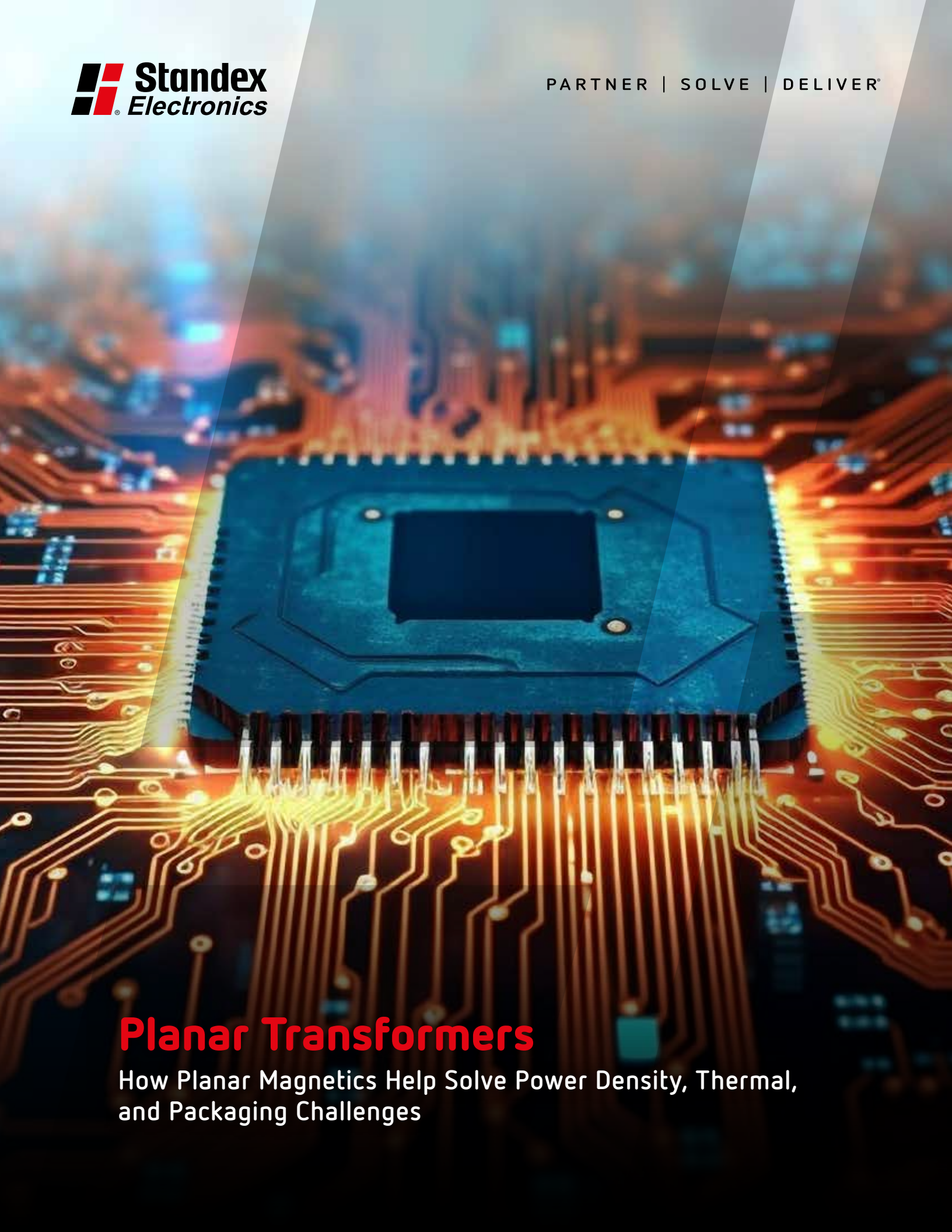
Standex Electronics

PARTNER | SOLVE | DELIVER®



Planar Transformers

How Planar Magnetics Help Solve Power Density, Thermal, and Packaging Challenges

CONTENTS

How Planar Magnetics Help Solve Power Density, Thermal, and Packaging Challenges

Introduction

The drive for smaller, quieter, more power efficient devices is present in all areas of electronics, but this is especially true in power systems. Every electronic device needs a power source, and power could be drawn from batteries, the grid, or an integrated power regulator, all of which need precise regulation with low noise and high power conversion efficiency. In addition to noise and efficiency, low profile with mechanical stability is often desired as it leaves room on a PCB for other important components and helps a designer achieve size, weight, and performance (SWaP) targets.

