



## Reducing EMI With Vishay's IHLE Power Inductor

By Tim Shafer, VP Product Marketing - Inductors

Electromagnetic interference (EMI) is inherent in every electronic device that has a switched mode power supply or microprocessor circuit, and reducing it can take a great deal of engineering resources and adds considerably to the cost of a device. Regulations are in place that limit the amount of EMI transmitted by an electronic device to protect other nearby devices from this interference. EMI testing is expensive and it is important to design in good EMI reduction practices in order to ensure compliance. A good understanding of the source of these electromagnetic fields can provide a solid foundation for a low-EMI design.

### WHERE DOES EMI COME FROM?

Anytime there is conductor carrying electrical current, two perpendicular fields are produced, as shown in Fig. 1. As the current and voltage increase in the conductor, the amplitudes of these fields increase proportionately. One of the perpendicular fields is called the "B" field, which consists of lines of magnetic flux. These lines are the key to the operation of electro-magnetics, motors, and generators. Without the magnetic field associated with an electrical current, it would be impossible to convert electrical current into a force that could do work. So the B field is desired and useful when it is contained and controlled. If not contained, the B field can induce voltage across other nearby components or conductors, causing EMI or noise.

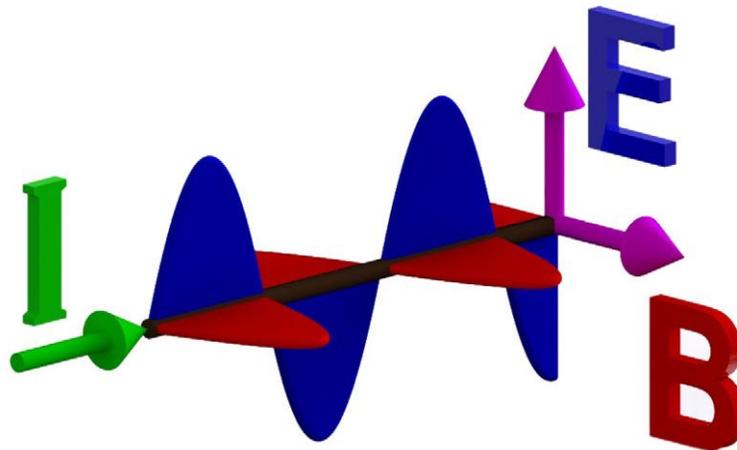


Fig. 1 - "B" field and "E" field associated with a conductor carrying current

The other perpendicular field is the "E" field, or the electrostatic field. The E field is what is captured and stored in capacitors. It causes static cling and is responsible for the charge that creates the spark when a metal object is touched after shuffling across a carpet-covered floor. This E field also enables radio, television, Wi-Fi, Bluetooth, and cellular communications. Current is modulated through an antenna, which causes modulated E fields that are transmitted over the air. These E fields, in turn, induce an electrical current in the receiving antenna - which is decoded into data, voice, or video - and permits wireless communication. Unfortunately, noise can be transmitted just as easily as data or video and can be picked up by other antennas or electronic components that can act as antennas. This EMI or noise is highly undesirable as it can cause interference with our communications.

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### CONTROLLING EMI

Both E and B fields can contribute to the EMI radiated from a device and great efforts are expended to contain them. Many tricks are employed in the PCB design and layout, in addition to using layered PCBs with ground planes to help mitigate EMI radiation. Despite these efforts, the only solution to containing EMI is often to cover the electronic components on the PCB with metal shields, as shown in Fig. 2. These shields are typically connected to ground and capture the E and B fields and attenuate them or short them to ground to keep EMI from straying outside of the device.

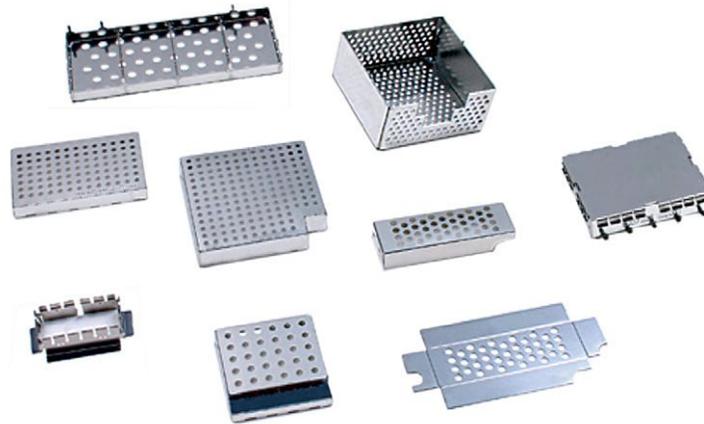


Fig. 2 - Metallic shields used to reduce EMI emitted from electronic components

The B field can be problematic for EMI in inductive components with one or more coils of wire that concentrate the B field and store that energy or transfer it from one winding to another, as in a transformer. Multiple coils provide for a much higher density of the B field, which can result in greater EMI effects on nearby components. If the inductor or transformer has an open magnetic path or large gaps in the core material to control magnetic saturation, the B field can radiate well outside the body of the inductor and create noise problems with nearby components. See Fig. 3 for a typical flux pattern for a rod inductor. This type of inductor is typically called a shielded inductor. A shielded inductor, like the composite Vishay IHLP® series, completely surrounds the coil winding with magnetic material that contains almost all of the B field inside the inductor, greatly reducing the B field that can escape the inductor and cause EMI.

