the conference program also addresses motor magnetics. You'll find the full list of ECCE 2026 conference papers [here](#). Note that this list does not include information on the Special Sessions. For general descriptions of those, see the [final program](#).

A note on format: In this article, papers from the lecture sessions are listed first and then the posters. The sessions and papers are listed in the order that they are shown [online](#), which means that they also appear according to their order in the conference schedule. Hence the sessions are listed here by conference date and time.

Papers From Lecture Sessions

Monday, October 05, 2026 (15:10-16:30)

A2L-08 Induction Machines and Transformers 1 Session

"Electrothermal Design of a Medium-Voltage Medium-Frequency Transformer for Railway DAB Converter" by Simone Palazzo, Enzo de Santis, Giovanni Busatto

This paper presents an electrothermal design of a medium-frequency transformer (MFT) for a 20-kW medium-voltage DAB converter with 3.3-kV SiC MOSFETs. The MFT design is based on commercially available materials and two feasible structures, obtained from a developed design procedure, are realized and tested experimentally. After verifying an equivalent electromagnetic behavior, the two structures have been compared in 3-D FEM simulations to evaluate their steady-state thermal response and select the optimal solution for the DAB converter.

Tuesday, October 06, 2026 (08:30-10:10)

B1L-01 Isolated DC-DC and Active Bridge Topologies Session

“Impact of Transformer Partitioning Factor on Circulating Current in Single-Phase-Shift Controlled Three-Phase Dual Active Bridge Converters” by Mohamed Mansour, Olorunfemi

The three-phase dual active bridge (3-DAB) converter has emerged as a promising topology for medium- and high-power isolated dc-dc conversion due to its inherent bidirectional power flow capability, modularity, and soft-switching potential. However, the presence of circulating currents between converter bridges significantly impacts converter efficiency, transformer stress, and RMS current levels.

This digest investigates the origin and characteristics of circulating currents in the 3-DAB converter under single phase shift (SPS) modulation. *Analytical expressions describing the circulating current components are derived, and their dependence on phase-shift variables and transformer magnetic model is examined. The analysis highlights the impact of circulating currents on transformer design.*

B1L-11 Emerging Power Electronic Technologies and Applications 1 Session

“Design and Optimization of Inductor-Integrated Transformer for LCC Converters” by Tianyi Gu, Xiaohan Yu, Ziyang Chen, Hong Chen, Xiaotao Han, Shaozhe Zhang

Leveraging high efficiency and effective utilization of transformer parasitics, the inductor–capacitor–capacitor (LCC) resonant converter is well suited for high-voltage power supplies (HVPSs) used in vacuum electronic microwave sources, where electron emission and acceleration require electric fields on the order of tens of kilovolts. In such systems, the required insulation clearance between the primary and secondary windings often dominates the transformer geometry and constrains further miniaturization. Moreover, the additional resonant inductor degrades system power density and efficiency, thereby limiting compact implementation.

To improve the power density of LCC HVPSs, this paper optimizes the magnetic design by co-optimizing core dimensions, Litz-wire selection, and insulation thickness. A magnetic-shunt-based integration approach is then adopted to co-package the transformer and resonant inductor, eliminating the volume overhead of an external inductor. Finally, finite-element analysis (FEA) and simulations are conducted to validate the optimized magnetic and electrical design.

Wednesday, October 07, 2026 (16:05-17:45)

C4L-02 Architectures and Modelling of Specialized WPT Applications Session

“Sensitivity-Driven Optimization of IPT Magnetic Core Layout for Ferrite Reduction and Loss Suppression” by Yaolin Zhang, Chong Zhu, Xi Zhang, Tenghui Dong, Hua Zhang

In electric-vehicle inductive power transfer (IPT) systems, ferrite core layout significantly affects the coupling coefficient and system losses. However, the optimization process involves a high-dimensional design space and may lead to non-manufacturable solutions. This study employs Morris global sensitivity screening to identify key ferrite regions and uses symmetric mapping to transform the design space into local continuous coordinate variables, reducing the number of variables from 36 to 6 and thereby accelerating algorithm convergence.

By integrating PyAEDT with an improved NSGA-II algorithm, the ferrite core structure is optimized with total loss and weight as the objective functions, while fair comparison is ensured through constant output-power calibration. Compared with the baseline structure, the proposed framework reduces ferrite weight by 30% to 50% and total loss by 14% to 17% while maintaining efficiency, thereby providing a reusable approach for the lightweight design of high-power IPT magnetic couplers.

C4L-06 Control and Design of DC-DC Converter Topologies Session**“Coupled Inductor-Based Interleaved ZVS Four-Switch Buck-Boost Converter” by Hucheng Bai, Jiawei Guo, Li Zhang**

The four-switch buck-boost (FSBB) converter is suitable for photovoltaic applications, while the interleaved parallel scheme can be adopted to meet the demand of capacity expansion. However, conventional interleaved FSBB converters suffer from redundant magnetic components and large magnetic volume, limiting their power density. In this paper, coupled inductors are adopted in the interleaved FSBB converter to address the problem.

The influences of forward coupling and reverse coupling on inductor current and core magnetic flux are analyzed, and the results verify that reverse coupling can simultaneously suppress the inductor current ripple and core magnetic flux. To determine the optimal coupling coefficient, the relationship between the coupling coefficient and core dimensions is analyzed, and the correlation between the coupling coefficient and core volume is further established. Finally, an experimental prototype is built, with the peak efficiency at 99.60% and a 33% volume reduction of the inductor.

Thursday, October 08, 2026 (08:30-10:10)

D1L-02 Capacitive Power Transfer and EMI Management Session**“Efficiency Improvement Using Integrated Magnetics in a 6.78-MHz Modular Capacitive Wireless Power Transfer System for EV Charging” by Ayush Dixit, Sreyam Sinha**

This article presents an integrated magnetics based two-module capacitive wireless power transfer (CWPT) system suitable for EV charging. The proposed system improves system efficiency by integrating the compensating inductors of both the modules in the same structure on either side of the coupler. Furthermore, a reduction in magnetics volume is achieved by introducing a distributed core approach, which outperforms the conventional air core magnetics at multi-MHz frequencies. A comprehensive design methodology is proposed for both integrated air-core and integrated distributed-core inductors.