One of the major considerations in power systems design is selection of magnetics, specifically transformers that can support the required current, frequency, and size objectives. Many off-the-shelf options are too space-inefficient for modern power system designs; they are simply too large, too heavy, have excessive parasitics, or some combination of these problems. Getting to a more aggressive form factor generally requires a custom design, which can increase costs and may not produce a low-profile product. Such size problems with traditional magnetics creates other problems with leakage and parasitics, which are undesirable in power systems for advanced applications.

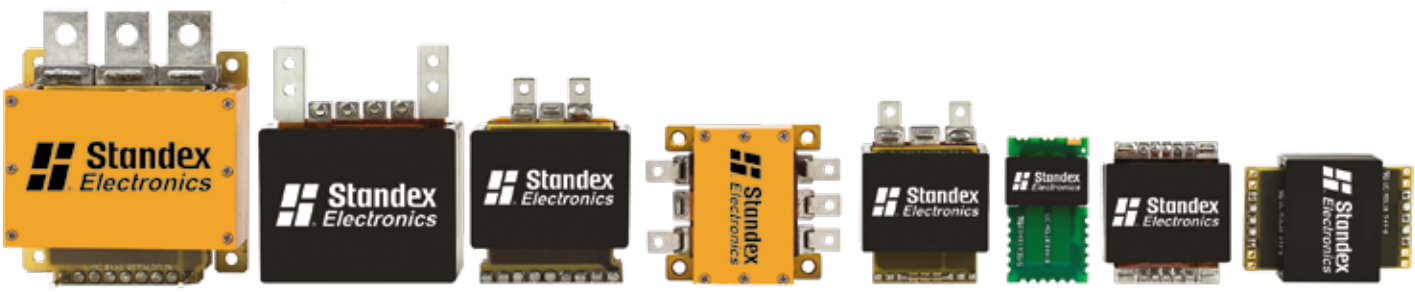
Instead of selecting traditional PCB mount transformers or wire-wound inductor coils, which tend to have very bulky profiles, planar magnetics are a low-profile option for many systems where SWaP is a concern. Areas like aerospace, automotive, portable power systems, and industrial systems are some areas where the low profile and tight coupling provided by planar magnetics brings additional benefits for these systems.

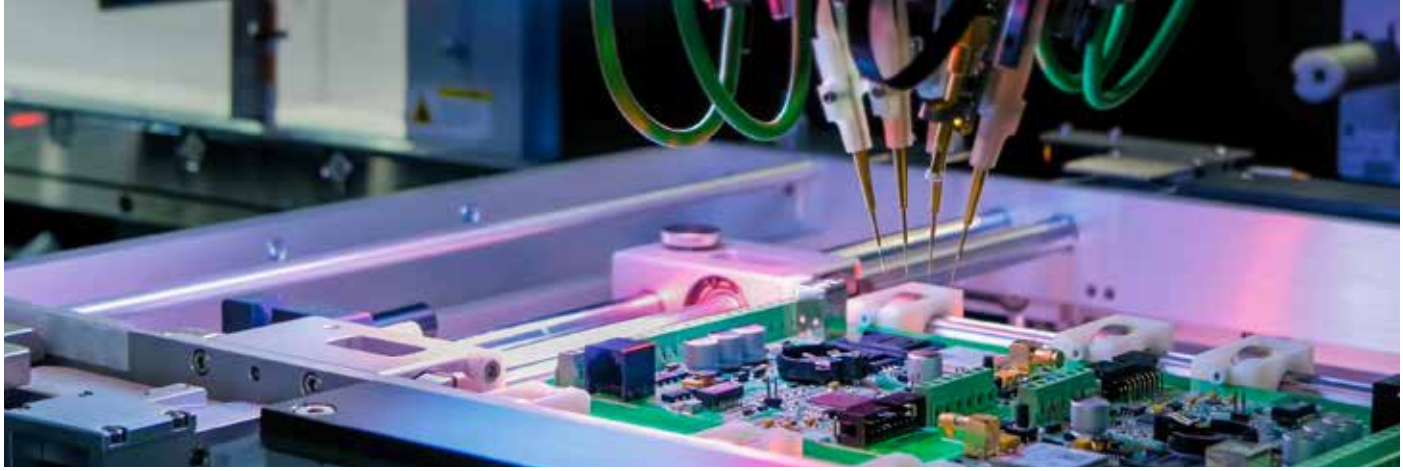
What Are Planar Magnetics?

