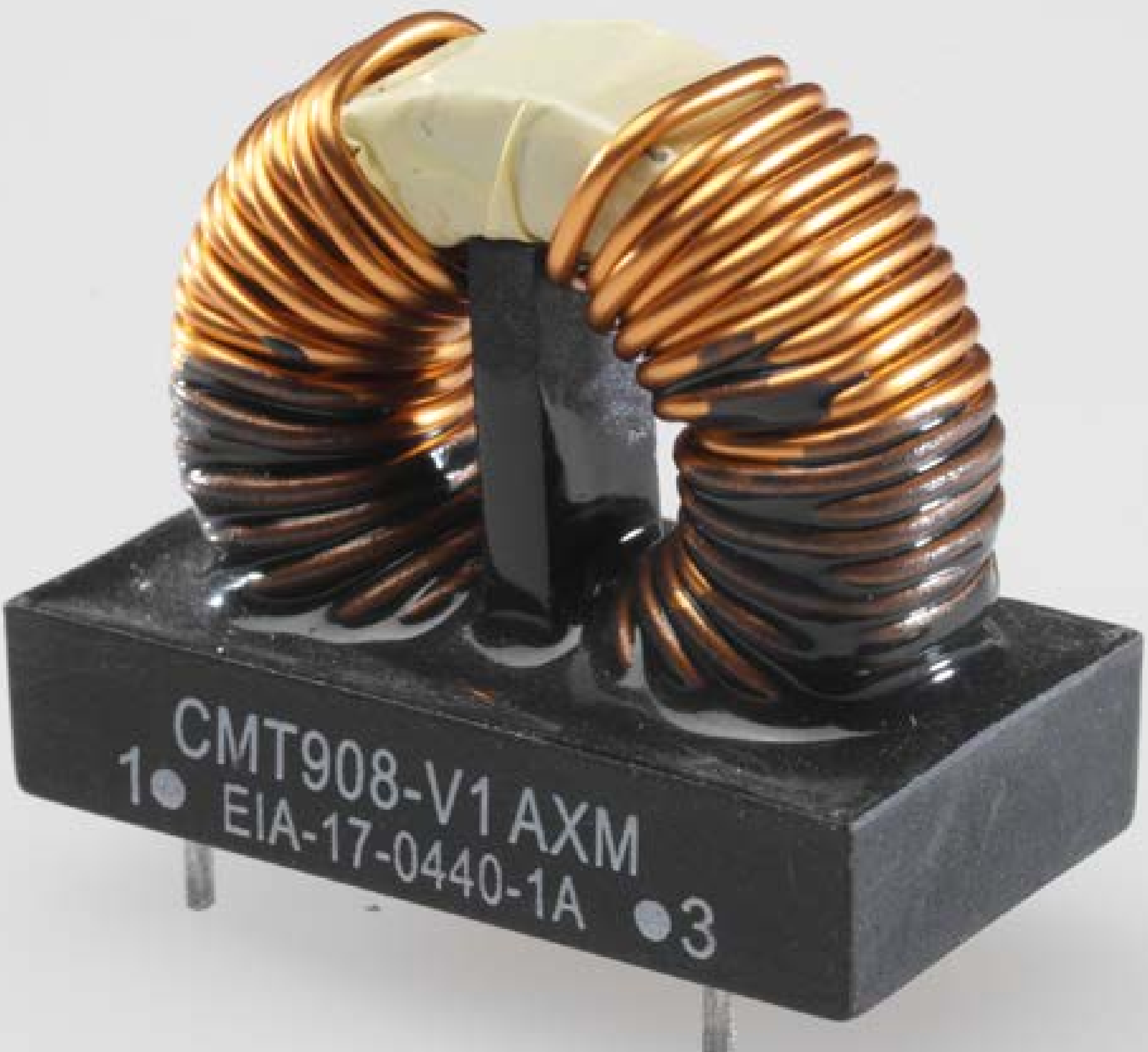
Guide to Inductors:
Inductance



TRIAD MAGNETICS' GUIDE TO INDUCTORS

Lodestone, one of the most common iron core oxides, is made of the mineral magnetite. As its name implies, it is naturally magnetic.