Compared with a discrete air core design, the integrated air core design reduces losses by 21%, whereas the integrated distributed-core approach reduces magnetics volume by up to 42% compared to its air-core counterpart. A 6.78-MHz 3.7-kW two-module CWPT prototype is built with conventional air-core and the proposed distributed-core integrated magnetics, with the later achieving a 31% higher measured quality factor. The prototype incorporating the integrated distributed-core inductors is experimentally tested at a scaled-down power level of ~1 kW, achieving an overall system efficiency of 85.3%.

D1L-07 AI for Power Electronics Design and Modelling Session**“Physics-Inspired Compact-DeepONet for Transient Magnetic Hysteresis Modeling” by Yunqi Zhang, Xufu Ren, Teng Long**

Accurate long-sequence modeling of magnetic hysteresis is essential for power electronics design and efficiency optimization. While deep learning models such as LSTM and Transformer achieve high prediction accuracy for sequence modeling, they rely on autoregressive inference, making them susceptible to recursive error accumulation and offering limited physical interpretability. This paper presents a Physics-Inspired Compact-Deep Operator Network (PIC-DeepONet) that eliminates autoregressive dependencies through direct operator inference.

The proposed architecture integrates a compact physics-inspired memory state into a low-dimensional latent representation and employs two parallel modules to separately model static hysteresis through a compact DeepONet and dynamic hysteresis through a physics-inspired circuit model. The proposed model contains 1,182 trainable parameters while achieving an average NRMSE of approximately 11%. Validation on five magnetic materials from the MagNetX database demonstrates robust prediction performance and strong generalization across a wide range of operating temperatures and excitation frequencies.

"Hybrid Finite-Element and Physics-Informed Learning Framework for Accurate Magnetic Core Loss Prediction" by Shui Zheng, Xinyu Liu, Qiuyun Zhang, Chuhan Peng, Ping Wang, Xu Li, Hongtao Tan, Shuai Zhou, Longsheng Xu, Liping Zha

Core-loss prediction is a fundamental challenge in the design and reliability evaluation of magnetic components for power converters. The underlying mechanisms of core loss are highly nonlinear and strongly dependent on multiple coupled factors, including excitation waveform, frequency, temperature, and dc bias. Existing modeling approaches often struggle to capture these interactions, particularly for molded cores, limiting their accuracy and applicability.

To address this challenge, this work proposes a dual-branch loss prediction method combining data-driven and physics-constrained models, integrated with finite-element numerical simulation to enhance prediction accuracy. The proposed method is validated on a Ferroxcube 3C90 E19/8/5 core under PWM excitation across a frequency range of 50 to 150 kHz, a duty cycle of 0.5, a temperature of 25 °C, and dc bias fields up to 35 A/m. Experimental results show that the maximum prediction error is limited to 10.2%, demonstrating the effectiveness and practical value of the proposed approach.

"Machine Learning Assisted EM FEA for EMI Prediction of Stacked Magnetic Goods" by Jingchen Liang, Peng Han, Pavan Gottipati

Electromagnetic interference (EMI) generated by large stacks of magnetic goods,* particularly cargo packages, must adhere to International Air Transport Authority (IATA) specifications for air transportation. As an alternative to conventional full-scale electromagnetic finite element analysis (EM FEA) simulation approach, this paper presents a Machine Learning (ML) based magnetic field prediction framework that uses EM FEA data combined with EM superposition principles to evaluate stack configurations of magnetic goods. The proposed method achieves a 30 times reduction in computational time while maintaining prediction error within 5%.

**Not related to power supply magnetics, but interesting nonetheless.--Editor*

D1L-12 Magnetic Components and Materials Session**"A Design Paradigm for a Common-Mode Shorting Network Inductor" by Harshita Singh, Scott D. Sudhoff, Drummond Fudge, Prateek Chatterjee**

Mitigation of electric drive common-mode (CM) voltage and current is a step towards prolonging machine lifetime. A common-mode shorting network (CMSN) may be used to effectively reduce the CM excitation of an electric machine over a prescribed frequency range. The CMSN does not conduct the load current, which facilitates a small size. However, the CMSN utilizes a specialized inductor whose design has not been addressed in the literature. This paper sets forth a design procedure for the CMSN inductor (CMSI). This procedure is validated numerically and experimentally.

"Integrated Inductor-Transformer Design Using a Concentric Pillar Structure" by Daniel Perez, Yasin Abdolahi, Behrooz Mirafzal

This paper presents a concentric pillar-based integrated inductor-transformer design that provides a controlled leakage flux path between transformer windings. The proposed magnetic structure is applicable to dual-port and multiport transformer configurations. The integrated inductor-transformer employs two sets of inner pillars, where the primary winding is wound around both sets of pillars, while the secondary winding is wound only around the central pillar. Consequently, the pillars linked exclusively by the primary winding establish a controlled leakage flux path, allowing the leakage inductance to be precisely tailored.

The proposed design achieves high leakage inductance, making it suitable for soft-switching converter applications. The proposed concept was evaluated through frequency-domain measurements of impedance, series resistance, and leakage inductance. Finally, the prototype was validated in a dual-active-bridge converter, and the corresponding experimental waveforms are presented.

"A 2-W LLC Auxiliary Power Supply with Embedded PCB Transformer Achieving 10-kV Insulation via Multi-Physics Optimization" by Yu-Chen Liu, Shang-Syun Wu

High-voltage isolated auxiliary power supplies require sufficient insulation capability and low common mode (CM) noise. Increasing the primary-to-secondary spacing reduces the maximum electric-field strength and transformer parasitic capacitance, thereby improving insulation reliability and suppressing CM current. This paper addresses the insulation-spacing and CM-capacitance tradeoff in a 2-W LLC APS by reshaping the PCB-integrated transformer geometry.