Although composite inductors do a good job of containing the B field, all inductors are emitters of the E field, regardless of their construction, and this radiated E field can be a problem for design engineers. Often the inductor is one of the components with the highest level of current on the PCB and one of the largest contributors to E field intensity and radiated EMI. So in order to reduce the EMI of the inductor, engineers may have to locate the inductor inside a metal shield on the PCB, which in turn may place it near more sensitive components inside the shielded area. The metal shield may also need to increase in size to accommodate the inductor, which increases costs and could potentially make the overall device larger than desired.

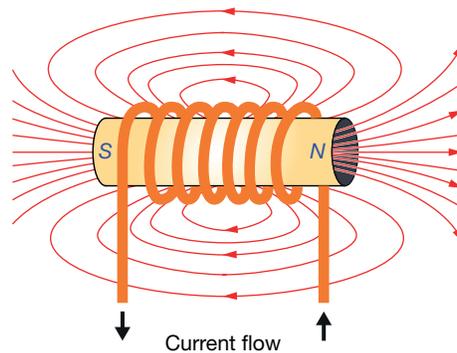


Fig. 3 - The open magnetic circuit of a rod core inductor allows B field to escape and cause EMI

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### IHLE - A SOLUTION TO CONTROLLING E FIELD EMISSIONS FROM POWER INDUCTORS

Vishay, known as a leader in composite inductor technology with its IHLP series of power inductors, has developed the new IHLE series featuring devices with an integrated E shield on top of the IHLP inductor (see Fig. 4).

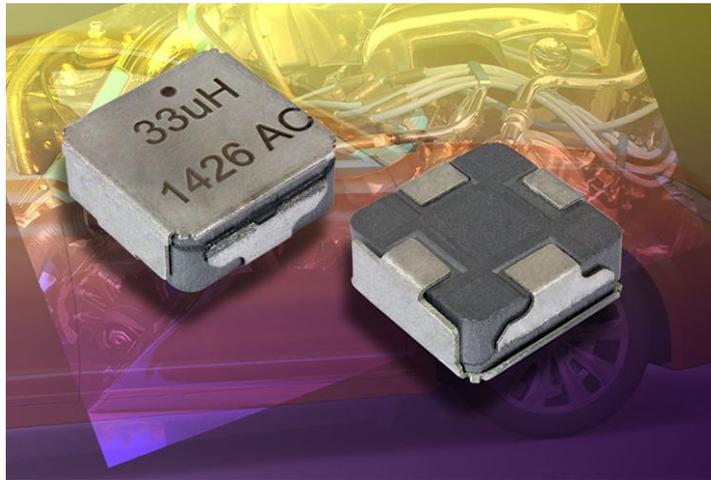


Fig. 4 - Vishay's new IHLE inductor has an integrated E shield for reduced EMI

The integrated E shield adds just 0.3 mm to the profile of the standard IHLP inductor. When the IHLE E shield is connected to ground, the E field emitted from the inductor will be reduced by up to 20 dB at 1 cm. The shield is a carefully designed copper plate with a thickness and coverage that maximizes the attenuation of the E field, while preserving the compact size and performance of the IHLP inductor. The shield is plated with a flash of nickel (for whisker mitigation) and is finished with a layer of 100 % Sn to enable soldering of shield terminals to the PCB, where it connects to ground. The shield must be soldered to ground to have any significant effect in reducing the E field.

Fig. 5 is a demonstration of the performance of the IHLE compared to other inductors. The graph shows the radiated field measured from three different inductors in the same circuit. All inductors were 1  $\mu$ H and had a similar size and current rating. The test circuit consisted of a DC/DC converter operating at 500 KHz with 12  $V_{IN}$  and 1.5  $V_{OUT}$  and a 15  $A_{DC}$  fixed load. A detector coil was placed directly above the inductor at a distance ranging from 0 cm to 8 cm, and the induced voltage from the fields emitted by the inductor were measured and recorded.

The graph shows that the open magnetic circuit, drum core inductor produced the most EMI with a reference voltage induced in the pickup coil of approximately 3.4 mV. The IHLP composite inductor, by itself, provided a significant improvement in induced voltage and read about 1.0 mV at 1 cm. The IHLP eliminated most of the B field imparted on the pickup coil compared to the ferrite drum core inductor, but had some level of E field that caused induced voltage. This E field was further reduced by the introduction of the integrated E shield of the IHLE, which provided the lowest reading of about 0.28 mV.

