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Trends Place Focus Upon Inductive Solutions

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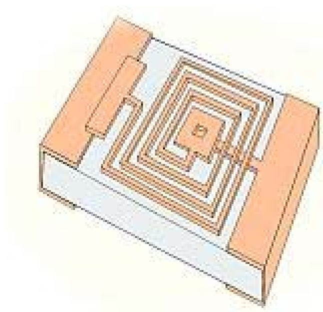
Today's low operating voltages and high data rates force circuit designers to think deeper to safeguard noise performance. Rapidly increasing component and interconnect density, bringing increased risk of crosstalk, only adds to the challenges. At the same time, older through-hole PCBs are continuing to transition to surface mount technology. All of these individual trends are together driving up demand for advanced, small-footprint, low-profile inductors in surface mount packages.

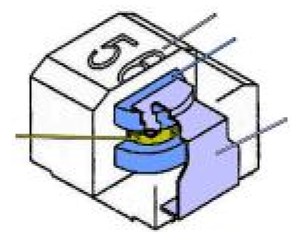
At the high signal speeds encountered in 3G or broadband infrastructure products, residential gateways, PCs, multimedia phones and advanced gaming terminals for example, filter designers are already working on a knife-edge to achieve the right response to separate unwanted noise without slowing signal edges excessively. Designers not only need small component dimensions to meet strict enclosure size limits, but also need to be able to achieve the exact inductance value required, as well as meeting other parameters including DC resistance (DCR) current rating (DCI), and Q-factor.

The power management requirements of today's telecommunications systems require high current rated, shielded power inductors in low profile formats. As operating voltages of DSP and networking chips decrease, the DC current levels increase for point-of-load regulators, dc-dc converters and switch-mode power supplies used to power cellular infrastructure, servers, network switches, and routers. High current (DCI rated 70A) shielded SMT power inductors have been developed for use in wired and wireless data and telecom networks applications. Power supplies and voltage converters for telecommunications applications also present an increasing noise filtering challenge. Switching frequencies are rising, to operate the power MOSFET at higher efficiency and to minimize capacitors needed. With these higher switching frequencies come higher noise frequencies. And because of the small voltage excursions of digital components inside these products, and the high signal speeds, excessive EMI from the power side of the circuit could have a detrimental effect on the product's ability to perform normally. Developers of power and signal inductors, therefore, are facing demands for a greater number and wider variety of SMT inductors. The modern fashion for very low profile end user products such as mobile phones, flatscreen TVs and laptop PCs is focusing much attention on general improvements in inductance to volume ratio to achieve smaller package dimensions, and more specifically on techniques to enable lower profile inductors. Custom inductors, as well as applications assistance to overcome esoteric design issues, are also forming a larger part of inductor vendors' value-add.

Modern Inductor Choices

Increasing operating frequencies are driving up the numbers of inductors per board dedicated to safeguarding signal integrity, at the same time as demanding generally smaller amounts of inductance in each location. Demand for precise high frequency filtering, requiring inductance values in the 1.0nH to 10nH range, has stimulated the emergence of thin film surface mount inductors (Figure 1 – Below Left - cutaway showing thin film inductor structure). Thin film technology has the edge over wirewound or multi-layer construction in such applications, as precision tolerances (+/-0.3nH and +/-5%) are standard and reduced size footprints, such as **0201** - and even smaller -, are available for high-density designs. Inductors in precision tolerances, in this size, are not yet possible using wirewound or multi-layer construction. Thin film also enables significantly lower component profile: the lowest profile surface mount inductor currently available from NIC Components Corp. is a thin film device of **0.28mm nominal package height**. Thin film technology is also able to sustain higher **DCI (DC Current)** ratings than multilayer construction Multi-layer inductors, on the other hand, enable cost-effective filtering in a wide range of applications extending well into the GHz range. Popular surface mount standard outlines including 0603 and 0402 are widely available. Where the high Q factor of a wirewound inductor, or the precision characteristics and miniaturization of thin-film are not necessary, multi-layer inductors fulfill an enormous number and variety of filtering duties in diverse products. These include communication equipment, domestic appliances and home entertainment systems, automotive control units and industrial scientific and medical instruments. Wirewound technology – using modern, miniature construction and high permittivity core materials - enables superior performance in designs requiring a higher "Q" quality factor at high frequency (Figure 2 –Right- internal structure of miniature wirewound inductor). This allows designers to maximize out of band rejection in systems requiring very high selectivity, for example to combat a specific, high frequency noise source.