The transformer is designed by jointly considering resonant-tank characteristics, electric-field distribution, parasitic capacitance, magnetic loss, and footprint. Under a 10-kV fault-induced voltage difference across the isolation barrier, finite-element analysis (FEA) predicts that the peak electric field remains below the adopted 3-kV/mm air-breakdown reference under the specified 10-kV electrostatic condition. Compared with an enlarged ring-core design, the proposed transformer reduces the footprint by 67.6%, while conducted EMI measurements show a 26-dB reduction at the fundamental frequency and more than 11-dB improvement up to 20 MHz.

"Role and Design of Absorber Cores for EMI Noise Suppression in Motor Drive Applications" by Abiezer Tejeda, Hans Hoffmann Sathler, Szym

Common-mode resonances can occur in the $\{0.3\}\{3\}\{\text{mega}\}\{\text{hertz}\}$ range in inverter-fed motor-drive systems connected through long motor cables. These resonances are often difficult to attenuate using EMC filters alone because component, cable, and wiring parasitics limit the achievable damping in this frequency range. Absorber cores are commonly applied on the filter load side to suppress such peaks.

This paper describes the mechanisms that produce common-mode resonances in motor-drive installations and presents a practical impedance-guided method to select and combine absorber cores for effective attenuation around the frequency range of interest. The method is experimentally evaluated on a $\{22\}\{\text{kilo}\}\{\text{watt}\}$ drive system with a $\{50\}\{\text{meter}\}$ motor cable.

"AC Resistance Reduction in Planar Transformers Using Uneven Current Sharing" by Daniel Perez, Behrooz Mirafzal

The ac resistance of planar transformers can be significantly reduced through controlled uneven current sharing between parallel turns, achieving more than a 25% reduction compared with conventional even current sharing. Due to proximity effects, parallel turns exhibit different effective ac resistances; therefore, equal current sharing is not necessarily the minimum-loss condition.

The proposed approach controls current distribution through winding layout optimization, where the vertical placement of parallel turns determines their flux linkage and resulting current sharing. Two performance metrics are also developed to evaluate winding layouts with uneven current sharing and accurately calculate their ac resistance. These methods are validated through analytical modeling, finite-element analysis (FEA), and experiments. A prototype transformer with a custom distributed-air-gap core and laser-cut windings was built and evaluated through frequency-sweep measurements and operation in a dual-active-bridge converter.

Thursday, October 08, 2026 (10:35-12:15)

D2L-07 Wireless Power Transfer and EMI Session**"92.3% Efficiency Inductive Power Transfer for Magnetic Alignment Based Consumer Electronics" by Yanchao Li, Liang Jia, Srikanth Lakshmikanthan**

Magnetic power profile (MPP) from the existing 15-W to a high-power 50-W capability, making the wireless power transfer system more efficient becomes the key to achieving good thermal performance with compact mobile devices. This paper presents and analyzes two approaches for achieving high efficiency 50-W wireless charging for magnetic-alignment-based power receiver devices: a high-voltage solution based on traditional power receiver architecture and a novel reconfigurable receiver coil (RRC) architecture.

A comprehensive theoretical analysis and comparison have been performed for both approaches, including coil requirements, system efficiency, power loss distribution, and power transmitter (PTx) voltage requirements. The experimental results show that both presented approaches achieve more than 91% peak efficiency. The presented RRC architecture offers better wireless power transfer performance over a wide range of load conditions due to its superior flexibility. It achieves about 5% lower total system losses compared to the high voltage approach when charging at full load conditions.

"Modeling of a Non-Destructive Near-Field EMI/EMC Pre- and Post-Compliance Testbed" by Richard Alves, Robb Raffaelli, Di Zhang

The developed non-destructive near-field EMI/EMC testbed evaluates system vulnerabilities by generating localized interference that exceeds MIL-STD-461G levels across the 1-MHz to 100-MHz band. Building on previous hardware descriptions, this paper focuses on a robust circuit-level model designed to accurately predict these injected interference levels. The research analyzes the impact of critical design parameters, *including H-field antenna geometries*, cable lengths, and signal generator/amplifier configurations. All of which are verified through experimental results. The paper concludes with evidence-based user recommendations for improving EMC testing procedures and post-compliance margin assessments.

"A Novel Concept of Functional Multiplexing Metamaterial for Performance Improvement in Dual-Band WPT System" by Henghao Shan, Hui Yang, Huaqing Zhu, Peng Chen, Cunhao Rong, Qi Bao, Xunhui Cheng, Heyun Lin

This paper focuses on the design and optimization of a novel functional multiplexing low-frequency metamaterial to enable effective magnetic field manipulation for enhancing dual-band wireless power transfer (WPT) systems. Using a mechanical switching mechanism for frequency-selective switching, the metamaterial exhibits distinct electromagnetic characteristics, resulting in significant improvements in power transfer efficiency, spatial compactness, and anti-misalignment robustness.

The working principles are introduced, demonstrating magnetic field convergence through negative permeability at 13.56 MHz and magnetic field isolation through near-zero permeability at 6.78 MHz. A comparative analysis evaluates the electromagnetic performance of the proposed structure against conventional dual-band systems under various transmission distance and spatial misalignment scenarios. Both simulation and experimental results verify its superior capability in mitigating efficiency attenuation and enhancing spatial tolerance. Detailed analyses will be provided in the full paper.

"Multi-Frequency Multi-Receiver MHz Wireless Power Transfer Using an Impedance-Shaped Class- $\Phi 2$ Inverter" by Justin Yuhang Sun, Jungwon Choi

This paper presents an impedance-shaped Class- $\Phi 2$ MHz wireless power transfer system for simultaneous multi-frequency power delivery to multiple receivers using a single inverter and transmitter coil. Instead of suppressing the inverter's intrinsic third-harmonic voltage, the proposed design intentionally shapes the drain impedance to utilize both the fundamental and third-harmonic components for concurrent power transfer. A multi-frequency resonant compensation network is co-designed to provide near-resistive, low-loss impedance at both operating frequencies, reducing reactive power circulation and enabling harmonic-based power partitioning.

A MHz prototype demonstrates simultaneous delivery over a 15-mm coil separation, supplying 355 W at the fundamental-frequency channel and 19.2 W at the third-harmonic channel. The system achieves 374.2 W total load power with 74.2% DC-to-load efficiency.

