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Inductor
&
Coils Technology

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Inductor & Coils Technology

Inductors & Coils Electrical Specifications

Inductance
That 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). The following table can be used to convert units of inductance to microhenries. Thus, 47 mH would equal 47,000 µH.

1 henry (H) = 10^6 µH
1 millihenry (mH) = 10^3 µH
1 microhenry (µH) = 1 µH
1 nanohenry (nH) = 10^{-3} µH

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.

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. (Also see Incremental Current and Permeability)

Incremental Current
The DC bias current flowing through the inductor which causes an inductance drop of 5% from the initial zero DC bias inductance value. This current level indicates where the inductance can be expected to drop significantly if the DC bias current is increased further. This applies mostly to ferrite cores in lieu of powdered iron. Powdered iron cores exhibit "soft" saturation characteristics. This means their inductance drop from higher DC levels is much more gradual than ferrite cores. The rate at which the inductance will drop is also a function of the core shape. (Also see Saturation Current)

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. (Also see Incremental Current and Saturation Current)

Permeability (Core)
The permeability of a magnetic core is the characteristic that gives the core the ability to concentrate lines of magnetic flux. The core material, as well as the core geometry, affects the core's "effective permeability". For a given core shape, size and material, and a given winding, higher permeability magnetic materials result in higher inductance values as opposed to lower permeability materials.

SRF (Self-Resonant Frequency)
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. (Also see Distributed Capacitance)

Distributed Capacitance
In the construction of an inductor, each turn of wire or conductor acts as a capacitor plate. The combined effects of each turn can be represented as a single capacitance known as the distributed capacitance. This capacitance is in parallel with the inductor. This parallel combination will resonate at some frequency which is called the self-resonant frequency (SRF). Lower distributed capacitances for a given inductance value will result in a higher SRF value for the inductor and vice versa. (Also see SRF)

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:

$$Q = \frac{X_L}{Re} = \frac{2\pi fL}{Re}$$

Since XL and Re are functions of frequency, the test frequency must be given when specifying Q. XL typically increases with frequency at a faster rate than Re at lower frequencies, and vice versa at higher frequencies. This result is a bell-shaped curve for Q vs. frequency. Re 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.

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:

$$Z = XL = 2\pi fL$$

L is in henries and f is in hertz. This equation indicates that higher impedance levels are achieved by higher inductance values or at higher frequencies. Skin effect and core losses also add to the impedance of an inductor. (Also see Skin Effect and Core losses)

Operating temperature range

Range of ambient temperatures over which a component can be operated safely. The operating temperature is different from the storage temperature in that it accounts for the component's self-temperature rise caused by the winding loss from a given DC bias current. This power loss is referred to as the “copper” loss and is equal to:

Power Loss = $(DCR)(I^2_{dc})$