Planar magnetics are low-profile options for magnetic components, referring specifically to planar inductors and planar transformers. These components use magnetics and packaging with a flat profile, involving windings that effectively stack on each other while wrapping around a large cross-sectional area. This provides very strong coupling to the magnetic core, which keeps magnetic flux confined within the body of the component package. The magnetic core may be wrapped around a PCB substrate or within molded packaging, giving a more compact design than traditional off-the-shelf transformers and wire-wound inductors.

Proper mitigation for such vibrational damage isn't an isolated fix, but rather a part of a general approach to system hardening. Some of the actions that can be taken against vibration at the board level, like thermal potting of components for example, can also address vibration absorption if semi-elastic materials are used, and the solution is spread in all appropriate areas, not just those needing it for thermal management.

AC/DC and DC/DC converter and regulator designs for power systems need transformers and inductors for basic functionality. This includes the need for step-up or step-down power conversion, isolation and coupling in high current switching regulators, filtering, and ripple reduction. Planar components can perform the same functions as traditional components in these applications. The difference is in the profile and footprint. The flat packaging used in planar transformers creates a low profile component that can be mounted to a PCB substrate. Mounting options are generally through-hole components, although smaller planar magnetics components may come packaged as modules with castellated holes that are mounted as SMD components.





Typical transformer or inductor designs have some specific differences that should be considered in power systems designs:

- **Turns count:** To ensure high inductance and low flux leakage, traditional off-the-shelf transformers and inductors tend to have higher turns count. Planar transformers can generally meet the same inductance and flux leakage goals, but with lower turn counts.
- **Z-axis height and mounting:** Off-the-shelf magnetics tend to sit high above the board and may only have through-hole options available. Some SMD options for standard magnetics may have comparable inductance as a planar magnetics component, but they may not have high current limits due to the higher turns count and smaller required package.
- **Cooling:** The aspect ratio of traditional magnetics packaging can make cooling difficult. In particular, it's quite difficult to build a heatsink into the package, or to optimize the package for fan mounting and forced airflow.

Some application areas where these packaging and performance aspects are important include power systems in aerospace, automotive, and industrial products. In the automotive and aerospace sectors, the major challenge today is in balancing SWaP goals, where high power density and high power conversion efficiency are most important. In particular, in electric vehicles, advanced DC/DC switching converter topologies in power converter designs must provide high power density with very low loss. In industrial systems, low-profile is compelling in industrial designs that require greater space utilization. Some designs, such as portable power tools with a battery charger, already have very tight clearances that limit design freedom. Planar transformers can easily meet space utilization goals in many products thanks to their low profile, particularly in applications where the lateral size of the component footprint is not a major consideration.

Advantages of Planar Magnetics

Some of the major advantages in planar magnetics originate from their low profile construction and aspect ratio. Some of the major advantages of planar transformers are seen in their mechanical, thermal, and electrical characteristics, as well as the ease with which custom designs can be created.

Low Vibration

Unintentional vibration in industrial systems, aerospace, and automobiles is a major reliability concern that decreases the mean time between failure for solder joints. The lower weight and lower profile of planar magnetics inhibit low-frequency, high-amplitude vibrations that can damage solder joints on these components. For this reason, planar magnetics components are often targeted for high reliability applications, where combating vibration is often an important consideration that drives component selection.