Power management design trends using high efficiency voltage regulators operating at switching speeds up to 1MHz require SMT wirewound power inductors with lower loss core materials and frequency characteristics (and self resonant frequencies) extending above 1MHz. An increasing number of circuit designers are designing voltage regulation at the point of load. Changing load current requirements present challenges in selection of correct power inductors. Review of **saturation current** (**Isat**) and **self-heating current** (**Irms**) specifications of power inductors under consideration, is an important aspect to optimum component selection. Winding wire characteristics, including frequency dependent skin effects and related self-heating, need to be considered during the power inductor component selection. Review of the unique circuit requirements with vendor can prove valuable in proper power inductor selection.

Device Selection

The dominant factors influencing inductor selection by circuit designers include the required inductance value, current levels in the circuit, component size and unit cost. Other trade-offs include the noise performance of the inductor: if sensitive components are mounted nearby, a shielded inductor will likely be necessary. On the other hand a non-shielded inductor can be specified if the board design permits, enabling a smaller component outline and lower unit cost. Alternatively, in cases where stability at high frequency or higher current rating is needed, a custom inductor may be necessary. All of these factors influence the choice of technology, choice of individual component, and the choice of supplier.

For example, vendors with the ability to offer multiple SMT inductor technologies, including a variety of **thin film**, **wirewound chip**, w**irewound power**, and **multi-layer ceramic** and **ferrite** devices usually take a more active role in satisfying all the filtering requirements for a given product.

NIC Components supports each of these technologies, and is able to provide quick and easy technology and pricing comparisons with the majority of alternative devices on the market. This saves customers considerable time and effort in identifying and contacting numerous suppliers for all the inductor technologies required, requesting information and samples, and comparing all the potential alternatives.

NIC QUICK KIT Build Custom Kits

In addition, NIC has created a unique "**Quick Kit"** Program that allows design engineers to select and build free kits from **over 300 SMT power & chip inductors** held in NIC's "Quick Kit" inventory. The Quick Kit **user customized free kit** program has been expanded to also include complementing passive components to SMT power inductors (Quick Kits also include: Low ESR Capacitors and Current Sensing Resistors) making it a valuable resource for power circuit designers.

Working with Vendors

Today's designers need to be able to select from a wide range of standard products, to minimize cost, time to market and lead-times. On the other hand, the increasingly physical and mechanical constraints imposed by modern product design can tend to increase reliance on custom devices. In any case, designers need to be able to rely on their suppliers' knowledge of available ranges and properties to determine the optimal off the shelf solution or recommend the best way to customize at the least risk and cost, and without adversely impacting time to market. Ongoing design support, for example using web-based techniques, is another aspect of the design services now being introduced by inductor vendors such as NIC, to support engineers using a wider variety of more precise and close tolerance inductors than at any time before.

One of NIC's flagship support services is web-based **Live Help** application assistance. Live Help gives customers privileged access to NIC component designers, who understand the intricate strengths and limitations of each technology in a wide variety of usage scenarios. Of course, a great many of today's products after prototyping and first article build close to home, are built offshore, Transferring a product offshore is a notoriously problematic process that demands the commitment of product designers, prototype builder, component vendors and offshore manufacturing engineers to ensure success. Inductors may seem a small element of the total mix, but NIC has implemented a unified global logistics and engineering support system spanning Europe, Asia and the Americas. This enables seamless support for multiple build locations.

The Future - Driving Inductor Attributes Higher

Thin film-type chip inductors are highly dependent on advances in material characteristics if they are to offer higher inductance per unit volume in the future. This implies ongoing development of new materials, construction methods and treatments that will allow higher inductance per unit volume, while also meeting circuit current, DCR and Q-factor requirements. For wire-wound inductors, future technical directions will focus on enhanced permittivity core materials, wire characteristics and winding techniques. Improved winding techniques result in higher inductance by maximizing flux linking, leading to a higher inductance per winding. On the other hand, the use of smaller gauge wire in inductor windings allows a higher winding count (and proportional inductance value) within a given set of core dimensions. However, diminishing wire thickness tends to increase DCR and also reduces the maximum current rating. Power inductor development is driven by industry trend towards lower voltage of operation and resultant increase in current levels. Each successive generation of electronic products feature increased levels of functionally and performance resulting in little decrease in power dissipation as voltage of operation is reduced. Power inductor development continues to focus upon increased current ratings, reduced DCR and improved performance at higher frequencies, through the use of lower loss higher efficiency materials and innovative design. Reduced profile power inductors, for use in high density designs, is an increasing trend, to support market growth for reduced size, portable and handheld products.

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