

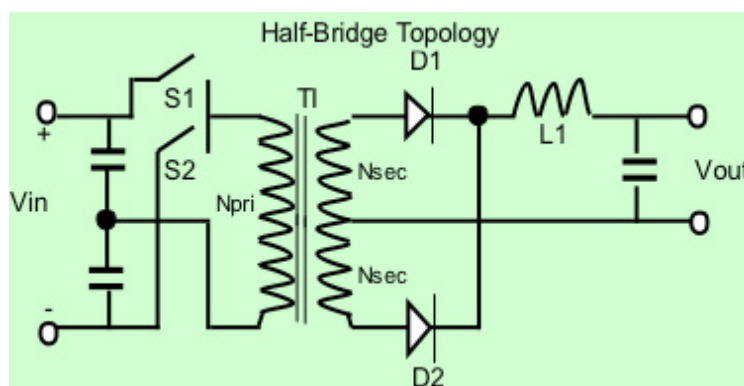
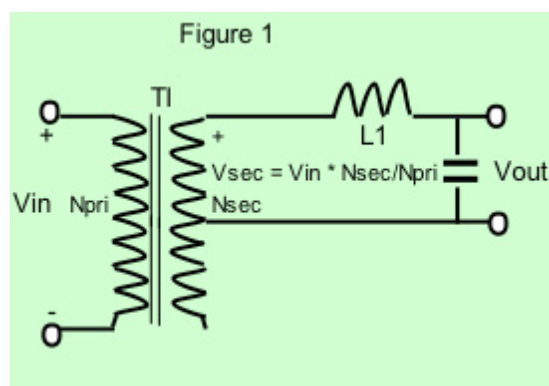
NEXT GENERATION PLANAR TRANSFORMERS

Introduction

Pulse Electronics has introduced some significant cost reductions and performance enhancements in planar magnetics in recent years. For more information on this, the reader is referred to <https://www.power.pulseelectronics.com/flat-coil-planar-transformer>. However, the basic windings structure, with its multi-sequential winding layers, continues to limit their application to lower power (<250W) applications. This article explains how tighter coupling between windings is necessary to meet demanding efficiency targets at higher powers. Two further advancements in planar design which extend the performance and the power capability of the Pulse planar transformer to 1KW, one in the optimization of the design of the planar core and another in a patent-pending winding technique, are presented here.

Convert Topologies for Higher Power Applications

The relatively simple interleaved winding structure of the existing planar solutions works well for the forward converter topology delivering power up to 250W. Above this, the bridge converter is the topology of choice for higher power, but the available planar solutions have some limitations here. The following block diagrams illustrate the principle of operation of the half-bridge converter and the issues that arise.



Switches S1 and S2 alternate to drive conduction through one-half of the secondary winding at a time, generating an output voltage that is proportional to the N_{sec}/N_{pri} turns ratio and regulated by the duty cycle. Good coupling between the primary and each half of the secondary, and the secondaries themselves, is key to maximizing efficiency. This is difficult to implement with the multilayer windings of the existing solutions without the added complexity of winding segmentation, which adds pin count and cost. The optimum solution is complete interleaving between windings with the minimum number of winding turns and without segmentation. This is achieved with a new winding structure and core design which are presented in the following sections.

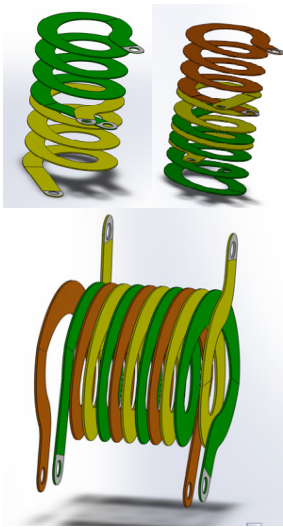
Deep Interleaved Flat Coil Winding

Pulse has developed a patent-pending winding technique to match the complete interleave capability of multilayer PCB technology while continuing to offer the cost and performance benefits of the existing flat coil planar technology. The flat coil windings are corkscrewed into each other, as demonstrated by the following illustrations.

Selective coupling between the windings, where a very low level of leakage inductance is required, can now be effectively implemented. Complete interleaving is achieved without any additional segments. In fact, a reduction in the number of existing winding segments used in the available solutions is possible, as outlined in the following table.

