CLOSING THE LOOP

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Designing Planar Magnetics

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Designing planar transformers is no different than designing conventional magnetics when it comes to core saturation and turns ratio. For off-line applications a patented isolation system is used to achieve as much as 12mm creepage and clearance (U.S. Patent 5010314). The big difference is the knowledge to control the parasitic effects, such as leakage and interwinding capacitance, at different operating frequencies. For example, there may be completely different stacks of layers at 250kHz and at 500kHz. The core material, dielectric thickness, amount of copper and interleaving of the primary and secondary are different for the same output power with different frequencies of at least 100kHz apart. In the same planar structure 2oz to 8oz and/or up to 1mm copper leadframes are used for best performance.

The dc-dc market demands up to 2500Vdc of isolation between the primary to core and secondary. This is achieved by using multilayer boards with controlled materials to get the highest performance. When designers try to integrate the low profile EE ferrite cores into the p. c. board, some of the flexibility to control all the elements is lost, and it drives the cost of the board up. Material costs have been dramatically reduced in the last few years, which makes the planar transformer a cost acceptable solution.

Optimum transformer size and frequency depends on the maximum environmental temperature. Experience shows that the transformer size versus the frequency reduces the most when the frequency is in the 20kHz to 180kHz range. At frequencies higher than 180kHz the size reduction is not noticeable, unless the thermal and efficiency aspects are addressed. Planar technology, with large surface area and the close to 99.5% efficiency, provides the solution.

For some time now, planar technology has been used by power supply designers. The reasons are obvious: This technology provides a very efficient compressed power unit. Among the reasons for this broad usage are:

- Unparalleled working frequency range from 20kHz to a few MHz
- Dramatically reduced size and weight requirements (from 5gms per 100W)
- When replaced by a 20kW switchmode power supply at 100kHz a 60Hz transformer can be reduced from 70kg to 3kg, a 23:1 reduction.
- Minimum footprint occupancy
- High efficiency, typically 98 to 99.5%
- Unmatched parameter performance repeatability
- Low leakage inductance (less than 0.2% for ungapped cores)
- Competitive prices
- Minimum EMI
- Operating temperature range from -55° C to +150° C.
- A compressed power unit - 2W to 25,000W in one unit
- 4kV primary-to-secondary dielectric isolation with UL recognized materials
  - FILE E174040 - CLASS B - 130° C
  - FILE E174040 - CLASS F - 155° C
  - FILE E174040 - CLASS H - 180° C
  - UL FILE - W177412 (M) for multilayer transformers
  - CSA FILE - E177412(M)
- 6-12 mm creepage and clearance distance between primary and secondary windings
- Works with all SMPS topologies, including boost inductors

The T250 size requires a volume of 4.23 in.^{3} or 71.28 cm^3 and can provide up to 2.6kW at 200kHz and 700W at 20kHz and 2MHz. For example, if the output power is 2.6kW and the efficiency of the transformer is 99%, then the power dissipated is 26W. At 1.7°/W thermal impedance the hot spot will be around 125°C when the transformer is attached to a two-side heat sink at 80°C. The goal is to keep the hot spot temperature under 125°C.

Natural Cooling (Hot Spot – Air)	Blowing Air 3m/sec (Hot Spot – Air)	One Side Heat sink (Hot Spot – Heat sink)	Two Sides Heat sink (Hot Spot – Heat sink)
9°/W	5.5°/W	3.4°/W	1.7°/W

Table 1. *Shows the typical thermal impedance for different cooling conditions for a size 250 Payton planar transformer.*