FLAT COIL PLANAR TRANSFORMERS

Introduction

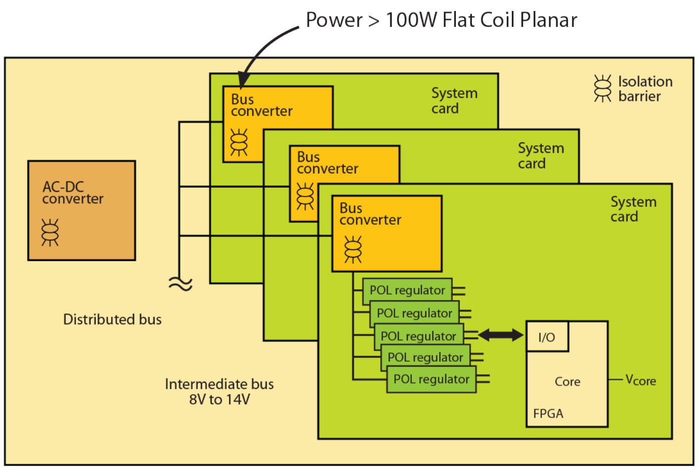
Pulse has led the development of planar magnetics, providing technical solutions for datacom, industrial automation & control, aeronautics and robotics industry over the last 20 years. Much has been written about the benefits of planar over conventional wound magnetics. The reader is referred to https://www.power.pulseelectronics.com/planar-vs-conventional-transformers for more information.

As a discrete component, the planar transformer have been primarily implemented as a high power (>100W) low profile (< 10mm) solution for medium to low voltage conversions because of the current handing capabilities of the planar windings. A typical example is the intermediate bus converter in the distributed power architecture. Emerging trends have increased the popularity of this product as an embedded cost saving technique despite the price premium associated with a planar solution.

This paper discusses the distributed power architecture, the recent trends that are driving new opportunities for planar magnetics and cost effective planar solutions. A new generation pulse product offering is presented that both increases the technical performance compared to the existing offering and reduces the price. Finally, further development activity is outlined which is further reducing the price, increasing the power capability and functionality of new pulse planar solutions.

The Distributed Power Architecture & Emerging Magnetic Requirements

Since it first began to replace the central power source in the 1980's, the Distributed Power Architecture (DPA) has been implemented in a wide variety of complex electronic systems. By eliminating the need of a direct wiring between the source and each individual loads, replacing this with bus voltages and Point of Load (POL) conversions, the DPA is smaller in size and higher in efficiency. The fundamental blocks of the DPS are shown in the following diagram.



Distributed Power Architecture

The front end AC/DC converter provides reinforced insulation from the mains source and a medium level bus voltage. The isolated Intermediate Bus Converter (IBC) provided a loosely regulated, lower board level voltage. The POL regulator provides the very low voltage conversion as close as possible to the load. This minimises the length of high current tracks and improves the system efficiency. The DPA is adaptable and scalable according to the emerging power needs of the system.

While the front end AC/DC converter has largely remained a centralised power source at a system level, the popularity of the DPA has driven the DC/DC converter market into a multibillion dollar industry. A wide range of power modules are available with standardised input and output voltages and tailored for various market requirements.

Pulse has developed a wide portfolio of magnetics for DC/DC conversion from low cost inductors for the POL to high end transformers for the IBC, with constructions ranging for low cost convention wound for lower power to planar windings for applications that require higher currents in a low profile.

In the recent years, a second quiet revolution has taken place that has driven the development of a new range of magnetics. The DPA needed to adjust to the requirements of more complex and power hungry loads. DSP's, FPGA's and ASIC's, requiring careful load monitoring and power sequencing, has lead to a wider implementation of POL's with digital controllers to facilitate the load management. Increasing current levels has driven the requirement for higher efficiency inductors. While this topic is not covered by this paper, the reader is referred to http://www.power.pulseelectronics.com/round-wire-coil-inductor for more information.

A direct consequence of the wider implementation of POL's is a simplification of the IBC. Previously, these tended to be complex multiple output modules to provide several voltage rails. These are now being replaced with single output converters and with the strong trend to implement these as an embedded solution. However, the increasing power requirements and the height restrictions demand low profile, high efficiency and cost effective solutions. Conventional wound magnetics may still satisfy the power requirements up to 100W. Above 100W these solutions become quite bulky.

The planar transformer, with its low profile windings, is the optimum technical solution. However, these currently come with a significant price premium. The focus of this paper will be on an alternative winding technology for cost optimization.

Flat Coil Winding Technology

Planar magnetics achieve higher power in lower profile by replacing the cores and windings of conventional wound magnetics with flatter alternatives. Traditionally, Pulse has used planar cores with multi layer PCB for the medium voltage/medium current primary winding and copper plates for the low voltage high current secondary winding of the IBC transformer. Two standard series planars are available, the PA08xxNL & PA09xNL (Gen1) series, with power capabilities up to 140W and 250W respectively.

The PCB is the most significant cost factor, its cost linked directly to its size and manufacturing volume. There is limited design flexibility and a new tooling required for each variation. While some economies of scale have been achieved on the 140W series, the cost increases rapid for higher currents (more PCB layers) and larger platforms (more PCB area).