"Fail-Safe Receiver Side Regulation of Double-Side LCC Wireless Power Transfer System Utilizing a Variable Inductor" by Hsin-Che Hsieh, Hao-En Liu, Ganesh Rai, Jih-Sheng Lai

The double-side LCC is a popular topology in wireless power transfer (WPT) applications, which inherently generates a load independent constant current output. It is typically regulated by periodic output shorting through either a synchronous rectifier (SR) stage, or a shorting switch. This popular method is capable of output regulation across a wide range without needing wireless communication. However, as the constant current output of the double-LCC topology cannot be safely open-circuit, a high voltage would be generated at

the output of receiver (Rx) side if the shorting regulator ever becomes inoperative under light-load conditions, which can damage the Rx side itself as well as all down-stream equipment.

In this paper, a fail-safe Rx side regulation scheme based on a variable inductor is proposed. While allowing wide-range regulation of output voltage, the variable inductor inherently drops the gain and output voltage of the Rx side to a minimum under any load condition if the Rx side controller ever becomes inoperative. The proposed regulation and protection scheme is experimentally verified with an 80-W, double-side LCC topology based prototype WPT system.

Poster Sessions

Monday, October 05, 2026 (17:20-19:00)

A3P-21 AI for Power Converter Design and Control Session

"Self-Evolving LLM Agent-Driven Transient Modeling of Hysteresis Loops for Transformer Magnetic Components" by Jiahua Ying, Bowen Su, Yunhao Xiao, Huan Chen, Zengle Ge, Annan Li, Kai Sun

Accurate hysteresis loop modeling is essential for magnetic component design in power electronic converters, yet traditional mechanism-based models have notable flaws and data-driven methods lack transient modeling capability and demand heavy ML expertise. LLM agents for automatic ML algorithm design have not been applied in power electronics, so this paper proposes a self-evolving LLM agent integrated with physical mechanism information, featuring a four-module generation–evaluation–evolution closed loop and two strategies to enhance physical interpretability.

Experiments on 10 materials from the MagNet Challenge 2 dataset show the agent completes 28 hours of human-unintervened iteration, evolving a physically interpretable bidirectional LSTM-based network that outperforms manually designed algorithms for all materials. This paradigm eases AI algorithm development in power electronics, offering a new approach for high-precision transient hysteresis modeling and a feasible framework for relevant AI applications in the field.

"AI-Based Design of High-Frequency Isolated Resonant Converters with Surrogate Transformer Model" by Rintaro Kaneiso, Wenying Xu, Kien Nguyen, Hiroo Sekiya

This paper proposes a circuit design method using metaheuristic optimization algorithm. By incorporating a mathematical model of the circuit components, including magnetic components, into the circuit model, the proposed method enables the simultaneous optimization of circuit parameters and transformer specifications without relying on the designer's expertise.

As a design example, an isolated class-E converter operating at 6.78 MHz with a 1-kW output was designed, which successfully reduced the prediction error of the transformer's electrical parameters to approximately 1%. Furthermore, the fabricated circuit achieved a power conversion efficiency of 90.3% at a 1-kW output in experimental verifications, demonstrating the validity and effectiveness of the proposed design methodology.

A3P-23 Induction Machines and Transformers 2 Session

"Optimal Design of a Medium-Voltage Medium-Frequency Multiwinding Planar Transformer" by Giovanni Martino, Fabian Groon, Hamzeh Beiranvand, Francesco Porpora, Yoann Pascal, Mauro Di Monaco, Marco Liserre, G

This paper presents an optimal design methodology for a dry-type medium-voltage (MV), medium-frequency (MF) multiwinding planar transformer intended for a isolated multi-port converter structure. The proposed methodology focuses on the integrated design of the winding arrangement and insulation structure to balance efficiency, power density, and manufacturability. The optimal solution is identified through an $\eta - \rho$ Pareto-based brute-force optimization algorithm and subsequently validated using finite-element analysis. A dedicated experimental setup was developed to validate the MV insulation design, including partial discharge monitoring.

A3P-27 Modelling Techniques for Power Electronic Components and Applications Session**“Improved Core Loss Calculation Method for Single-Phase Totem-Pole PFC Boost Converters” by Tim Geboers, Wout Vanderwegen, Wilmar Martinez, Camilo Suarez**

Although single-phase totem-pole PFC boost converters optimize grid efficiency and minimize reactive power circulation, their operation generates complex magnetic flux waveforms characterized by two frequency components that differ in order of magnitude and time-varying duty cycles. For iterative magnetic design and multi-variable optimization, FEA is due to this computationally impractical. Numerical approaches require electric circuit simulation, which must be updated with each iteration of the magnetic design.

To address these problems and to provide a viable alternative, this paper proposes analytical core loss expressions applicable to coupled inductors for single-phase totem-pole PFC boost converters. A comparative analysis of the analytical iGSE results with standard numerical iGSE showed the feasibility of this model to improve computation and be an alternative to the already existing core loss determination methods. The final paper will include a full outline of the analytical derivations, a comparison of the computational performance of the analytical with numerical and FEA derivation, and an experimental validation.

“Physics-Informed Closed-Loop Autoregressive Framework for Transient B-H Hysteresis Modeling” by Minzheng Liu, Yaohua Li, Delin Zhao, Ziheng Xiao, Yi Tang

Accurate dynamic hysteresis modeling under transient excitation is essential for system-level simulation of power-electronic magnetic components. Data-driven models that perform well in one-step prediction can degrade in closed-loop deployment, where predicted fields are fed back into later input windows and small errors accumulate over long horizons. This paper proposes a physics-informed closed-loop training framework for autoregressive B-H forecasting.

The forecaster keeps the same compact dual-LSTM as the point-wise baseline, so the gains come from the training strategy, not added capacity. Horizon-K rollout training exposes the model to its own recursive errors, dual-space normalization mitigates the feedback scale mismatch, and flux-increment-weighted energy and smoothness terms preserve trajectory continuity.

On measured MagNet transient data, the method reduces both the average and the maximum sequence relative error at all known-prefix settings, and improves every reported mean energy error and 95th percentile over the baseline. This shifts the whole error distribution rather than only clipping extreme errors, while leaving the deployed model and inference cost unchanged.