Thermal Management

The low profile of planar magnetics components presents a flat face on top of the component package, as well as a flat surface on the bottom side. The tight coupling between different portions of the component provides high heat transfer away from the core and onto the packaging, where it can be dissipated with forced airflow. This means planar magnetics components can be easier to cool with forced airflow across the component packaging. For additional heat sinking, the bottom surface can be thermally bonded to the PCB substrate, and the substrate to the device enclosure, to create an efficient path for heat away from the component. Additional heat sinking measures can be built into the packaging to provide higher heat dissipation.

Strong Magnetic Coupling

The low profile of planar transformers ensures high magnetic coupling across the transformer core, which leads to higher power conversion efficiency. Similarly, for planar inductors, the low profile of a planar transformer provides greater confinement of flux in the transformer core compared to a traditional transformer, wire-wound inductor, or foil inductor. As a result, fewer turns are needed in the coils for planar magnetics components, which reduces DC losses and further increases power conversion efficiency and reliability.

Customization and Modularity

Planar magnetics have simple structure and design, meaning these components can be easily modified into custom components. Customization of packaging dimensions, footprint, terminations, and mounting style. Because the structure of these components is easy to modify, they could

also be designed to have smaller reactive parasitics that would be demanded in more advanced power systems. These components can also be made modular with multilayer PCB supports so that mounting style can be customized on new planar magnetics designs.

In addition to these points, other basic specifications for planar magnetics are competitive with those of traditional magnetics. These components are preferred from a reliability standpoint in many systems as they can have higher current limits for comparable inductance values, while the low profile and aspect ratio of the packaging ensures high heat dissipation away from the component.

Summary

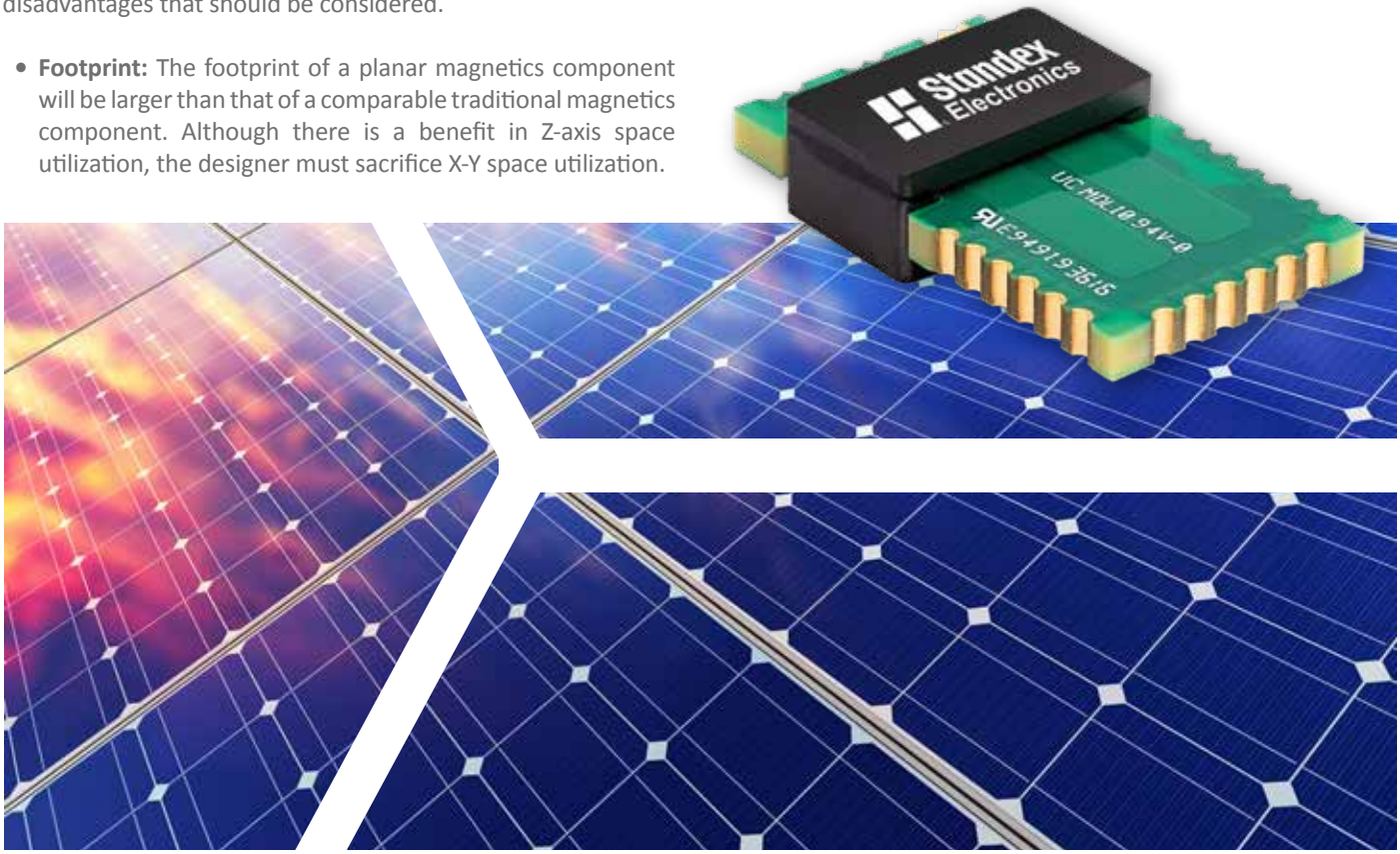
Planar transformers are certainly a useful option to support the next generation of power systems designs. In particular, they are highly desirable for systems carrying high reliability requirements due to their low profile design and low weight. The same structural characteristics in planar magnetics make these components superior in terms of their flux leakage and losses, ensuring high power conversion efficiency in power system designs.