Pulse has developed a cost effective alternative by replacing the multilayer PCB winding with a flat coil windings, reducing the price by approximately 20%. The copper fill factor of this technology is twice that of PCB, so the DCR of the primary winding is reduce by 50% in the new generation (Gen2) PH08xxNL and PH09xxNL series. This increases the power rating by 20% in the a new size and pin compatible standard series. Eliminating the cost and time to fabricate PCB's for new winding arrangements, the flat coil planar has the additional advantages of flexibility and speed to prototype custom variations.

Further Technological Advantages of Flat Coil Windings

For power levels up to ~ 150W, the forward converter topology is commonly selected and the PA08xxNL had been an effective transformer solution. However, for the next power range, other topologies such as Push Pull and Half Bridge are generally chosen. These require centre taped windings and with current conduction in the windings only during certain periods of the switching cycles, the coupling between windings becomes a critical design aspect. Traditional multilayer PCB windings with up to 8 consecutive winding layers give rise to high leakage inductance, producing unacceptably high voltage spikes and snubber circuit losses.

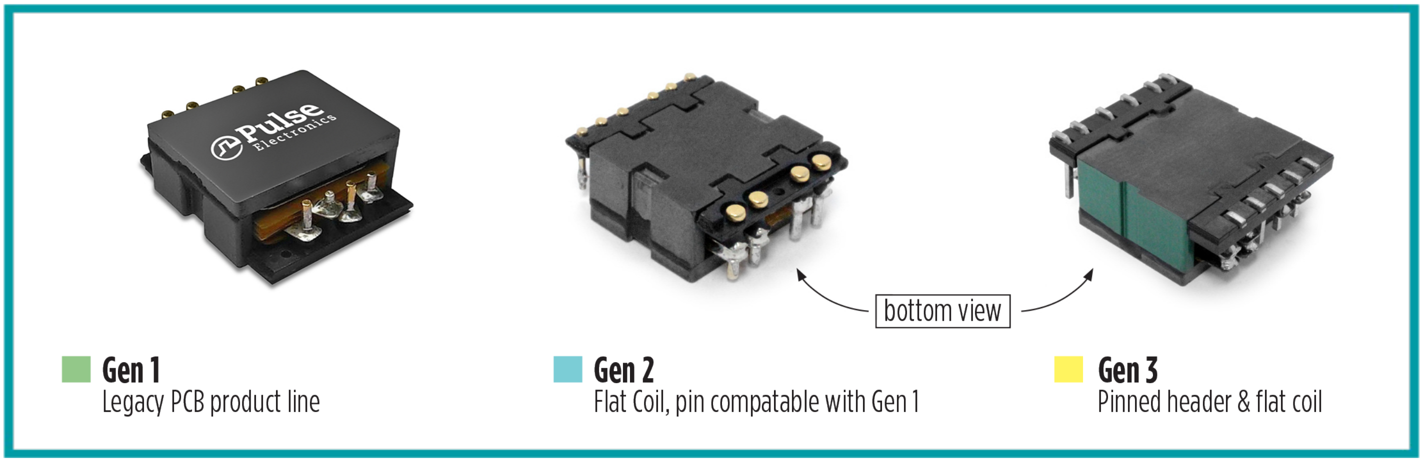
The multilayer PCB can be replaced with lower number of flat coil winding layers connected in series. This provides immediate benefits by reducing AC proximity effect copper losses. In addition, more winding segments and selective coupling between simultaneously conduction windings can be implemented to reduce the leakage inductance. This improved interleaving capability has been demonstrated to improved transformer efficiencies for higher power customized designs on standard platforms. The following is a case study for a 4:4:4 ratio bridge topology transformer and the reduction in leakage for when using flat coil windings which yielded a increase in PSU efficiency from 95.2% to 97.5%.

	Conventional Planar Construction	Optimized Construction
Turns Ratio Np:Ns:Ns	4:4:4	4:4:4
Stack up	1T/Sec A/1T/1T/Sec B/1T Four 1T connect in series	Sec A 2T/Pri 2T/Sec B 2T/Sec A 2T/Pri 2T/Sec B 2T 2T Primary, Sec A & Sec B connect in series
Leakage Inductance (nH)	130	97

The Next Generation (Gen3) Planar Transformer

The manual pining and soldering of the current planar construction is a second significant cost factor. To address this, Pulse is developing a new process that greatly reduces the assembly time. A pinned header allows the individual winding elements to be quickly stacked and terminated by solder immersion.

A modification to the pad layout for the flat pins of the pinned header is required if replacing a round pin Gen1 or Gen2 planar. However, with a 20% further price reduction compare to the Gen2 version, the Gen3 solution is recommended for new designs. PH08xxCNL and PH09xxCNL series are being developed as alternatives to the current product offering, with a new and larger PH10xxCNL platform extending the power capability to 500W.



Conclusion

Pulse continues to address the market needs with ongoing development of planar platforms and winding technologies. The new Gen2 series is drop in replacement standard product offering for immediate price reduction. Gen3 products offer further price reduction for new development activity. The current development road map includes optimised core designs to push the power capability up to 1KW as well as an innovative winding technology to minimise leakage inductance for higher power transformer design and higher levels of isolations. The reader is encouraged to contact Pulse to discuss their particular needs. The annex to this paper provides an overview of the complete planar product offering.

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