Planar Magnetics Technology for High Frequency Power Conversion

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In the 21st century the electronics industry continuously demands ever increasing high power density solutions for power conversion systems. Energy Efficiency Regulations in power conversion and no-load power consumption require higher efficiencies in today's high frequency Switchmode Power Supplies (SMPS).

The magnetics design in a power conversion system plays a vital role in realizing a higher efficiency and power density. Planar magnetics technology provides cost effective solutions for high frequency power conversion systems.

Low profile planar magnetics designs are becoming more popular as SMPS frequencies progressively increase. One obvious appeal of planar magnetics is the low profile feature. However, planar magnetics provide other significant advantages including:

- **Low leakage inductance**
- **Exceptional repeatability of performance**
- **Economical manufacturability**
- **Mechanical reliability**
- **Excellent thermal characteristics**

Planar Transformers

Planar transformers designs use copper trace windings that are etched on multi-layer printed circuit boards (PCB's) enclosed by a low profile ferrite core, *Figure 1*. Windings can also be constructed utilizing flat copper layers (lead frames). The 'lead frames' are single turn flat conductors which are shaped to fit the core. These winding techniques allow for greater efficiency due to lower AC resistance as compared with round wire.

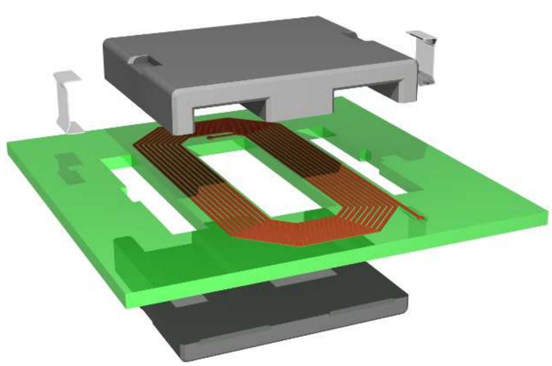


Figure 1. Planar Transformer

The results are a solid high power density planar transformer that is normally 30% of the volume and weight of a conventional wire-wound transformer. The repeatability features of planar components are of significant importance, particularly, when used in high frequency resonant topologies.

Planar Core Geometry

Planar cores are available in various shapes and sizes. The most popular is the planar EE or El core. Other cores include low profile planar versions of standard cores such as RM, ER, PQ and pot cores, *Figure 2*.

Figure 2. Planar Ferrite Cores

Copper Losses

The magnetic flux 'B' density of a ferrite core is proportional to its cross sectional area 'A.e' and the numbers of turns 'N' by *equation 1*. The larger cross sectional area of planar cores allows for fewer turns in so doing reduces the amount of copper used.

$$N := \frac{V_p \cdot 10^8}{4 \cdot B \cdot A_e \cdot F}$$

Equation 1.
(Vp= applied volts, F= frequency)

The reduction in copper used in the windings lessens the effects of parasitics elements thereby improving to the overall performance and efficiency.

Leakage Inductance

The reduced number of turns and the flat copper layers of the windings also help in minimizing the leakage inductance. The reduction in leakage inductance can be as much as 10 times less as compared with a conventional transformer design. Since leakage inductance represents lost energy this is yet another improvement in efficiency