While planar magnetics carry several advantages from the perspective of space utilization and efficiency, they carry some disadvantages that should be considered.

- **Footprint:** The footprint of a planar magnetics component will be larger than that of a comparable traditional magnetics component. Although there is a benefit in Z-axis space utilization, the designer must sacrifice X-Y space utilization.
- **Capacitance:** Lumped capacitance can be higher in these components compared to a comparable magnetics component due to the strong coupling between windings. As a result, the frequency limit can be lower in planar magnetics. For high frequency switching converter designs, a designer would need to compensate with higher inductance or a multiphased design.
- **Convection cooling:** Because these components are so closely packed, they are less optimized for convection cooling within the body of the package. Thermal management must rely on conduction to the top surface, followed by natural or forced airflow to remove heat from the component.

When the disadvantages listed above are properly accounted for by the designer, planar magnetics can oftentimes yield higher system efficiencies and power densities than their wire-wound counterparts.

Designers who are considering using planar magnetics in their power system designs should consider the broad line of products from Standex. The planar transformer and inductor options from Standex are designed to provide high efficiency power conversion and regulation with high power and current limits in power system designs. Contact Standex today to learn more about its line of high power, high reliability planar magnetics components.



PARTNER | SOLVE | DELIVER®

Standex Electronics

Standex Electronics
Worldwide Headquarters
4150 Thunderbird Lane
Fairfield, OH 45014 USA
+1.866.STANDEX (782.6339)
info@standexelectronics.com

Agile Americas (NH)
+1.800.805.8991
info@agilemagco.com

Minntronix Americas (SD)
+1.605.884.0195
productsales@minntronix.com

Renco Americas (FL)
+1.800.645.5828
sales@rencousa.com

StandexMeder Europe (Germany)
+49.7733.9253.200
salesemea@standexelectronics.com

StandexMeder Asia (Shanghai)
+86.21.37606000
salesasia@standexelectronics.com

Standex Electronics India (Chennai)
+91.98867.57533
salesindia @standexelectronics.com

Standex Electronics Japan (Kofu)
+81.42.698.0026
sej-sales@standex.co.jp

IATF 16949 CERTIFIED · ISO 9001 CERTIFIED · ITAR · NIST · AS9100 CERTIFIED

standexelectronics.com

MAG-COM-WP250205