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Leading Edge Smart Grid Magnetics

Designing Power Magnetics Components to Meet Today's Smart Grid Standards

Today's smart grid goes far beyond bidirectional power and data flow. It must possess integrated sensing, measurement, and control capabilities as well as effective information/communication. This ensures that smart grids are flexible, resilient, reliable, sustainable, and stable.

Modern electric power systems have evolved into highly interconnected, complex, and interactive networks. The growing demand for energy independence and the modernization of legacy infrastructures with new technologies has posed a challenge for energy providers. Today's smart grid is generally envisioned as the platform for the strategic development of power grids and optimized allocations of energy and resources. The new paradigm for success calls for the integration of various renewable energy and storage solutions and more efficient utilization of energy and assets. Systems must be self-healing and resilient to attack from natural disasters. This underscores the need for sustainability and control, and it is this need that will motivate the development of the new smarter grid in the 21st century and beyond.

Advanced Control and Communication

Across the United States, more than 6 million miles of distribution lines and more than 200,000 distribution circuits provide the critical link between the bulk power grid and 160 million electricity customers. These lines and circuits must be supported with digital sensors and switches with advanced control and communication technologies to automate feeder switching; voltage and equipment health monitoring; and outage, voltage, and reactive power management. Automation can improve the speed, cost, and accuracy of these key distribution functions to deliver reliability improvements and cost savings to customers.

New Decentralized Energy Production and Consumption

Today, utility companies produce energy from increasingly varied sources, including renewables. Renewable energy also comes from private individuals and companies, who feed their self-generated power into the network from the edges. Alongside this, new patterns of energy consumption are emerging as the number and type of energy-consuming technologies, such as electric vehicles, increase. Power distribution networks were not designed with these needs in mind, which means they can become unstable.

Tomorrow's smart grid must deliver higher energy efficiencies. To achieve this goal, one must incorporate low-cost, or even cost-neutral components with minimum losses. The smart grids of the future face several challenges that can only be overcome by components that interact in the grid of the future. Smart grids must also confront the fact that power will no longer be sourced from a small number of central suppliers but from a diversity of decentralized sources. Among these are power from solar plants, wind turbines, or CHP plants that feed into the grid, which can cause power fluctuations. These fluctuations are likely to increase as the number of feed-in sources and new forms of energy grow. The need to transport all this power represents a new and ever-growing burden for the grid.

This ultimately underscores the importance of using the right, highly efficient components. The power density of today's power supplies is rising, as are the operating temperatures generated by solar inverters. This is forcing device designers to address thermal management problems. While the current load of active components has continuously increased, often doubling, the issue of thermal problems in suitable passive components has sometimes been ignored. This is why optimizing passive components has taken center stage and why the thermal properties of passive components are increasingly being designed to ensure adequate long-term stability. A lifespan of up to twenty years is not uncommon for power supplies in smart grids. This highlights the need for more robust passive components, especially those used in offshore wind turbines, which face difficult and complex maintenance procedures as well as stricter requirements.

Smart Grid and the Rise of High-Frequency Magnetics

A revolution in power transmission and distribution, driven by environmental and economic considerations, is occurring all over the world. This revolution is spearheaded by the development of the smart grid, which has brought profound changes to both power systems and a host of related industries. In particular, the development of the smart grid has given rise to high-frequency magnetics. Here, many factors come into play, including electromagnetic compatibility, magnetic field-based measurement/monitoring, and magnetic energy storage/conversion. The use of cutting-edge magnetics technology directly impacts the development of smart grids. To meet the ever-changing patterns in power grid management, such as bi-directional power flow, increased share of renewable energy sources, and highly distributed generation in the grid, utility companies are now employing 3GPP 4G and 5G network solutions to strengthen the security and resilience of power grids, as well as boost operational efficiency across the board.

Sensing and Control Magnetics

These magnetics can be leveraged to help regulate the flow of electricity in smart grids, provide a path for electrical current, and efficiently harvest energy. Power electronic systems, such as inverters, converters, motor drives, and sensing and control magnetics provide power conversion, regulation, and control. Similarly, in renewable energy systems, such as solar- and wind-power systems, sensing and control magnetics are ideal for power conversion and control. While their use can offer many benefits for smart grid applications, it's important to choose the right type of magnetics for a specific application. Failing to do so can create problems for smart grid systems. Choosing a device that is too small can create resistance, resulting in energy losses. Conversely, a device that is too large can lead to excessive inductance.

To automate power transmission and distribution and to ensure power grids respond resiliently, magnetic-field-based measurement technology can help monitor and report line conditions in real time for rapid diagnosis. Magnetic field measurement can provide broadband measurement and evaluation of magnetic interference caused by transients in smart substations, where secondary systems are closer to HV equipment.