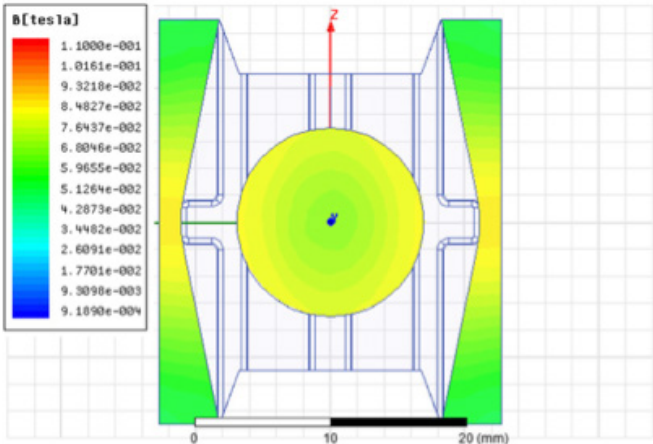
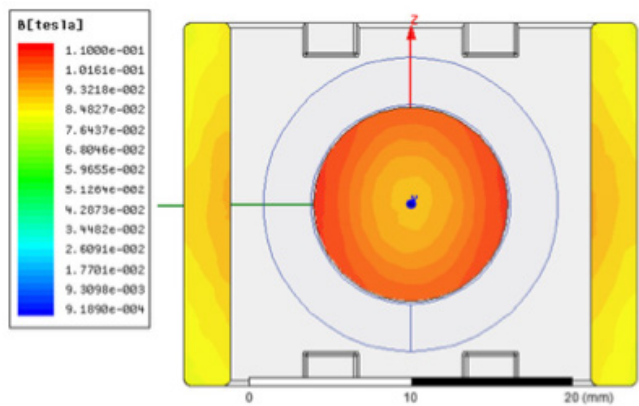
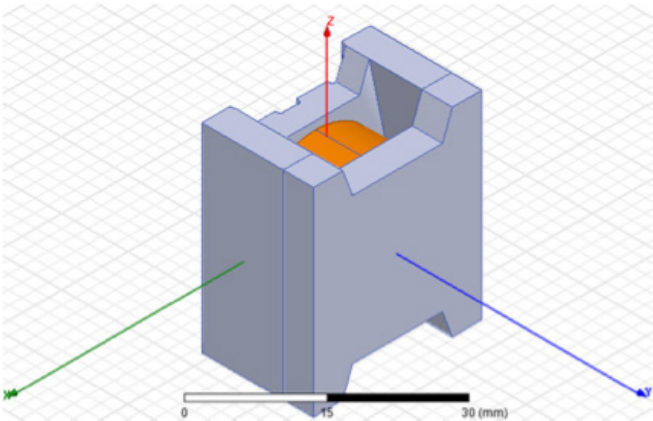
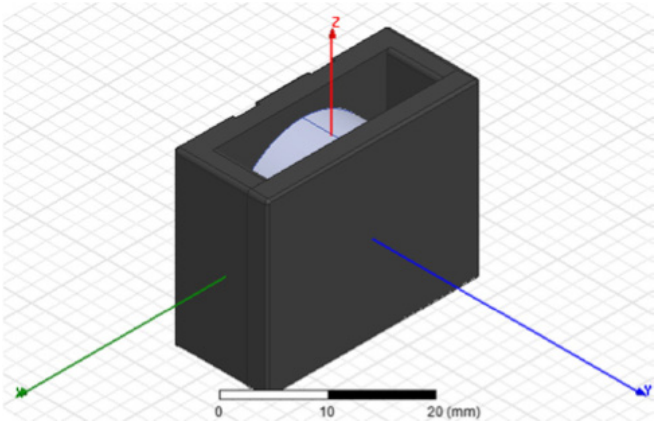
	T/R (Pri:Sec:Sec)	LL (μH)	FC Quantity	Total Pins
PH0903NL Current Solution	5:2:2	0.10 nH	6 pcs	9 pcs
Deep Interleave Solution	5:2:2	0.06 μH	3 pcs	5 pcs

The leakage inductance is reduced with this simpler winding construction and the winding segment and pin count reduction yield a cost reduction of 20%. A further reduction in leakage inductance is achievable by optimizing the core design to reduce the number of turns. This is discussed in the next section.