It is clear that the IHLE will not completely eliminate the E field and EMI, but it will reduce it significantly compared to other inductor solutions. The IHLE will also not reduce EMI caused by other components, so by itself the IHLE is not the single solution to EMI, but it can provide improvement in the EMI emitted by the power inductor. This improvement may enable the design engineer to relocate the power inductor on the PCB or in some cases eliminate the need for a separate metal shield.

Due to its four soldering connections, the IHLE's resistance to vibration and mechanical shock are enhanced over the two-terminal IHLP, providing an additional measure of mechanical security where high levels of shock and vibration are required.

The IHLE is currently available in the popular 4040 size (10 mm x 10 mm x 4.3 mm) and is available in any standard IHLP-4040 inductance value with the same current rating and DCR. Vishay plans to release the IHLE in more popular sizes soon. These sizes include the 5050 (13 mm x 13 mm), 3232 (8 mm x 8 mm), 2525 (6.5 mm x 6.5 mm), 2020 (5 mm x 5 mm), and 1616 (4 mm x 4 mm).

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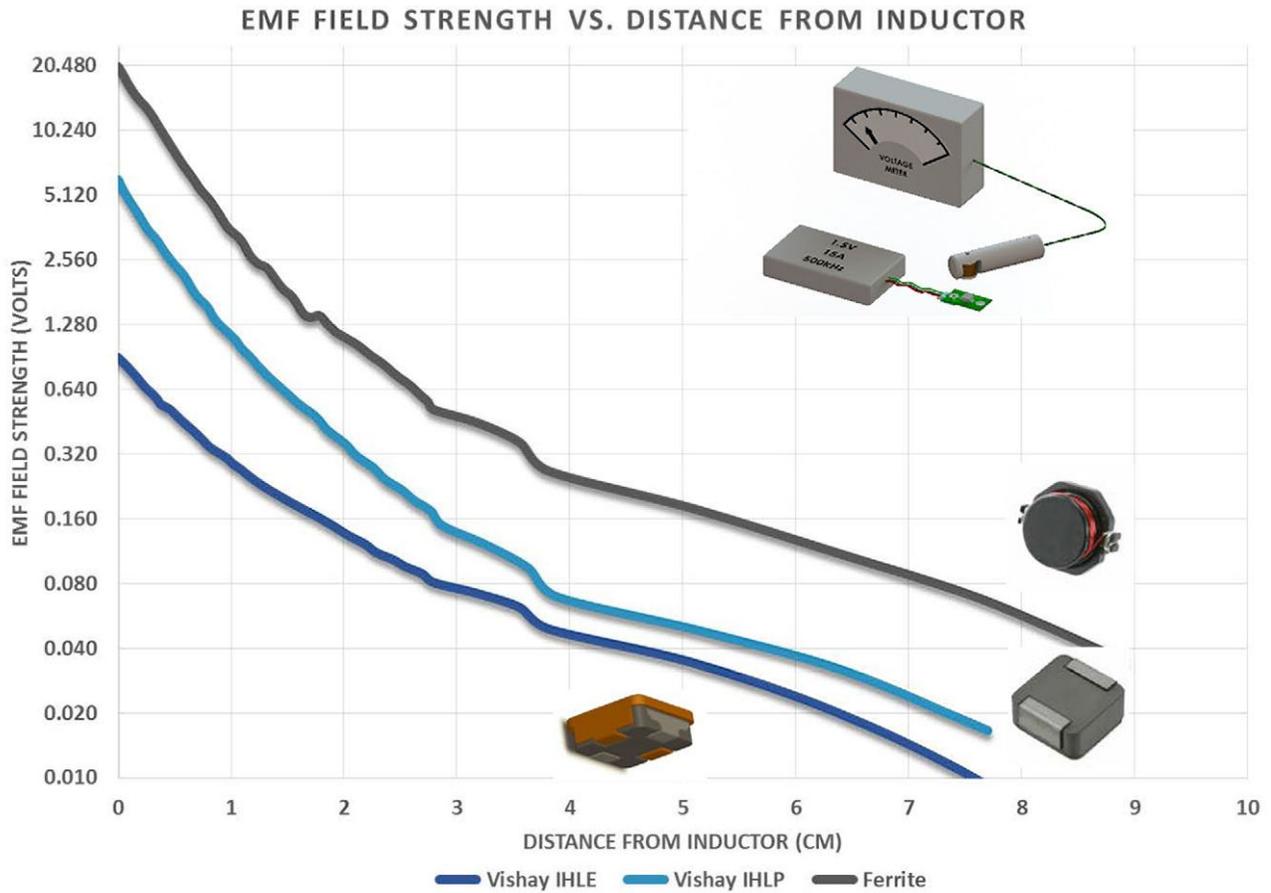


Fig. 5 - Graph showing the IHLE's lower induced EMF compared to other inductors

About the Author: Tim Shafer is the Senior Director of Marketing for the Inductors Division of Vishay and has 38 years of experience in magnetic materials and devices.