Sensing and Control Magnetics Components

Transformers: Widely used in power distribution systems, low-frequency transformers are available in the 50/60 Hz to 400 Hz range; high-frequency transformers and power assemblies come in 20 kHz to RF range. Smart transformers are power-electronics-based and adopt advanced control and communication technologies to regulate the voltage level from MV to LV grids and provide ancillary services to the grid.

Harvesting Current Transformers: Inherently isolated from the grid to power low-voltage components that enable smart monitoring and control of the grid.

Current Transformers: Used in metering systems and power monitoring systems. They provide direct measurement, offline isolation, and the ability to measure large currents — especially a clamp-on.

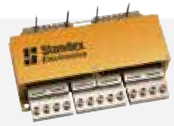
Inductors: Used to filter high-frequency noise, store energy, and generate magnetic fields. High current flat wire inductors have exceptionally low DC resistance for greater efficiency. These magnetically shielded inductors achieve high current ratings.

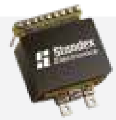
Three-Phase HV Power Line Chokes: Current-compensated, three-phase power-line chokes are designed for high-voltage applications. Rated for voltages up to 760Vac, some feature a plastic casing, separating strip, and grid plate. The toroids used can be constructed of MnZn ferrite material or nanocrystalline material resulting, thus, in high insertion losses even in broadband applications. Ideal for use in frequency inverters and high-performance charging stations.

Sensing and Control Magnetics Benefits Summary

Sensing and control magnetics isolate electrical energy, regulate electrical energy, store electrical energy, control the flow of power, ensure power remains safe, and keep power within efficient limits.

Planar Magnetics





One aspect of sensing and control magnetics is planar magnetic technology. Typically in the form of a transformer or copper-wound inductor, these magnetics are usually composed of flat copper sheets wound around a rigid or "flex" PCB, but can also be a hybrid. These are inserted in a low-profile magnetic core made from a "soft" ferrite. Their copper tracks have rectangular cross-sections, which differ from conventional wire-wound components that have circular cross-sections. This technology leads to more compact solutions. For example, planar magnetic components can be up to one-half or even less than the height of conventional counterparts.

Planar Transformers also provide improved overall system performance. By controlling and fine-tuning leakage inductance, planar devices can increase a system's efficiency. In addition, such components exhibit superior thermal characteristics to conduct heat and maintain device temperatures lower than wire-wound devices. This is because planar magnetic cores have a higher surface area-to-volume ratio than conventional devices, resulting in better heat exchange characteristics with the surrounding environment.

Planar Magnetics Benefits Summary

Planar Magnetics provide large power capacity (up to 20KW per unit), high power density (triple compared to conventional transformers), high current capability (up to 200 amps per winding layer), high efficiency (up to 98% without volume increase), low profile (suitable for a wide range of applications) low leakage inductance (about 2.0% of primary inductance), low EMI emission (efficient core shielding), high parameter repeatability (fixed, pre-tooled winding structure), a wide operating frequency range (from 200kHz to 1MHz), good thermal conduction (short thermal path, lower temperature rise), and good heat dissipation (by attaching to a chassis or heat sink).

Uniting Power Electronics and High-Frequency Magnetics

Solid-state distribution transformers are designed to combine power electronics and high-frequency magnetics for more compact transformers and new control capabilities. These transformers can be deployed in strategic locations to leverage their enhanced functionality and flexibility. They can perform many functions currently performed by a variety of devices, including voltage regulation and reactive power supplies. They can be used to form hybrid AC and DC systems that can increase total system efficiency. They can also be used to manage the interaction between microgrids and utility systems. Solid state transformers can regulate the process of disconnecting and reconnecting with the main grid, quickly and precisely change the direction of power flows, and limit fault currents.

Conclusion

From basic transformer coils to value-added assemblies, Standex Edge's world-class magnetics experts can assist today's engineering teams in navigating the rigorous safety and performance standards of the modern smart grid. Our reliable high-quality transformers, coils, inductors, and reactors provide effective solutions that meet a wide variety of applications. This includes low-frequency transformers in the 50/60 Hz to 400 Hz range. And high-frequency transformers and power assemblies ranging from 20 kHz to RF. Additionally, our planar magnetics, power inductors, and common mode chokes can be made with exact values from economic standard packages.

A Standex **Electronics** Business

The new brand name for the Standex Electronics Magnetics division exemplifies the position occupied by Standex Magnetics engineers in relation to magnetic component innovation.

Standex Edge expertise spans transformers, inductors, current sensors, chokes and other advanced magnetic components used across multiple industries.

Combining decades of engineering innovation with global manufacturing capabilities, Standex Magnetics Engineers are leaders in component miniaturization, thermal management, robust design, and efficient production. They have firmly established their position at the **Edge** of innovation, where energy meets possibility.

Welcome to **Standex Edge**.

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