“Characterization and Simulation Modeling of Nanocrystalline-Based Common-Mode Filters” by Isaac Wong, Bharadwaj Reddy Andapally, Naoki Ito, Maira De Paula Nunes, Andre Luiz Silva De Oliveira, Mariana Perez

Modeling tape-wound nanocrystalline cores for electromagnetic interference (EMI) filtering applications is challenging due to inherent manufacturing anisotropies and a lack of high-frequency dielectric properties in commercial datasheets. This paper presents a non-intrusive, iterative hybrid methodology that combines finite-element analysis (FEA) and material property inversion to extract the wideband apparent complex permittivity of nanocrystalline cores.

By combining a single-turn impedance measurement with the Havriliak–Negami relaxation model, the proposed workflow extracts the apparent core properties over a frequency range extending to 50 MHz without requiring proprietary structural data. The extracted permeability and permittivity are validated at the application level using fabricated single-phase, common-mode chokes with 4, 8, and 16 turns. Experimental results demonstrate close agreement with FEA simulations, showing a maximum impedance deviation of less than 30% across the entire evaluated frequency range.

“Physics-Informed Transformer Modeling of Transient Hysteresis in Power Magnetics” by Yang Li, Qingcheng Sui, Yuqian Zhang, Jiaze Kong, Bangli Du, Wilmar Martinez

Accurate modeling of transient hysteresis trajectories is essential for loss evaluation in power magnetic

components. This paper addresses magnetic field trajectory reconstruction when complete $B(t)$ is available but only the first 10% of $H(t)$ is observed, a setting motivated by incomplete synchronous B–H measurements in online monitoring or rapid characterization. A physics-informed transformer is proposed with a non-autoregressive encoder, a $dB(t)$ feature for magnetization direction encoding, a masked residual output for observation consistency, and an energy-consistency regularization term based on a hysteresis-area proxy.

Experiments on the MagNetX transient dataset show that, for two unseen materials (3C90 and N87), the proposed method reduces the root mean square error (RMSE) by about 30% on average compared with a standard transformer and keeps the mean relative energy error below 0.5%, supporting loss evaluation under partial observation.

“Mass-Optimized Geometry for Magnetics in Space Applications” by Albert Rhee, Al-Thaddeus Avestruz, Solomon Adera, Jinia Roy

Power converters are commonly optimized for volumetric power density; however, many space power systems are constrained by mass rather than volume. This work investigates the relationship between magnetic core geometry and achievable mass performance using the magnetic sizing metric Kgfe. Core geometries are first classified according to magnetic-path connectivity, and an empirical comparison across commercial cores shows that the donut class achieves the lowest mass per Kgfe. Within this class, analytical optimization demonstrates that a toroidal core with a stadium-shaped cross section minimizes core mass for a given magnetic requirement.

When winding mass is also included, the optimal geometry shifts to a circular-cross-section toroid due to changes in the objective function. The analytical results are compared with commercially available cores and further evaluated using finite-element analysis and transformer prototypes to examine practical non-idealities. The results establish analytical lower bounds for mass-optimized magnetics and provide design insight for converters in space applications.

“Current Sharing Analysis and Modeling of Parallel Winding of the Coupled Inductor for High-Power SiC-Based Applications” by Majid Ghasemi Korrani, Debanjan Chatterjee, Harrison Strag, Slavko Mocevic

Coupled inductors with parallel windings offer a promising approach for reducing current-sensing cost in SiC-based high-frequency, high-power applications with input/output LC or LCL filters. However, current sharing between parallel windings is highly sensitive to magnetic parameters and has not been explicitly modeled. This paper presents an analytical model for predicting current sharing in coupled inductors with parallel windings.

The model captures the effects of coupling coefficient, leakage inductance, and core nonlinearity in current sharing between the parallel winding in a shared core by using zero-dc-bias (ZDB) parameters of the split inductor. The proposed approach is implemented in PLECS and validated through experimental results. For validation, three versions of coupled inductors with different winding configurations are designed and fabricated. Double-pulse testing (DPT) demonstrates strong agreement between the simulation of the model, and experiments.

“Magnetic Core Referencing Strategies for E-Field Control in Medium-Voltage Inductors” by David Nam, Arthur Mendes, Ning Yan, Timothy Thacker, Dong Dong, Rolando Burgos

Medium-voltage (MV) inductors are key components in emerging MV converters enabled by high-voltage SiC devices. As voltage levels increase, insulation coordination within the inductor structure becomes the dominant design constraint. Magnetic cores may be referenced to ground, winding potential, or allowed to remain electrically floating; however, the electrostatic implications of these choices are rarely analyzed. Many magnetic components in the MV class range employ grounded cores, but this architecture can impose severe winding-to-core clearance requirements as voltage scales, leading to excessive component volume. Referencing the core-to-winding potential can also require complex connectivity solutions for partial discharge free operation.

This paper examines magnetic core referencing strategies and shows that a floating core assumes a capacitance-weighted potential determined by nearby voltage nodes. The resulting electrostatic behavior is analyzed, and design implications for electric field management in MV inductors are discussed. A 22-kV prototype inductor is used to illustrate the proposed design approach.

Tuesday, October 06, 2026 (10:35-12:15)

B2P-14 Power Converter and Balancing Circuit for Batteries Session

"A Single-Inductor Active Cell Balancing Strategy for Lithium-Ion Battery Packs" by Hosadu Ashwin Kumar, Ankit Kumar Pratihasta, Durvesh Kumar, Vivek Nandan Lal, Rajeev Kumar Singh

Cell imbalance in lithium-ion battery packs reduces usable capacity and accelerates battery degradation. This digest presents a single-inductor-based active cell balancing strategy capable of transferring energy directly between cells with unequal state of charge. The proposed topology uses a shared inductor and a controlled switching network to redistribute energy from higher state of charge cells to lower state of charge cells. A proportional state of charge based control strategy is employed to regulate the balancing current and coordinate the energy transfer process.

The controller continuously identifies the cells with maximum and minimum state of charge and dynamically transfers energy between them until the imbalance falls below a predefined threshold. The proposed balancing system is modeled and evaluated using MATLAB Simulink for a six-cell lithium-ion battery pack.

