Why EMI Inductors?

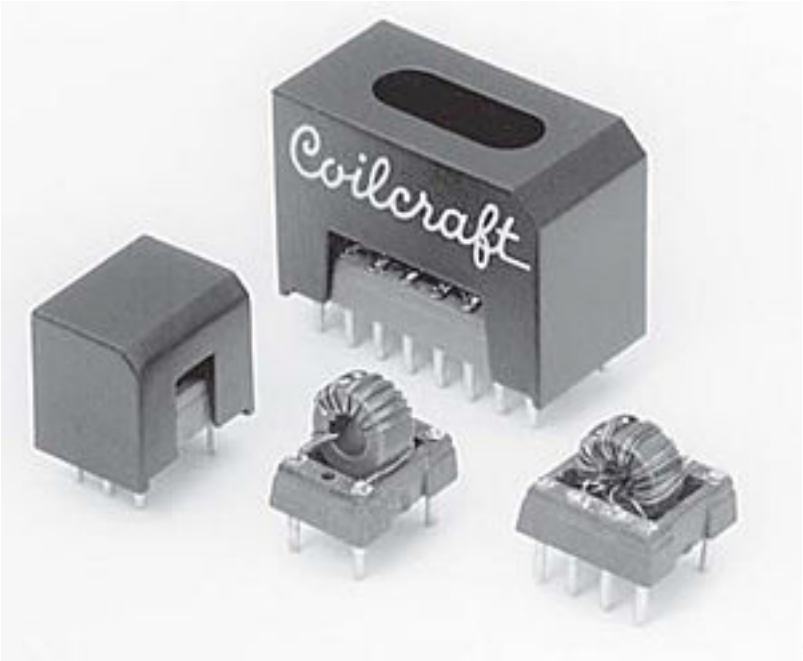
By Janine E. Mooney, Editor

Inductors are a vital part of most EMI filters, and can be a smart addition to your design.

Connectors, enclosures, resistors, capacitors, attenuators, inductors... and how does this all relate to EMI? EMI inductors “ideal inductors” as opposed to “real” inductors; they have inductance but no resistance or capacitance and they do not either dissipate or radiate energy. In layman's terms, when current through an inductor is increased or decreased, the inductor "resists" the change by producing a voltage between its leads in opposing polarity to the change.

Inductors are typically constructed as a coil of conducting material. They are usually copper wire wrapped around a core made of either air, ferromagnetic or ferrimagnetic material, which actually increases the inductance. In fact, a magnetic core can actually increase the inductance of the coil inductor thousand-fold.

The common mode inductor is a vital part of most EMI filters since it has extremely high impedance (effective resistances) over a wide range of frequencies. It needs to do an excellent job in suppressing high frequency power supply spikes.



Common Mode & Differential Mode Inductors

In order to suppress EMI, a typical filter will include two types of inductors. The first would be common mode inductors and the second differential mode inductors. The inductors become high impedances to the high frequency noise and either reflect or absorb this noise. To actually be effective, the common mode inductor must provide the proper impedance over the entire switching frequency range.

Common mode EMI inductors are wound with two windings of equal quantity of turns. These windings are placed right on the core so that the currents in each of the windings create fluxes (electromagnetic forces) that are exactly equal in size but opposite in phase, thereby cancelling each other out. This leaves the core in a state that is not biased.

The differential mode inductor is quite different from the common mode inductor in that it has only one winding. This means that the core will need to support the current of the entire line without becoming saturated.To prevent the core from becoming saturated, the differential mode inductor must be made with a core that has a low effective permeability. This means that it would need to be constructed of gapped ferrites or powder cores.

Since the common mode inductor can use a high permeability material and obtain a very high inductance, the core can be relatively small. This is a significant size advantage for design purposes.

Inductors Shape Up

Common mode filters can be wound into many different shapes. Most commonly, though, they are wound using toroids. The reason for this is two-fold. First of all, toroids are generally less expensive (from a material standpoint) than other shapes because they are one piece. Other shapes require two halves. When cores come in two halves, they must have flat ground on their mating surfaces to make them smooth and to reduce the air gap between them. High permeability cores often require an extra lapping procedure to make them even smoother producing a finish that resembles a mirror. Toroids do not require these extra manufacturing steps. The only disadvantage of toroids is their high winding cost. Due to their shape, often they will need to be wound manually. Since the number of turns in common mode inductors is usually quite low, the winding cost does not become too prohibitive. For the above reasons, toroids are the shape of choice in common mode inductors.

Design Considerations

You must look at three key areas when choosing an inductor – input current, impedance and frequency. The size of the conductor needed for the windings is determined by the input current. A common design value for calculating wire size is four hundred amps per square centimeter. This value can change, however, depending on the suitable temperature rise of the inductor. The most commonly used is almost always single stranded wire because it is so inexpensive, plus it helps reduce noise through high frequency skin effect losses. An inductor's impedance is generally specified as a minimum value at a given frequency. This impedance, along with the line impedance, should supply the desired noise attenuation. This is tricky, as the line impedance is often unknown. Designers must test the inductor using a Line Impedance Stabilization Network (LISN). To determine an inductors frequency, you must use proper testing. Signals flow through an inductor in inverse relation to their frequency. Low frequencies and DC flow easily;

high frequencies become increasingly blocked.

Because inductors may actually create and radiate EMI (inductors turn electric currents into magnetic fields), you must carefully consider them when designing into an EMI filter. Also take into consideration that inductors cost more than resistors and capacitors, so may not always be the best choice.

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