

Planar Transformers

How to Select Planar Magnetics for Low Profile,
High Reliability Industrial System Designs



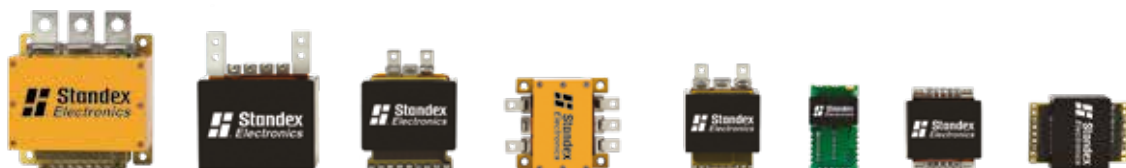


Introduction

Industrial electronics used to be large, clunky, loud, and sometimes dangerous. As the rest of the electronics industry has focused on miniaturization and sleek packaging, industrial electronic systems are finally starting to catch up, simply out of a need to pack more features into smaller areas. Industrial products have also typically focused on process automation, and later robotics, but today's advanced industrial systems have expanded functionality that makes them smarter and more connected. While the industrial electronics landscape has changed over time, what hasn't changed are the power handling and reliability requirements in industrial electronics. In industrial production systems, reliability is paramount as these systems must have high uptime and highly consistent performance, especially in today's era of connected factories.

Each production facility is different, with varying reliability challenges like thermal management, low noise, and power delivery. Even though reliability challenges abound, the need to pack more functionality into smaller packaging creates pressure on systems designers to select extremely low-profile, yet highly reliable components. Within previous industrial systems, which often had integrated power regulation and management sub-systems, larger transformers, inductors, and other magnetic components were some of the bulkiest. The traditional off-the-shelf options tended to stand high on the board, were heavy, may have had problems with noise coupling, were difficult to keep cool, or may have failed from excessive vibration.

One excellent alternative class of magnetics components is planar magnetics, or more specifically, planar transformers and inductors. Compared to a typical board-mounted transformer or inductor coils, planar magnetics have a lower profile with a unique structure that provides several advantages. The compact nature of these components helps designers meet size, weight, and form factor requirements, but without losing the power handling capabilities of larger magnetic components. Planar magnetics are superior in terms of power conversion efficiency, heat management, and ability to withstand vibration, making them an excellent choice for high-reliability applications that are demanded in industrial power systems.



Why Use Planar Magnetics?

Magnetics are typically selected by considering a specific power conversion target, inductance value, or voltage/current rating. Important aspects like form factor are often ignored in off-the-shelf components with a focus on these primary electrical specifications. In cases where an aggressive form factor is needed, designers may need to contact a magnetics manufacturer to help them design and produce a custom component, something which can be costly but does not provide any additional advantages over off-the-shelf board-mounted magnetics. Planar magnetics provide several advantages in these cases, offering an innovative solution to form factor and reliability challenges.

Advantages to Planar Magnetics

In today's industrial systems, form factor and reliability go together, and they need to be considered alongside the primary electrical specifications. The form factor of some components will determine some of the critical aspects of reliability in industrial systems, specifically how heat can be removed from these components with a cooling strategy, as well as mechanical characteristics (like vibration and shock). The form factor of planar magnetics gives these components some important advantages over off-the-shelf or custom board-mount transformers typically found in industrial systems.

Size and weight - In the past, this was less of a consideration, and systems might be intentionally over-designed so that bulkier magnetics components could be easily accommodated on the board or chassis. Planar magnetics exchange z-axis height with x-y plane span, so they can fit in a smaller enclosure, such as might be demanded in robotic production equipment.

Vibration - Off-the-shelf transformers that sit high on the board could be more prone to vibration due to their weight and shape along the z-axis. These components will have a lower natural frequency that is more easily excited by motors or mechanical shocks, which could lead to solder fatigue or packaging damage. The lower profile and larger mounting area allocated to planar transformers means they can more easily withstand lower frequency vibrations. Their stacked structure also provides greater resistance to low frequency vibration within the assembly.

Strong pri-sec coupling - Most board-mount transformers have a core structure that can allow for leakage of magnetic flux outside the transformer core. A shell-type transformer will have lower leakage and higher efficiency due to the coil-in-coil design. The compact structure of a planar transformer uses a similar structure as a shell-type transformer, where the compact structure of the component ensures stronger coupling over a smaller distance between coils. Strong coupling then produces comparably higher power conversion efficiency for a given set of power handling ratings.