Optimized Planar Core Design

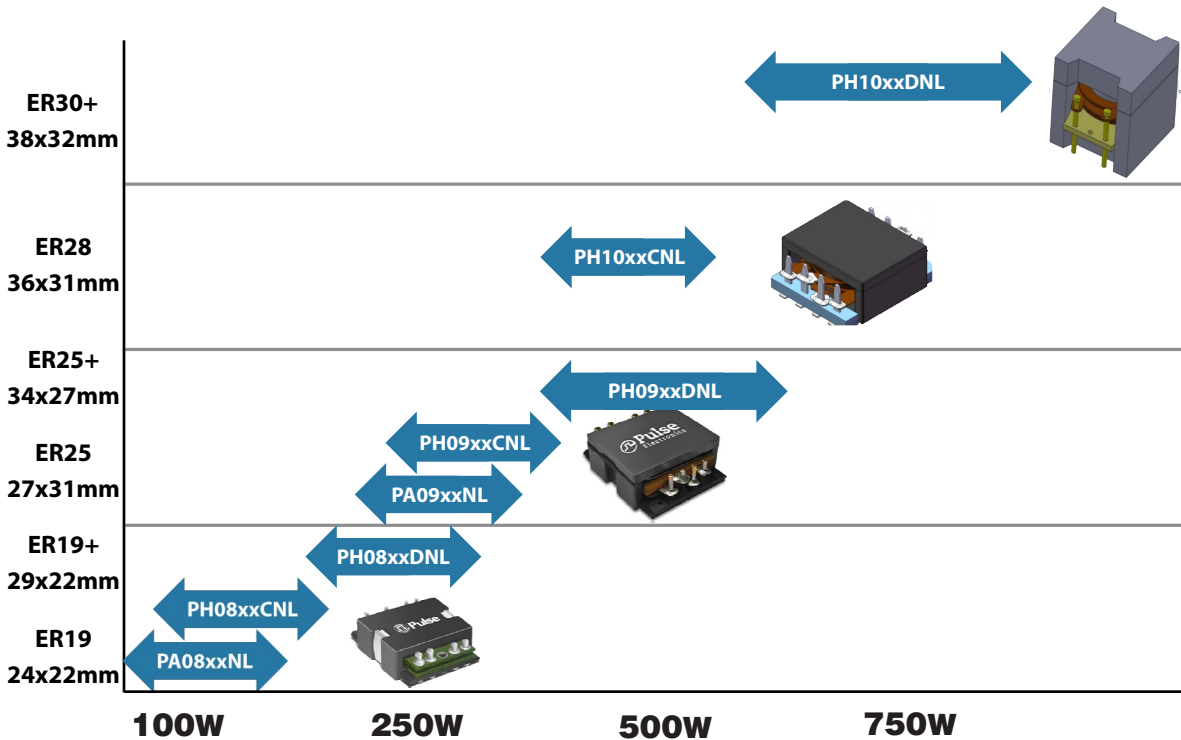
Traditionally, the ER planer cores have a large aperture for the multiple pins required to connect and terminate the windings. The windings and the pins generally extend far beyond the core, resulting in a relatively large board space required for a planar solution. However, with the reduced pin count of the deep interleaved solution there is the opportunity to optimize the core geometry for a more compact mechanic. Finite element analysis of the flux field can be used to redesign the core to increase the effective cross- sectional area. The outcome is a new core design, which is introduced below and compared to the present core shape.



The finite element analysis of the existing current shape reveals a non-uniform flux distribution with a higher density in the center leg. The optimized ERPlus shape achieves a more uniform distribution through the flux path while at the same time increasing the effective core cross-sectional area by 40% within the same core geometry. Since the number of required winding turns is inversely proportional to the core cross-sectional area, the number of turns can be reduced for a given performance level. This reduces both the direct current resistance (DCR) and the leakage inductance so the power capability increases. For a given ER platform size the throughput power of a similar-sized ERPlus platform increases by approximately 50%.

Conclusion

Two important advancements have been presented which yield a quantum leap in throughput power capability while continuing the trend in planar magnetics price reduction. The ERPlus platform provides 40% greater core cross-sectional area compared to the existing platform of comparable size, while the new deep interleave winding technique yields a reduced cost of 20% by reducing the complexity of the winding and assembly with a comparable coupling performance. This next generation planar design is scalable and extends the Pulse Electronics planar power capability to 1KW. An overview of the technology roadmap is presented below.



Written By: Gerard Healy