Though its magnetic properties were known upon its discovery in antiquity, no major research was done into magnetite until Hans Christian Oersted discovered the relationship between electricity and magnetism in 1820. He posited and proved that a magnetic effect could be created by flowing electricity.

Following Oersted, Joseph Henry and Michael Faraday studied coil circuits, proving that the spark created by circuits during a current interruption was caused by an electromotive force created by the coil itself. Further, they proved that magnetic movement can produce electrical current.

Together, these three men are considered to be the fathers of modern electronics.

Inductance and Related Parameters

Technicians and electrical engineers alike regularly use or encounter inductors in the course of their work. The design and manufacture of such inductors is best left to specialists, but it is important for anyone using them to have a thorough understanding of their basic functional and operational principles.

Inductance

When the electric current flowing through a coil is varied, such as an AC flow, this change creates a similar change in the coil's magnetic field.

The resultant change in magnetic field induces a second current, in opposition to the source current, in the coil. This is known as self-inductance, or inductance, which is defined as the property of an electric circuit that opposes changes to the current that is flowing through it.

More specifically, inductance (represented as L in equations and measurements) is the amount that rate of change in current is multiplied by in order to obtain the induced electromagnetic force (EMF). The equation for this is: $e = -L(di/dt)$.

Here inductance, L, is the constant — it is referred to as the coefficient of self-induction and is measured in henrys (H). It is negative in the equation to indicate that the inductance voltage has opposite polarity from the source voltage. One henry is equivalent to an induced EMF of 1 volt per one ampere-per-second of current change.

The amount of inductance in a coil is determined by the amount of flux linking that coil. The amount of flux itself is determined by the size of the coiled wire, the number of turns in the coil, and the arrangement of those turns. The presence, or absence, of a magnetic material in the core of the coil is also a factor.

Flux

The energy stored in the form of magnetic flux is known as a flux linkage. This energy level is determined by the inductance of the coil and the value of the coil's current, represented by this equation: $W = \frac{1}{2}LI^2$. In this way, an inductor can be used to store energy in addition to its primary transfer capabilities.

The flux of a coil (ø) is measured by number of lines or by maxwells (Mx). The number of lines of force per unit area, the flux density (B), is measured in gauss. Flux density is a measure of maxwells per square centimeter and is proportional to magnetizing force (H), depending on the permeability (μ) of the core medium: $B = \mu H$.

A coil is not required to have a magnetic material core in order to have inductance. Coils with high frequencies in particular do not require a magnetic core. On the other hand, they are basically essential for a reasonable amount of inductance to exist in medium and low frequency coils.

Permeability

The permeability of a medium is defined as the ratio between lines of force in a medium and the number of lines the same magnetizing force would create in air.

The amount of permeability is further complicated by two factors. The first is hysteresis, or the concept that the permeability of an iron core depends on the core's past usage, or its "history" so to speak. The second is the presence of an incoming DC current flow into the coil.

The presence of DC flow in a coil makes incremental permeability a necessary factor in establishing inductance. Incremental permeability is the permeability of a magnetic material to AC currents that are superimposed on top of a DC current.

Time Constants

It is normal for inductors to have some ohmic losses. These losses, when in series with inductance (L), are represented as a resistance (R). As voltage (V) is applied to an inductor, the current gradually rises to its steady value (V/R), as represented by this equation:

$$I_r = [(V/R)(1 - \varepsilon^{-tR/L})]$$

The time constant, L/R = T, is a measure of the time, in seconds, it takes a given current to reach 63.2% of its ultimate value. An inductor's current decay follows a logarithmic curve provided by a similar equation:

$$I_d = [(V/R)(\varepsilon^{-t/T})]$$

Inductors from Triad

Over the course of more than 70 years, Triad Magnetics has emerged as a leading manufacturer of high quality magnetics components, including toroidal and power inductors. Our inductors maintain some of the highest available levels of stability when used in a diverse range of temperature and voltage applications.

To learn more about Triad Magnetics' custom magnetics components, custom design services, or inductors in general, visit **TriadMagnetics.com** today.

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This is the first installment of our 3 part series: Guide to Inductors

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