Easier thermal management - Planar transformers may be easier to cool via conduction as the packaging can be designed in such a way that a heat sink can be integrated into the assembly. In some cases, where an external fan is needed, a heat sink could also be mounted directly onto the exposed surface of the component with a thermal compound. Planar magnetics can be difficult to cool via convection or forced airflow because they are so compact but adding a heatsink or mounting directly to an enclosure helps overcome this challenge. The compact structure of these components also means they require fewer wire turns to reach the required inductance, so they have lower DC losses and will generate less heat at high current than other board-mount transformers with the same power handling and turns ratio.



Important Specifications for Planar Transformers

Input/output power handling - Several factors will go into determining the power handling available in a planar transformer, although this will typically be the starting point when looking at transformers for power applications. One reason for this is the standardization of voltages used in industrial environments, but in terms of the input AC power (e.g., 85-265 VAC) and the desired output DC value (5 V, 12 V, or 24 V are standard). The other important points are pri-sec isolation (needed for low noise coupling).

Switching frequency limit - Planar magnetics tend to have lower frequency limit, thus they might be more likely to be used in a typical LLC resonant topology or flyback topology. In either case, these systems must be designed while considering both the primary coil inductance and the switching limit. These factors will limit the available gain in a resonant converter topology, so the switching frequency, external inductance, and coil inductance should be chosen carefully.

Cooling method - Planar magnetics components can be difficult to cool via forced airflow simply because they are so compact. Heat must be dissipated through the package into a heat sink, which can then be used as a channel for forced airflow. The other possibility is that the transformer package is mounted or bonded to the enclosure so that it can dump heat directly into the system chassis. The mounting style and package aspect ratio will both determine which cooling methods will be more feasible and effective in planar magnetics.

Mounting style - Like any other transformer or inductor, planar magnetics can be placed as SMD components or as through hole components. Physically larger components will eventually need to be mechanically fixed to a board, enclosure, or chassis, although these will be able to withstand more mechanically demanding environments than a standard through-hole component. Something like processing equipment might prefer a bulkier through-hole or chassis-mount component, while smaller power systems or robots will be fine with a board mount option.

Parasitics - All systems contain parasitic R, L, and C. In industrial systems, we would ideally prefer zero leakage inductance (LL) and zero lumped capacitance (CP). The former is more important for high current power conversion and regulation as we would ideally prefer to have maximum efficiency and thus low flux loss during switching. In something like an industrial networking product, computer system, or robotics, we would prefer lower lumped capacitance as this is responsible for coupling common-mode current loops around these systems. This then creates mixed-signal EMC challenges that require a unique grounding strategy to solve.

Isolation - Finally, transformers that are intended for use in power applications should provide galvanic isolation to meet safety requirements. All transformers have some isolation value that can reach kV levels in some components, with the specification normally provided at the full DC power handling rating. Safety is an important consideration when designing any power system; to receive UL qualification and other industry certifications, some minimum level of isolation should be provided between the primary and secondary transformer coils in the power conversion stage. Planar transformers can provide high galvanic isolation in a physically smaller package than an off-the-shelf transformer with comparable power handling specifications, which provides an easier path towards safety compliance without sacrificing power output.

Which Specifications are most important?

The most important specifications for planar magnetics components depend on the application area and deployment environment. For example, processing equipment may induce excessive vibration and mechanical shock, so a surface-mount planar transformer or inductor would not be the best option to ensure reliability. In robotics or motor control, low profile and current handling are more important as power delivery may involve short bursts of current with high peak value. Noise coupling through leakage inductance is another important consideration in robotics as planar magnetics might be placed on the same board as digital components.

In an area like power conditioning in an industrial environment, the leakage inductance, DC resistance, pri-sec isolation, and rated AC frequency limit are more important. These specifications will be the major determinants of power conversion efficiency, so they should be examined first before looking at other specifications or focusing on specific form factors. If used in a power system that will be frequently exposed to high temperature, the ability to cool the component may be the primary consideration as this will be the major determinant of reliability.



Summary on Planar Magnetic Selection

Advanced industrial processing equipment, power systems, robotics, and motor control equipment rely on high-reliability components like planar magnetics to ensure perpetual uptime. With this alternative class of components, form factor and reliability can now be the primary considerations in transformer selection, including in systems requiring low-profile board-mounted components in sleek packaging. Focusing on form factor allows important reliability considerations like heat management and vibration resistance to be the main driver of industrial power systems design. The modular nature of planar magnetics components also allows these to be easily designed to accommodate standard input and output voltages in power systems, so designers won't be limited in the power levels they can accept or output in their systems.

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



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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.

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