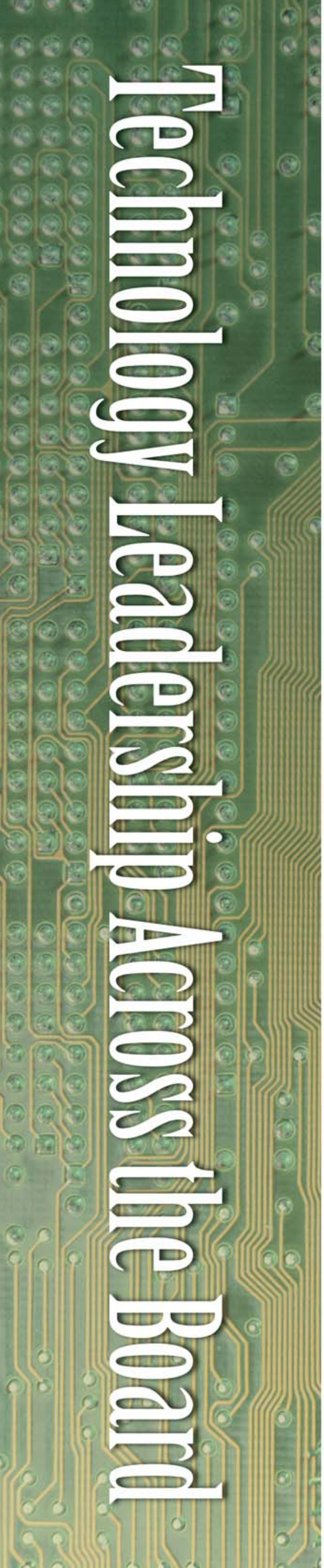


A Performance Comparison of Thin-Film and Wirewound Inductors

ABSTRACT:

This article evaluates the performance differences of thin-film and wirewound inductors. It looks at the properties of both technologies and evaluates the benefits particularly in wireless applications.

A version of this article was previously published in Wireless Design and Development, May 2006.

Ron Demcko
AVX Corporation

A Performance Comparison of Thin-Film and Wirewound Inductors

Ron Demcko
AVX Corporation

It is important to understand the specific performances between thin-film and wirewound inductors, particularly in terms of specific performance benefits in specific applications. In many cases, particularly in the wireless telecommunications industry, thin-film inductors may prove the better choice.

Simple wound inductors

In their most simple form, an inductor is nothing more than a piece of wire coiled in such a way that the magnetic flux linkage is maximized beyond that of a straight piece of wire. The number of turns, the dimensions of the turns/core and the core material itself determine the inductor's value.

The performance of a simple wirewound inductor is affected by the resistance of the wire used in the winding as well as the distributed parasitic capacitance along the length of the adjacent coiled wires. Prior to the emergence of thin-film inductors and commercially wound SMT inductors, RF engineers had to wind their own coils on forms to create inductors needed for their designs. Those engineers would constantly battle the desire to make small, light coils by using tightly wound, small AWG wire at the risk of hurting inductor performance.

Tightly wound thin wire would create low Q inductors due to high amounts of distributed parasitic capacitance and high levels of the winding wire ESR. Ultimately, companies were founded that would do nothing but wind families' of coils in the most optimal manner. Each different inductor family type had concessions made relative to inductor performance, size and frequency response. The different families were targeted at specific applications that could accept the performance of the coil type. It wasn't until recently that other manufacturing technologies were developed capable of producing high performance, low inductance value, miniature inductors.

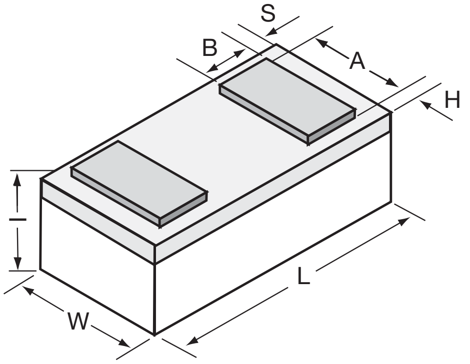
Thin-Film Inductors

Thin-film technology is commonly used in producing semiconductor devices. In the last few decades, this technology has evolved tremendously in performance, process control and cost. Applying this technology to the manufacture of miniature, low value inductors has created a family of components that can offer both electrical and physical advantages over existing inductor choices.