B2P-16 EMI Filters for Power Converters Session

"Near-Field Magnetic Mutual Coupling Extraction and Analysis on DM/CM Conducted Emission EMI Noise Attenuation Performance in EMI Filter" by Connor Reece, Jenifer Sherrill, Ayan Mallik

This work proposes a methodology to accurately estimate the effect of near-field magnetic coupling within a dense electromagnetic interference (EMI) filter on the realized insertion loss (IL) and output impedance of a given filter layout. By identifying differential-mode (DM) and common-mode (CM) parasitic circuit networks accounting for mutual magnetic couplings between filter chokes and capacitors, the equivalent IL and output impedance expressions are derived. Further, for computing the mutual magnetic couplings, a partial element equivalent circuit model is developed.

Across four EMI filter layout topologies, the proposed model demonstrates low estimation error over a 100-Hz to 30-MHz frequency span, with <2.7-dB root-mean square error (RMSE) in the filter DM IL estimation over all cases, <0.56-dB RMSE in DM output impedance estimation, <2.3-dB RMSE in CM IL estimation, and <1.15-dB RMSE in CM output impedance estimation.

"Modeling and Extraction of Magnetic Coupling Between Inductors and Capacitors in Power Converters" by Tete Yin, Yirui Yang, Shuo Wang

This paper investigated the magnetic coupling between a power inductor and a nearby X capacitor and derived an analytical impedance model for the coupled capacitor branch. The results show that the coupling significantly alters the impedance characteristics and cannot be represented as a simple ESL variation. The model proposed in previous work focuses on coupling inside DM filters and does not account for the parasitic parameters of power inductors.

To address this limitation, the proposed approach incorporates the parasitic effects of the power inductor and extends impedance-based extraction to cases involving inductors with significant parasitic parameters. By fitting the measured impedance response with the derived model, the mutual inductance M_{11} can be directly extracted from the impedance plot, providing a practical tool for fast evaluation of magnetic coupling in EMI systems.

"On the Use of the Delay Compensation Technique to Reduce the Volume of Traction Inverter EMI Filters" by Erica Raviola, Franco Fiori

The mitigation of conducted EMI is a major challenge in traction inverters, as bulky input filters are often required. Targeting the reduction of the filter volume, this work combines the four-leg topology with the delay

compensation technique to maximize the cancellation of the common-mode current at the inverter output during switching transients.

An iterative algorithm allows one to find the optimal delays for the switching legs for each commutation, resulting in around 30-dB EMI reduction in the 150-kHz to 1-MHz range. By relaxing the required insertion loss of the input filter, a conventional two-stage EMI filter can be replaced by single-stage solution with reduced inductance, resulting in a 70% lower filter volume.

Tuesday, October 06, 2026 (14:00-15:40)

B3P-14 Next-Generation Wireless Power Transfer: From Modelling to Industrial Applications Session

"A Megahertz Wireless Power Transfer System for Hovering Charging of Inspection UAVs Using a Symmetric Segmented Planar Spiral Coil" by Yan Xu, Weicen Liu, Zhuojun Yu, Zhe Liu, Siqi Li, Chengjie Si, Sizhao Lu, Tong Li

Wireless charging at transmission towers can extend the endurance of inspection UAVs, but the required hovering clearance leads to weak magnetic coupling, and the compact onboard receiver limits coil size and current. This paper presents a megahertz WPT system for tower-side charging of inspection UAVs using a symmetric segmented planar spiral coil. The minimum operating frequency is estimated using a mutual-inductance-based power relationship, while the coupler dimensions are selected according to magnetic field coverage and receiver-side constraints.

To mitigate high-frequency parasitic effects, the symmetric segmented structure improves parameter consistency among conductor segments, simplifying segmented series compensation and reducing residual voltage imbalance. HFSS simulations show that the proposed coil achieves a more uniform current-density distribution than conventional planar spiral coils. A 2-MHz prototype with a 500-mm transmitting coil and a 300-mm receiving coil delivers 295.2 W across a 300-mm air gap with 82.6% dc-dc efficiency, demonstrating the feasibility of the proposed system.

"Designing MHz Self-Resonant Planar Coils via Convex Optimization for Wireless Power Transfer" by Ghovindo Siadari, Maryam Fazel, Jungwon Choi

This paper presents a convex optimization to maximize the quality factor (Q) of megahertz (MHz) self-resonant planar coils for wireless power transfer (WPT). Self-resonant coils are attractive for high-frequency, high-power WPT because they utilize intrinsic capacitance and eliminate the need for external matching components. However, achieving high Q at MHz frequencies remains challenging due to eddy current losses and the complex coupling among geometric and frequency-dependent parameters.

To address this challenge, a mathematical model based on Archimedean spiral developed from previous study is used for the coil Q optimization. Under practical design conditions, the resulting Q expression is reformulated into a convex form, enabling global optimization using CVXPY while eliminating the need for stochastic searches or computationally intensive finite-element parameter sweeps. The optimized design is validated through Ansys simulations and hardware measurements. The optimized coils achieve Q factors exceeding 590 at 13.56 MHz. Power transfer experiments demonstrate delivery of 348 W over a 5-cm distance with a coil-to-coil efficiency of 97%, confirming the effectiveness of the method.

"Influence of System Specifications on Critical Performance Parameters of Multi-MHz Capacitive Wireless Charging Systems" by Ronaq Nazir, Sreyam Sinha

This paper presents a framework to evaluate the influence of system specifications and *inductor non-idealities* on the constant-current (CC) characteristic and the maximum achievable efficiency in multi-MHz capacitive wireless charging systems. The system specifications are shown to significantly affect these properties, and a method to improve the system's performance under such condition is highlighted. In addition, the sensitivity of the CC property to practical deviations in matching network component values is investigated, and a method to reduce such sensitivity is highlighted.

The proposed analysis is experimentally validated using two capacitive wireless charging prototypes: one rated at 48-V input, 12-V output, 80-W operating at 7.91 MHz, and another at 96-V input, 48-V output, 250-W operating at 6.84 MHz. The results show that the latter system achieves better CC characteristics and higher efficiency than the former with a dc-dc efficiency of 81% while maintaining CC charging within a boundary of 1.27%, in conformation with predictions.

