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Fixed Inductor Terminology & Glossary

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Magnetic Product Terminology & Glossary

Air Core Inductor (Ceramic Core Inductor)

Air core inductors are often referred to as "Ceramic Core" inductors. Air core inductor is most often used in high frequency applications where low inductance values, very low core losses and high Q values are required.

Ceramic has no magnetic properties. Thus, there is no increase in permeability due to the core material. Its main purpose is to provide a form for the coil. In some designs it also provides the structure to hold the terminals in place. Ceramic has a very low thermal coefficient of expansion. This allows for relatively high inductance stability over the operating temperature ranges.

Axial Inductor

An inductor constructed on a core with concentric leads on opposite ends of the core. Axial inductors are available for both power applications and RF applications, and are available in many core materials including the basic phenolic, ferrite and powdered iron types. Both rod and bobbin shapes are utilized. Axial inductors are very suitable for tape and reel packaging for auto placement.

RF Choke

Another name for a radio frequency inductor which is intended to filter or choke out signals.

What is Inductor?

A passive component designed to resist changes in current. Inductors are often referred to as "AC Resistors". The ability to resist changes in current and the ability to store energy in its magnetic field, account for the bulk of the useful properties of inductors. Current passing through an inductor will produce a magnetic field. A changing magnetic field induces a voltage which opposes the field-producing current. This property of impeding changes of current is known as inductance. The voltage induced across an inductor by a change of current is defined as:

Equation $V = L \, dI/dt$, where V (Induced Voltage); L (Inductance Value).

Thus, the induced voltage is proportional to the inductance value and the rate of current change.

DCR (DC Resistance)

The resistance of the inductor winding measured with no alternating current. The DCR is most often minimized in the design of an inductor. The unit of measure is ohms, and it is usually specified as a maximum rating.

EMI

EMI is an acronym for Electromagnetic Interference. It is unwanted electrical energy in any form. EMI is often used interchangeably with "Noise".

Ferrite Core

Ferrite is a magnetic material which consists of a mixed oxide of iron and other elements that are made to have a crystalline molecular structure. The general composition of ferrites is $xxFe_2O_4$ where xx represents one or several metals. The most popular metal combinations are manganese and zinc (MnZn) and nickel and zinc (NiZn). These metals can be easily magnetized.



Impedance

The impedance of an inductor is the total resistance to the flow of current, including the AC and DC component. The DC component of the impedance is simply the DC resistance of the winding. The AC component of the impedance includes the inductor reactance. The following formula calculates the inductive reactance of an ideal inductor (i.e., one with no losses) to a sinusoidal AC signal.

$$\text{Equation } Z = X_L = 2\pi fL.$$

This equation indicates that higher impedance levels are achieved by higher inductance values or at higher frequencies.

Inductance & Tolerance

The property of a circuit element which tends to oppose any change in the current flowing through it. The inductance for a given inductor is influenced by the core material, core shape and size, the turns count and the shape of the coil. Inductors most often have their inductances expressed in microhenries (μH).

Tolerance Letter of Inductance Table		
Letter	Tolerance	Inductance
F	$\pm 1 \%$	1 henry (H) = $10^6 \mu\text{H}$ 1 millihenry (mH) = $10^3 \mu\text{H}$ 1 microhenry (μH) = $1 \mu\text{H}$ 1 nanohenry (nH) = $10^{-3} \mu\text{H}$
G	$\pm 2 \%$	
H	$\pm 3 \%$	
J	$\pm 5 \%$	
K	$\pm 10 \%$	
L	$\pm 15 \%$	
M	$\pm 20 \%$	

Matched Impedance

The condition that exists when two coupled circuits are adjusted so that the output impedance of one circuit equals the input impedance of the other circuit connected to the first. There is a minimum power loss between two circuits when their connecting impedances are equal.

Multilayer Inductor

An inductor constructed by layering the coil between layers of core material. The coil typically consists of a bare metal material (no insulation). This technology is sometimes referred to as "non-wire wound". The inductance value can be made larger by adding additional layers for a given spiral pattern.

Quality Factor Q

The Q value of an inductor is a measure of the relative losses in an inductor. The Q is also known as the "quality factor" and is technically defined as the ratio of inductive reactance to effective resistance and is represented by:

$$\text{Equation } Q = X_L / R_e = 2\pi fL / R_e$$

Since X_L and R_e are functions of frequency, the test frequency must be given when specifying Q. X_L typically increases with frequency at a faster rate than R_e at lower frequencies, and vice versa at higher frequencies. This results in a bell shaped curve for Q vs. frequency. R_e is mainly comprised of the DC resistance of the wire, the core losses and skin effect of the wire. Based on the above formula, it can be shown that the Q is zero at the self-resonant frequency since the inductance is zero at this point.



Rated Current

The level of continuous DC current that can be passed through the inductor. This DC current level is based on a maximum temperature rise of the inductor at the maximum rated ambient temperature. The rated current is related to the inductor's ability to minimize the power losses in the winding by having a low DC resistance. It is also related to the inductor's ability to dissipate this power lost in the windings. Thus, the rated current can be increased by reducing the DC resistance or increasing the inductor size. For low frequency current waveforms, the RMS current can be substituted for the DC rated current. The rated current is not related to the magnetic properties of the inductor.

Saturation Current

The DC bias current flowing through the inductor which causes the inductance to drop by a specified amount from the initial zero DC bias inductance value. Common specified inductance drop percentages include 10 % and 20 %. It is useful to use the 10 % inductance drop value for ferrite cores and 20 % for powdered iron cores in energy storage applications.

The cause of the inductance to drop due to the DC bias current is related to the magnetic properties of the core. The core, and some of the space around the core, can only store a given amount of magnetic flux density. Beyond the maximum flux density point, the permeability of the core is reduced. Thus, the inductance is caused to drop. Core saturation does not apply to "air-core" inductors.

Self-Resonant Frequency (SRF)

The frequency at which the inductors distributed capacitance resonates with the inductance. It is at this frequency that the inductance is equal to the capacitance and they cancel each other. The inductor will act purely resistive with high impedance at the SRF point.

The distributed capacitance is caused by the turns of wire layered on top of each other and around the core. This capacitance is in parallel to the inductance. At frequencies above the SRF, the capacitive reactance of the parallel combination will become the dominant component.

Also, the Q of the inductor is equal to zero at the SRF point since the inductive reactance is zero. The SRF is specified in MHz and is listed as a minimum value on product data sheets.

Shielded Inductor

An inductor designed for its core to contain a majority of its magnetic field. Some inductor designs are self-shielding. Examples of these are magnetic core shapes which include toroid, pot cores and E-cores. Magnetic core shapes such as slug cores and bobbins require the application of a magnetic sleeve or similar method to yield a shielded inductor.

It should be noted that magnetic shielding is a matter of degree. A certain percentage of the magnetic field will escape the core material. This is even applicable for toroidal cores as lower core permeability will have higher fringing fields than will high permeability toroidal cores.

Toroidal Inductor

An inductor constructed by placing a winding(s) on a core that has a donut shaped surface. Toroidal cores are available in many magnetic core materials within the four basic types: Ferrite, Powdered Iron, Alloy and High Flux, and Tape Wound. Characteristics of toroidal inductors include: self-shielding (closed magnetic path), efficient energy transfer, high coupling between windings, and early saturation.