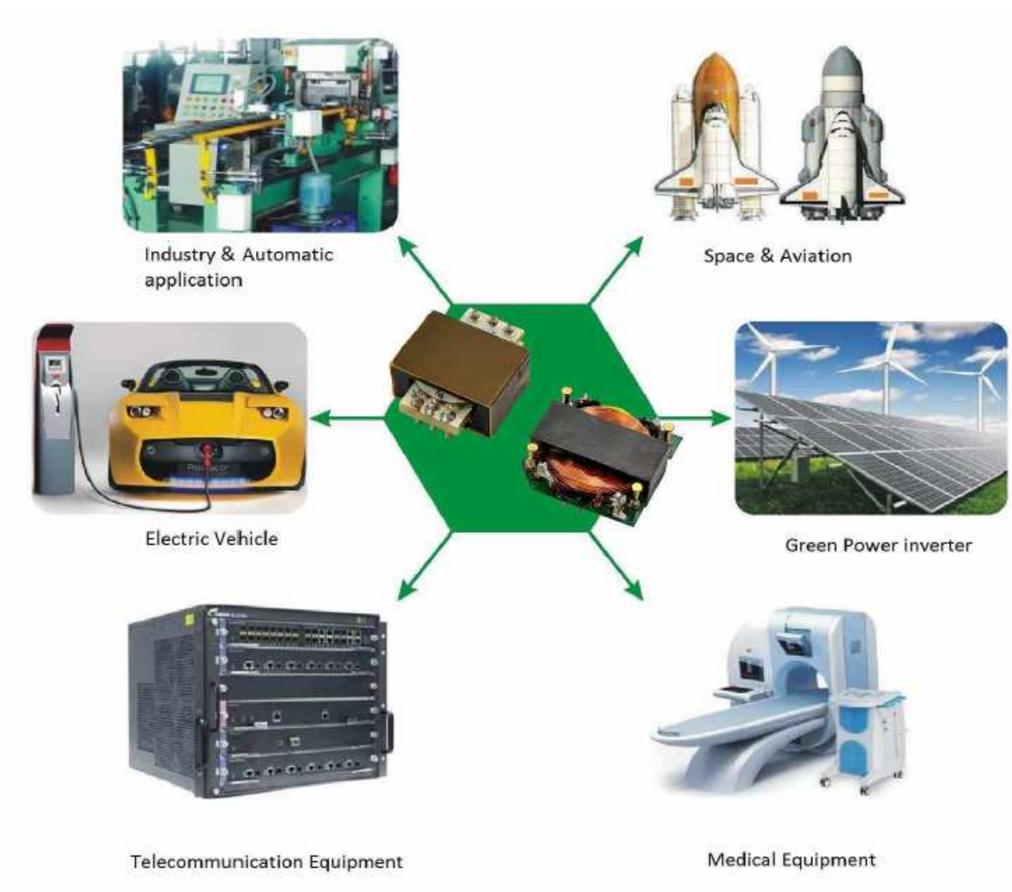
Core Loss

In high frequency transformer design there are always tradeoffs between copper losses and core losses. Allowing more turns of copper yields a lower flux density and lower core loss. However, allowing fewer turns of copper would yield a lower current density and lower copper loss. For planar transformers the minimum total losses are achieved by favoring the current density and allowing the flux density to increase.

Planar cores have a high ratio of surface area to volume. The heat generated within the core and conductors has the ability to spread over a greater area. Also, there is a much larger surface per unit of volume to radiate heat. The result is a transformer with a higher power density and a temperature rise that is well within acceptable limits.

Typical Applications

Planar transformers are suitable for many power conversion topologies, including soft switching, single or multiple outputs, high switching frequencies, and multiple input -output configurations. They can be operated by many Pulse Width Modulator (PWM) chip sets available from the major chip manufacturers including Power Integrations and Texas Instruments. Customization can be easily achieved without start-up or tooling costs.



Custom Planar Transformers Available From PALNOVA

Series	Max. Power (W)	Converter Topology	Frequency Range (KHz)	Dimensions (mm)	Isolation Voltage
PER14 20W	20	Forward | Flyback	300 - 500	15.0 x 14.6 x 6.0	1.5 KVDC
PRM06 50W	50	Forward | Flyback	200 - 500	17.5 x 17.1 x 8.0	1.5 KVDC
PEI18 50W	50	Forward | Flyback	200 - 500	26.3 x 18.3 x 8.0	1.5 KVDC
PEI18 100W	100	Half Bridge | Forward | Flyback	200 - 500	20.4 x 18.8 x 8.0	1.5 KVDC
PEI22-1 150W	150	Half Bridge | Forward | Flyback	200 - 350	25.3 x 22.0 x 10.0	1.5 KVDC
PEI22-2 150W	150	Half Bridge | Forward | Flyback	200 - 350	29.6 x 22.0 x 10.0	1.5 KVDC
PER23-1 80W	80	Half Bridge | Forward | Flyback	200 - 500	23.9 x 23.3 x 8.2	1.5 KVDC
PER23-2 120W	120	Half Bridge | Forward | Flyback	200 - 300	23.3 x 22.8 x 8.2	1.5 KVDC
PEL25 150W	150	Half Bridge | Forward | Flyback	200 - 500	30.4 x 25.1 x 8.8	1.5 KVDC
PER25-1 250W	250	Half Bridge | Full Bridge | ZVS | Push-Pull	200 - 300	30.0 x 25.3 x 10. 0	3.0 KVDC
PER25-2 250W	250	Half Bridge | Full Bridge | ZVS | Push-Pull	200 - 300	27.5 x 25.0 x 10.0	3.0 KVDC
PER25-3 250W	250	Half Bridge | Full Bridge | ZVS | Push-Pull	200 - 500	29.0 x 25.0 x 10.0	1.5 KVDC
PPQ35 600	600	Half Bridge | Full Bridge | ZVS | Push-Pull	200 - 400	34.6 x 41.5 x 17.6	3.0 KVDC
PER30 300W	300	Half Bridge | Full Bridge | ZVS | Push-Pull	200 - 300	34.1 x 30.0 x 10.0	3.0 KVDC
PER32 500W	500	Half Bridge | Full Bridge | ZVS | Push-Pull	200 - 300	36.5 x 32.5 x 11.0	3.0 KVDC
PPQ35 600W	600	Half Bridge | Full Bridge | ZVS | Push-Pull	200 - 400	34.6 x 41.5 x 17.6	3.0 KVDC
PPQ40 1000W	1000	Half Bridge | Full Bridge | ZVS | Push-Pull	100 - 200	44.2 x 40.0 x 18.0	1.5 KVDC
PEE43 2000W	2000	Half Bridge | Full Bridge | ZVS | Push-Pull	100 - 200	58.0 x 43.4 x 23.5	1.5 KVDC
PEE58-1 3000W	3000	Half Bridge | Full Bridge | ZVS | Push-Pull	50 - 150	79.2 x 58.5 x 21.0	2.5 KVDC
PEE58-2 3000W	3000	Half Bridge | Full Bridge | ZVS | Push-Pull	50 - 150	113.8 x 58.5 x 23.0	2.5 KVDC
PEE64 5000W	5000	Half Bridge | Full Bridge | ZVS | Push-Pull	80 - 200	87.9 x 64.0 x 20.8	3.5 KVDC