Benefits of a Hybrid Planar Transformer Package and an Overview of Product Screening Levels

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This presentation would walk the audience through the transition from traditional wire-wound magnetics to a planar PCB style. Briefly discuss why there was a need for this transition and the properties of a planar magnetic that support this transition. Then introduce our SGTPL product line and highlight the additional benefits of a SGTPL versus a planar magnetic. The presentation would then transition to discussing the variety of screening options offered for space-grade magnetics and discussing the pros and cons of each option.

Standard wire-wound transformers have become a design limitation in high-frequency applications. Copper losses such as skin and proximity effect play a larger role at higher switching frequencies and the geometry of typical round magnet wire result in increased copper losses as the frequency increases. Conventional wire-wound transformers can combat this using larger gauge wires, multi-filar windings, or LITZ style magnet wire but all these mitigation techniques require the overall part size to grow. The size of a transformer has also been pushed to smaller and smaller levels so the need for a different design approach was realized by the industry, a planar style magnetic.

Planar magnetics typically consist of foil windings embedded within printed circuit boards and use magnetic core geometries that offer large cross-sectional areas that enable lower profile cores. These style cores feature favorable core losses due to a larger ratio of winding window versus total core volume when compared to cores used on more conventional transformers. Low profile cores also withstand higher shock and vibration levels than standard height versions and allow designers to more densely package their designs. Planar magnetics mitigate copper losses using thin, foil windings that limit the influence of skin effect and can split up the windings and interleave them throughout the winding stackup to decrease the proximity effects. Combining the advantageous core geometry with the foil winding methodologies produce transformers capable of higher power densities with lower leakage inductances than traditionally designed ones.

There are some known drawbacks to planar magnetics that the industry must consider. First, the printed circuit boards within this style can be very costly to manufacturing. Second, the design and manufacture of the printed circuit boards can be time intensive and costly to customize for specific applications. Finally, copper thickness within the circuit board are limited so designs requiring heavy current applications may require multiple layers which add complexity and cost to the design.

Vishay's patented SGTPL Hybrid Planar Transformer product line aims to incorporate all the benefits of a planar style magnetic while eliminating the negatives previously described. The SGTPL uses similar low-profile core geometries as standard planar designs but replaces the PCB style windings with thin, rectangular magnet wire. The enamel coated magnet wire provides superior turn-to-turn isolation when compared to PCB style windings. The wire thickness does not have the same limitations as a PCB style design would allowing the SGTPL to have larger copper fill percentages within the core's winding area. These improvements result in an overall increase in power density with low DCR and leakage inductance.

The SGTPL's winding structure eliminates the costly printed circuit board manufacturing process. Instead, Vishay uses dedicated coil winding equipment to wind the rectangular wire in coils that efficiently utilize the core's winding area. This winding process is conducive to customization and allows Vishay to support low-cost, timely solutions to their customers. The SGTPL has an established heritage within the Space industry. Vishay offers both standard SGTPL products along with full custom design capabilities. Screening is offered in a multitude of levels for both the standard and custom variants. The following section briefly outlines many of the popular screening options for space-grade magnetics and describes the benefits and disadvantages of each.

- Traditionally, Space-grade magnetics have been built and screened against MIL-STD-981 Class S or B. This standard includes a wide range of best practices and workmanship requirements along with extensive screening (Group A) and Group B tables. MIL-PRF-27 fills any workmanship and screening gaps the MIL-STD-981 may have and was created to support general military applications for transformers and inductors. Often considered the highest level of screening for magnetics, this screening comes with high cost and long leadtime.
- EEE-INST-002 is another popular workmanship and screening standard developed by NASA for use on their Goddard Space Flight Center (GSFC) space flight projects and has been widely adopted throughout the industry. EEE-INST-002 offers screening and qualification plans at three different levels (1, 2, & 3) with some overlap with MIL-STD-981 at levels 1 & 2. EEE-INST-002's workmanship guidelines mirror closely with MIL-STD-981 or MIL-PRF-27 depending on the level and class rating of the magnetic. For screening, EEE-INST-002 offers a range of options from extensive 100% screening with lot qualification (high cost, long leadtime) down to minimal 100% screening with options to opt out of qualification with part heritage or past qualification history (low cost, short leadtime). Users must evaluate the risk allowed within their project and select the appropriate screening levels required.
- AEQ-Q200 is an automative grade standard that provides the minimum, stress test driven qualification elements for magnetics used in the automotive industry. This standard relies upon process controls within high-volume manufacturing and qualification testing to deliver reliable, magnetics to the customer. AEQ-Q200 lacks the 100% screening and workmanship requirements that MIL-STD-981 or EEE-INST-002 have so the procuring parties must be aware of the risks involved when purchasing automotive parts. This added risk comes the benefits of typically lower cost and quicker leadtimes.
- Custom screening has become another popular alternative for screening magnetics for space use. Often upscreening an automotive or even commercial part through a set of 100% screening tests and sometimes even conducting some level of qualification testing. Screening and qualification requirements are developed between the supplier and the user. Custom screening seeks to leverage the benefits of higher-volume automotive or commercial grade parts while lowering the risk through the implementation of some of the screening presented in MIL-STD-981 or EEE-INST-002.

Each of these screening options has their role in the space market but it is up to the supplier and the user to determine the right approach for their specific application. Factor such as application requirements, environmental exposure, product heritage, and process control should be considered during this evaluation. Low accepted risk and long-life requirements might dictate parts built and screened to MIL-STD-981 or EEE-INST-002 Levels 1 & 2. Whereas programs with high accepted risk and shorter mission life might benefit from custom screening plans or even automative grade devices.