Power Planar Magnetics and HEVs (Hybrid Electric Vehicles)

By: Jim Marinos - Executive VP Marketing & Engineering, Payton America Inc.

Abstract: The electronic circuits in a hybrid electric vehicle must operate in an extreme temperature environment with significant weight and size restrictions. The real advantages to using power planar magnetics in the electronic circuits of hybrid electric vehicles are described and quantified.

The HEVs are here – and more are coming.

A recent count (www.hybridcars.com) shows 16 hybrid electric vehicles available now, 8 in 2009, 7 in 2010, and 1 in 2011. In addition there are 4 plug-in hybrids scheduled for 2009 and 2010 and 11 concept cars.

The available models have combined MPGs between 46 and 19. Their price range covers $22K to $104K.

HEVs have an internal combustion engine and an electric motor and battery pack (www.transportation.ani.gov). A common element of these vehicles is electronics – the electronics between the motor/generator and the battery pack - which must be small, lightweight, efficient, and provide value for cost.

The environment is standard automotive – an extreme temperature range under the hood and varying shock and vibration levels.

Many of the active power components for the electronics are available and are being designed in. The passive power components are another story. The power magnetic components must be small, lightweight, and meet the environmental requirements. Magnetic components are made of wire or are wire-free. The automotive requirements can be met by the wire-free magnetic components – power planar magnetics – and Payton Planar Magnetics is working with the design centers to address the design issues being raised. Planar magnetic components have advantages compared to wired magnetic components, and designers should note these advantages when evaluating the technology for future designs.

What are the design requirements an Engineer looks for?

First is efficiency.

Power planar magnetics are 99.0% efficient at converting the input energy to the output energy. In comparison, wired magnetic components have a conversion efficiency of 90%. The high efficiency with the combination of conduction cooling reduces the internal temperature of the power box, dramatically improving the MTBF of the system.

Second is size.

Unlike wired magnetic components that are usually restricted to sizes - particularly the height - power planar magnetics can be "squashed" to reduce their height with an increase of their base area, for optimum cooling, so the magnetics fits into the space provided on the vehicle.

Third is temperature.

Power planar magnetics operate in the temperature range from -55 degC to + 150 degC. In addition the conduction cooling offered by the inherent mechanical characteristics of the planar construction can offer thermal impedance as low as 0.5°/W.

Fourth is weight:

Power Planar Magnetics can reach a weigh of approximately 10g per 100W.

Fifth is power.

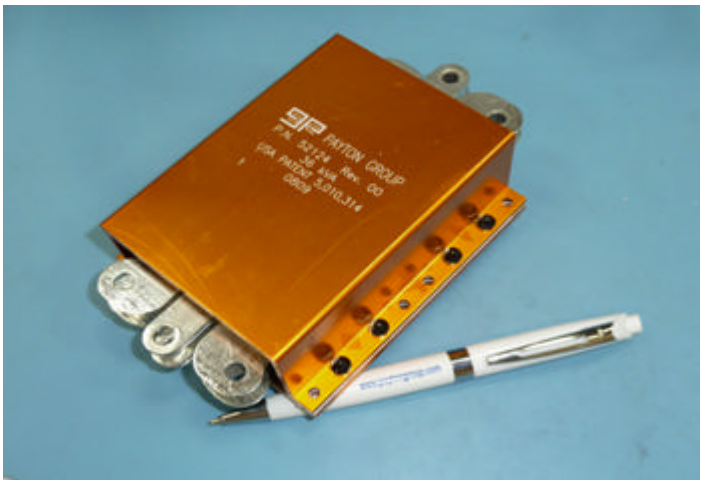
Power Planar Magnetics supply 5W to 20,000W in one unit. Payton has the technology and the know how to provide a typical hybrid power transformer for a full bridge ZVT application, at 100khz and 7KW output power, in a 2.2"x2.2"x.62" package at less than 200 grams. The same type of transformer using a conventional wired type will take 9 times the volume and 5 times the weight.

Sixth is repeatability.

With pre-tooled windings and well defined geometry, electrical parameters are predictable and repeatable. An engineer does not have to be concerned any more if the leakage inductance or the winding capacitance will change with time or if it will vary significantly from lot to lot. Experience with wired magnetic components has shown that many of the parasitic characteristics change from lot to lot and with time , and these changes will have an effect on the common mode noise and EMI.