B3P-15 Modular Multilevel Inverters and AC Power Conversion Systems Session

“Filter Inductor Size Reduction in Regenerative Cascaded Multicell Converter Based Medium Voltage Drive” by Satyam Jha, Shambhu Sau

Compared to a conventional three-phase filter inductor, a coupled inductor (CI) is more effective in attenuating the switching harmonics produced by active front-end rectifiers (AFERs) in the regenerative Cascaded Multicell Converter (CMC), thereby lowering the transformer's total VA rating. This paper presents the design methodology for CI used in CMC and validates it using ANSYS Simulation, particularly under unbalanced power sharing among cells. The overall core volume and copper requirements are compared for inductors in regenerative CMC.

3P-16 Power Converter Modelling 2 Session

“Analytical Modeling of a Magnetically Coupled N-Phase Interleaved Boost Converter with Input Inductor” by Mateus Constantino Orige, Douglas Mendes Sotoriva, André Luís Kirsten, Roberto Francisco Coelho, Lenon Schmitz

This paper presents an analytical modeling methodology for an N-phase interleaved boost converter comprising an input inductor and magnetically coupled phase inductors. By means of the simplified extended T-model, the coupled system is decomposed into additive and subtractive modes, allowing the influence of magnetic coupling on the converter current dynamics to be explicitly represented.

Based on this equivalent model, generalized expressions are derived for both the critical phase inductance and the critical operating condition of the input inductor. The analytical results are validated through PLECS simulations under different operating conditions, confirming the predicted conduction boundaries for both the phase inductors and the input inductor.

B3P-18 Power Converters in Sustainable Energy Applications 2 Session

“Unified Transformer-Based Comparison of DAB and CLLC Converter for High-Voltage DC Coupled Green Hydrogen Generation” by Gaurav Bhansali, Fang Luo, Rebecca Trojanowski, Meng Yue

Green hydrogen systems require efficient power electronic interfaces between renewable sources and electrolyzer loads. Conventional ac-coupled architectures require multiple conversion stages, resulting in cumulative losses and increased control complexity. This paper investigates isolated high-stepdown dc-dc converters for interfacing an anion exchange membrane (AEM) electrolyzer with a 1-kV solar-photovoltaic (PV) dc bus.

A comparative study of dual active bridge (DAB) and CLLC resonant converters is presented using a modular common-HFT platform, where the same planar high-frequency transformer (HFT) is used for both topologies. This benchmark isolates the effect of topology and modulation under identical magnetic, voltage, power, and semiconductor constraints. Detailed PLECS-based switching models are used to evaluate device loss, HFT current stress, output-current ripple, harmonic content, soft-switching behavior, and efficiency over a 20% to 100% rated-power range. The proposed modular platform supports application-specific topology selection while improving hardware flexibility.

Thursday, October 08, 2026 (14:00-15:40)

D3P-15 DC–DC Converters, DABs, and High-Frequency Power Conversion Session

“Optimization and Planar Inductor Design of Multiphase Ćuk Converters for Partial-Power Post-Regulators in DC Transformers” by Lukas Budiwicaksana, Dong-Choon Lee

This paper proposes design optimization and planar inductor design of multiphase Ćuk converters, specifically for partial-power post-regulators (P3Rs) in dc transformers (DCTs). P3Rs are beneficial for DCTs as they allow output voltage regulation while maximizing total system efficiency. Different from conventional P3Rs, which are based on buck converters, Ćuk converter offers wide soft switching operation with reduced current and voltage ripples.

Comprehensive modelling is introduced as the basis for selecting the optimum number of phases for maximum efficiency and minimum magnetic core size. In addition, a methodology to design a planar inductor is presented. By adjusting the winding sequence and direction, flux cancellation can be achieved. Hence, compared with conventional design approach, the core loss and equivalent series resistance can be reduced by 58.3% and 48.5%, respectively. Finite-element analysis, simulation, and experimental results for a 400-V 4.8-kW DCT based on LLC converter are presented to validate the performance of the proposed Ćuk converter.

“Volume Reduction of Interleaved Totem-Pole PFC Through Inductor Coupling and CMC Integration” by Max Wagner, Kai Franck, Benjamin Zacher, Christian Schumann

Reducing magnetic volume is a primary lever for increasing power density. This digest presents a two-stage magnetic optimization strategy for a two-phase interleaved totem-pole power factor correction. First, magnetic coupling of the boost inductors is exploited to reduce differential ripple, enabling a reduction of required inductance and core size. Second, the common-mode choke is integrated into the boost inductor core, eliminating redundant magnetic components and further decreasing total magnetic volume.

Results demonstrate that appropriately selected coupling lowers ripple-related energy storage requirements, while integrated magnetics reduce total magnetic volume with minimal compromise to stability or electromagnetic compatibility. The proposed concept achieves substantial magnetic volume reduction while maintaining grid current quality.

D3P-16 Power Converter Stability 2 Session

“Active, Virtual, and Resistive Transformer” by Phan Khanh Do, Yuan Li, Sajed Pourmirasghariyan, Jinli Zhu, Fang Zheng Peng, Brandon M. Grainger

Active, virtual and resistive transformer for transmission and/or distribution systems is a converter-assisted transformer that reshapes the terminal behavior of a conventional line-frequency transformer to appear predominantly resistive during transients. The proposed architecture uses fractionally rated series voltage-source converter to inject compensating voltage synthesized from measured line currents and a dc-link energy regulation loop.

By creating a virtual resistive component and offsetting effective inductive behavior, the proposed architecture increases damping, reduces resonance, and improves the controllability of power transfer at transmission and distribution interfaces without modifying transformer windings or core. Electromagnetic transient simulations demonstrate reduced overshoots and faster settling compared with the uncompensated transformer under disturbances. The proposed method features instantaneous response to ensure transient oscillation mitigation within milliseconds.

