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How to Specify Inductive Components in Power Electronics: Types, Specifications, and Uses

Introduction

Inductive components are a standard set of components in power electronics with uses in power regulation and filtering. There are many different inductive components that could make an appearance in a power regulation or power conversion system, and each component needs to be selected such that it helps ensure low-noise, precise regulation, and required isolation to prevent unintended coupling. High power systems in upcoming areas like RF power systems, EVs, and green energy carry specifications, and general-purpose coils or ferrites often cannot comply with design requirements.

Some of the major challenges in implementing inductive components in high power systems include:

- **High power density**: Inductive components can only handle so much current due to flux saturation and their DC resistance. Inductive components need to be accommodated the higher power densities available in today's unique regulator topologies and supplied by advanced semiconductors, such as GaAs and GaN on SiC.
- **EMI suppression**: Power systems must implement EMI cancellation measures to remain compliant with regulations, which typically involves chokes. Advanced high-power systems and the components that support them are also using PWM/PFM switching frequencies reaching well into the MHz range. Running at higher power creates stronger noise coupling, making common-mode and differential-mode noise more challenging to address.
- **Form factor**: In the past, the solution to the above two problems was simply to use a physically larger component as they tended to perform better in terms of power conversion efficiency, filtration, and saturation. Today, compact form factor is a selling point for many systems, and designers need smaller components with high inductance to ensure their designs meet performance goals.

The Laird™ Steward™ line of inductive components is extensive and satisfies multiple design requirements in power systems. Inductive components for power systems must comply with more than just DC current limits; issues like parasitic, nonlinearity due to flux saturation, and high temperature can compromise reliability or noise immunity in different portions of a system. Steward's inductive component product portfolio is adaptable to systems that run at high switching frequencies, high temperatures, and high currents.

Important Specifications for Inductive Components

Any electrical engineer that has designed a low-power regulator or DC-DC converter is familiar with the role of inductive components in providing regulation and filtration. Inductive components generate the back EMF required to counteract ripple during switching in high-power regulators, as well as provide low-pass filtration for DC power. In high power systems, each inductive component must be carefully chosen based on specifications. The specifications on Steward's inductive components span a range of possible values, giving designers plenty of flexibility to select components that balance the need for high current, high voltage, low resistance, and small form factor.

Input EMI Filtering

In order to comply with US and EU regulatory standards on conducted noise in grid-connected power systems, these systems require power factor correction and filtering on input lines to clean up noise. Input filtering is accomplished with a variety of components, including ferrite cable cores, common-mode choke coils, and SMD ferrites used for filtering. Some of the major specifications in Steward's inductive components required for EMI filtering are shown below.

	Common-mode Choke Coils	Chip Ferrite Beads	Beads on Wire and Cable Cores
Rated Current	0.07 to 82 A	1 to 10 A	N/A
Rated Max. Voltage	Up to 984 V (DC) or 250 V (AC RMS)	N/A	N/A
Inductance at 100 kHz	0.005 to 0.7 mH	N/A	N/A
Impedance at 100 MHz	Up to 2.8 kOhm	Up to 800 Ohms	Up to 210 Ohms
DC Resistance	As low as 0.8 mOhms	4 to 100 mOhms	N/A

Ferrite cable cores and ferrite beads used as conducted EMI filters are a good place to start developing an input EMI filtering circuit as they primarily require matching to a cable assembly. Once selected, a designer can consider the additional noise reduction needed and select additional components accordingly. Common-mode choke coils require particular care as they will directly conduct current around a ferrite core, putting them at risk of flux saturation or overheating. Make sure to pay attention to the current limit in your common-mode choke coils when designing EMI filtering on the input power stage.

High-Efficiency Power Conversion

Once filtered power is brought into a power system, it is typically converted or regulated down to the desired AC or DC value. AC-DC and DC-DC power conversion vot both involve passing the input through a transformer, and the transformer must be selected such that it does not experience saturation and begin acting like a nonlinear component. At high input current (for AC-DC conversion) or at high dI/dt switching (for LLC resonant DC-DC conversion), there is a risk the core saturates and limits the power factor of the design.

Steward's ferrite transformer and balun cores are designed to provide high inductance and high saturation over a broad bandwidth. The broad bandwidth and saturation limits in these materials are important specifications for LLC resonant converters, particularly when used for high-current regulation. These materials can also be used for custom wire wound inductors in high-current regulator stages to provide low ripple and filtering.

Reduction of Switching Noise in AC-DC and DC-DC Conversion

In AC-DC conversion and subsequent DC regulation with a switching converter, the switching action used in the converter generates harmonics on the input current waveform, which reduces the systems' power factor. PFC circuits are normally used between the rectification stage and output regulation stage to smooth out the input current waveform and ensure low-noise operation. The switching action used in PFC circuits requires inductors with similar specifications as used in DC-DC converter circuits.

Switching regulators that are used with rectified DC current are designed to dampen low frequency AC noise superimposed on the nominal DC input voltage. Inductors used in switching converters will be one factor that can limit the available DC current and total power, but they will also determine the AC ripple on the regulated output DC voltage and current. In high power systems, the inductor is often the major factor that determines the overall size of the system as it is often the physically largest component next to heatsinks and fans.

Steward's components provide a broad balance between form factor (primarily determined by component height), high inductance, and high DC current rating. These components are ideal for small-form factor power conversion systems that may need to operate over a broad current range. Some of the important specifications on these components are shown below.

	Molded SMD Inductors	Wirewound Inductors	Multilayer Power Inductors
Inductance	Up to 82 µH	Up to 8.2 µH	Up to 820 nH
Rated Current	Up to 34 A	Up to 19 A	Up to 8 A
DC Resistance	Down to 1.3 mOhm	Down to 3 mOhm	Down to 10 mOhm
Component Height	1.0 to 6.7 mm	1.0 to 4.0 mm	0.9 to 3.45 mm

Choose Steward for Inductive Components

Inductors and other inductive components are critical in power systems, and engineers can look to Steward for guidance on choosing the best inductive components for their designs. With a broad line of components, designers can create a custom, flexible solution that addresses multiple EMI problems in power systems without compromising form factor or excessive use of shielding materials. In addition to standardized components, Steward's technical staff can craft a custom solution targeting unique power conversion and regulation challenges in advanced electronics.

Contact Steward today to learn more.