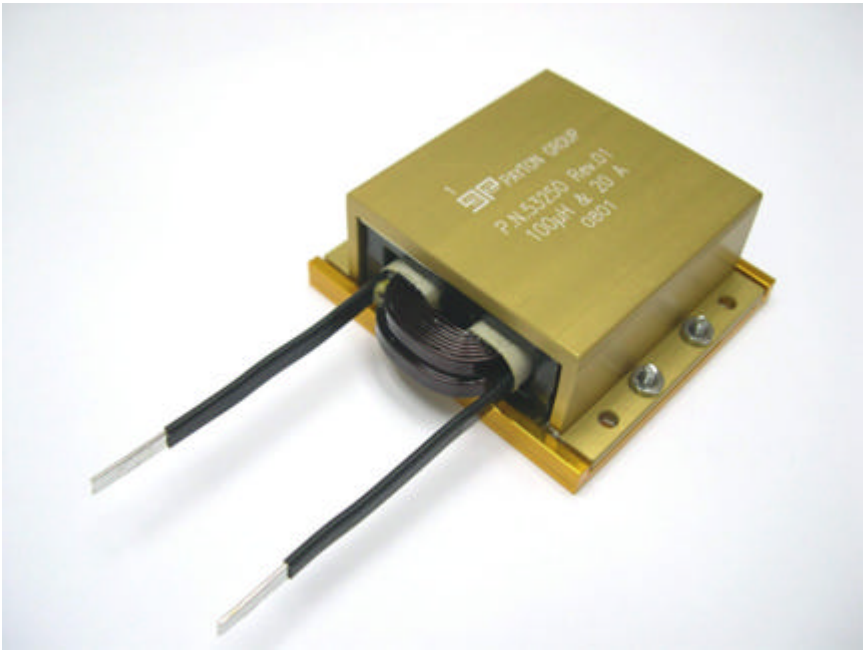
With these characteristics and advantages, more designers are looking to power planar magnetics for their designs in hybrid electric vehicles. Payton is committed to helping designers use power planar magnetics to achieve these improvements.

The planar magnetics can be qualified to AEC (Automotive Electronics Council)-Q200 for automotive use.



Custom designs as this example of a 36kVA power Planar application with 600Amps rms primary current and 230Amps secondary current in a 140mm(L)x90mm(W)x40mm(H) thermal package with 0.66ºC/W thermal impedance designed specifically for a cool plate high vibration environment. With 120watts of dissipation this design has an efficiency of 99.67%. The switching frequency is 60khz and the topology is push-pull.

1. Generic Type	: T1000AC-4-4—4C
2. Total output power	: 36 KVA (60V/600 Adc);
3. Operating frequency of transformer	: 60 kHz
4. Input voltage of transformer	: 250 to 390 Vpeak
5. Topology	: Full Bridge, resonant.
6. Operating duty cycle, max	: 0.96.
7. Volt-second product	: 1200 V-µsec.
8. Pri. to Half Sec. ratio	: 2 : 1. (424 Amps sec current)
9. Primary current, max	: 330 Apeak (230 Arms)
10. Dielectric strength	: 3750Vrms.
11. Ambient temperature range	: -40 to 50°C.
12. Estimated power losses	: 120W.
13. Estimated hot spot temperature	: 140°C.
14. Mechanical dimensions	: Length – 140 mm.
	: Width – 90 mm.
	: Height – 40 mm.



An example of a Filter Planar Inductor using flat magnet wire, Ferrite Planar cores and an aluminum clasp for mechanical mounting and best thermal performance.

1. Generic Type	: I250-100µH/20A.
2. Operating frequency	: 250 kHz.
3. Inductor application	: Filter
4. Inductance	: 100µH $^{+10\%}/_{-17\%.}$
5. Peak current of ripple	: 1Apeak-to-peak, max.
6. Peak of total current	: 20.5 Apeak, max.
7. Dielectric strength	: 500 Vdc.
8. Ambient temperature range	: -40 ÷ + 140°C.
9. Estimated power losses	: 16W.
10. Estimated temperature rise	: 30°C. (with external heatsink attached)
11. Estimated weight	: 280gr.(with clasp).
12. Mechanical dimensions	: Length – 52 mm
	: Width – 65 mm.
	: Height – 32 mm.

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Jim Marinos, Executive VP Engineering & Marketing for Payton Planar Magnetics, has been designing power supplies and involved in the magnetics business since 1982. Jim has worked in the power supply design capacity with ŒAG, ILC, Superior and Novatronics. Jim was the Director of Engineering for Lambda Novatronics. Jim is a senior member of IEEE, a Director with PSMA and has written technical papers. He holds a BSEE from Pratt Institute in Brooklyn NY.