D3P-17 Power Converters, System Architecture and Control for Data Center Session**"A 98.7% Efficient 800-to-50-V LLC-DCX Matrix Planar Transformer Stray Capacitance Optimization and Indirect Measurement" by Jiarun Xie, Panming Li, Xiang Zhou, Guozhao Zou, Zihao Song, Lantian Bi, Laili Wang**

For 800-V/50-V AI data centers, this paper evaluates two LLC-DCX paths: a 1,200-V SiC half-bridge and a 650-V GaN stacked half-bridge. A four-phase matrix transformer with integrated resonant inductance handles the high-current output. To suppress 800-V induced ringing, stray capacitance is optimized via potential distribution redesign and PCB layout refinement. Experimental results from 3-kW prototypes demonstrate a 98.7% peak efficiency and 584 W/in³ power density.

D3P-20 Distributed Energy Resources in Power Grids and Microgrids Session**"A Magnetic Integrated L-MLC Filter for Improving Power Density in Single-Phase Inverters" by Hassan Athab Hassan, Yifan Bao, Shuang Xu, Liuchen Chang**

Magnetic integration is an effective approach for reducing the size of passive components in inverter output filters, thereby improving the power density of grid-connected power converters. This paper investigates the application of an L-MLC filter employing magnetically coupled inductors for mitigating inverter switching harmonics while reducing the required inductance. The L-MLC filter utilizes a passive ripple-steering mechanism to redirect high-frequency switching current into an auxiliary branch through magnetic coupling, thereby reducing the ripple current injected into the grid.

The ripple-steering mechanism is explained, and an equivalent circuit model is developed to derive the filter transfer function and analyze the influence of magnetic coupling, the auxiliary branch, and the damping resistor on the filter characteristics. The analytical results demonstrate how the coupled-inductor structure enhances high-frequency ripple suppression while reducing the required magnetic components.

D3P-21 Control and Protection of Grid-Forming Inverters Session**"Transformer Inrush Current Sourcing: Case Studies from Utility Grid, Diesel Generator, and Grid-Forming Inverter" by Mahmoud Kabalan**

Transformer energization can produce inrush currents that reach several multiples of the rated current. While conventional power systems rely on strong utility grids or rotating machines to supply these transient currents, the increasing deployment of power-electronics-based resources raises questions about their capability to support such events. In particular, grid-forming (GFM) inverters are often assumed to have limited overcurrent capability, raising concerns for transformer energization in islanded microgrids.

This paper presents experimental case studies of transformer inrush current sourced from three different power sources: a utility grid, a diesel generator, and a grid-forming inverter. Measurements were collected from an industry-grade microgrid. The results quantify the magnitude and dynamics of transformer inrush current and the associated voltage disturbances under different operating modes. The findings provide experimental evidence that grid-forming inverters could successfully energize distribution transformers. The dataset presented contributes real-world measurements to the ongoing discussion regarding inverter capability in microgrid applications.

D3P-22 Emerging Power Converters and Applications Session**"A Novel Hybrid HVAC Saturated Core Fault Current Limiter Based on Precharged Capacitor" by Jiawei Liu, Jiaxin Yuan, Hang Zhou, Biao Yuan, Mrutyunjaya Sahani, Sanjib Kumar Panda**

Transient short-circuit current levels in high-voltage ac (HVAC) systems are continuously increasing with the

growth of renewable energy resources. Saturated Core Fault Current Limiters (SCFCLs) have always been a technical challenge in the protection of the excitation power supply and the rapid attenuation of current. To address this issue, a novel hybrid HVAC saturated-core fault current limiter based on a precharged capacitor (NHFCL) is proposed. NHFCL can effectively limit the amplitude and rise rate of fault current, protect the dc excitation system from fault and rapidly accelerate the attenuation of fault current.

First, the topology and mechanism of NHFCL is established. Then, a 500-kV simulation model is built by finite element analysis (FEA). Finally, the FEA results and transient current limiting characteristics of the NHFCL are analyzed. Simulation results show that the proposed NHFCL achieves a peak current-limiting ratio of 89.46%, reducing the first peak current from 89.54 kA to 9.44 kA. Compared with the conventional SCFCL, the first peak current is further reduced by 47.32%, verifying the enhanced current-limiting performance of NHFCL.

D3P-25 Gate Drivers 3 Session

"A Novel Concentric Solenoid Coupler in Flexible Printed Circuit for Medium-Voltage Gate Driver Power Supplies via AI-Driven Design" by Yixuan Huang, Jingyun Bi

This paper proposes a concentric solenoid-type flexible printed circuit (FPC) coupler addressing the isolation and power density trade-off in medium-voltage (MV) gate driver power supplies. Two AI-driven methods are developed: a multi-fidelity neural network (MF-NN) surrogate for global Pareto-front perception, and a Large Language Model-driven Space Mapping (LLM-SM) framework for constrained optimization under MV switching requirements.

The optimized design achieves $k = 0.703$ at $Cps = 4.97$ pF. A 5-kV insulation test validates the basic insulation capability, and LLC converter simulations demonstrate $\eta_{coil} = 94.9\%$ at 10-W output. The LLM-SM framework converges within 10 FEA evaluations (1.13 h), a 77% to 95% reduction over conventional methods, highlighting the potential of AI-driven surrogates to accelerate power electronics design.

"A GHz Isolated RF Gate Driver for WBG Devices" by Haoran Meng, Hao Yan, Seongho Shon, Bayaner Arigong, Hui Li

This paper proposed a 2.4-GHz Class-F⁻¹ rectifier-based RF gate driver for WBG devices. Compared with traditional isolated gate drivers for SiC and GaN devices that use fiber optics for signal isolation and transformers for power isolation, this gate driver employs RF frequency transformers for signal and power transfer. In addition, the GHz transformer enables chip-level design with low footprint.

The operating principle of this isolated gate driver with GHz transformers is presented with particular emphasis on the key element—the 2.4-GHz transformer. S-parameter is obtained through experimental measurements, which shows a calculated efficiency as 78%. Finite-element simulation of the transformer under 5-kV dc shows an electric field of 4 kV/mm between the primary and secondary sides. Finally, circuit-level simulation results for driving a 1.2-kV SiC MOSFET and 650-V GIT GaN HEMT are provided to demonstrate the gate driver operation and feasibility.