From a physical point of view and certainly compared to wirewound inductors, thin-film inductors are easy to pick, place and process. AVX thin-film inductors have a nickel barrier termination that allows them to be processed in the standard IR, vapor phase and wave solder processes typically used in assembly. Alternatively, manual soldering can be used with a preheat of the PCB to 100c and a 260c temperature-controlled soldering iron of 30 watts.

Thin-film inductor chips can be built in miniature SMT case sizes of 0402, 0603 and 0805. Termination styles of Land Grid Array are used on 0402 and 0603 devices and standard termination are used on 0603 and 0805 sizes. Land Grid array technology reduces parasitics and results in a higher Q than standard termination-style thin-film inductors. In addition, LGA termination technology helps miniature SMT inductors self-align during the assembly process.

Examples of LGA termination are shown in figure 1.



	0402	0603
L	1.0±0.10 (0.040±0.004)	1.6±0.10 (0.063±0.004)
W	0.58±0.07 (0.023±0.003)	0.82±0.10 (0.032±0.004)
T	0.35±0.10 (0.014±0.004)	0.61±0.10 (0.024±0.004)
A	0.48±0.05 (0.019±0.002)	0.66±0.05 (0.026±0.002)
B	0.17±0.05 (0.007±0.002)	0.23±0.05 (0.009±0.002)
S,H	0.064±0.05 (0.003±0.002)	0.10±0.05 (0.004±0.002)

Figure 1.
Land Grid Array Termination Dimensions by case size

Thin-film technology allows for the deposition of low ESR line width structures to the micron and below level. The result of such small structures yields extremely tight tolerance inductors in virtually any value imaginable. Typically, inductor tolerances as tight as 0.05 nH are available in low value 0402 and 0603 case sizes. The 0805 case size is available in values as low as 1.2nH and tolerances as tight as 0.1nH.

Though the maximum value of thin-film inductors is less than air-wound inductors' maximum values of 6.8nH and 22nH are available in 0402 and 0603/0805 sizes respectively. As RF frequencies increase, lower-value inductors become the more necessary in circuit design.

The tight tolerance and electrical characteristics of thin-film inductors is stable pre- and post-processing and have outstanding stability in application. Sometimes the processing of wirewound devices can interfere with their specific inductance values and make adjustments necessary. Further, the low height of thin-film devices makes them able to withstand high G forces and vibration while maintaining a high degree of electrical stability.

Thin-film inductors are also highly stable in environmental extremes of temperature, humidity, moisture and time.

Thin-Film Inductor Application Advantages

Thin-film inductors offer significant advantages over wirewounds for an ever-increasing number of applications (even though wirewound inductors may have a larger value range, or a higher Q and even a higher current capacity). In fact the standard terminated thin-film device can have a current capability of 1000mA. Depending on application, the thin-film inductors' lower Q is an actual advantage. One example of this is in frequency compensation on broadband amplifiers. Previously a resistor/inductor combination was used. A thin-film inductor has the capability of replacing those two components with a single component solution. Thus improving system reliability while saving circuit size and weight.

Thin-film inductors' maximum value is less than that of wirewounds' inductance values. However wirewounds may not be available in low inductance values and this is another problem. At some point, when designing a circuit (like a multi-GHz oscillator, for example) it is just not possible to obtain an extremely low value wirewound inductor. Manufacturing techniques do not exist to build such a low value wirewound part in a cost-effective manner.

At that point, the designer is left with the choice of creating a low value inductor with a meandering PC board trace design or choosing a thin-film inductor chip. In this case though the PC Board trace inductor could be considered free, it consumes a lot of board space and will have many disadvantages such as having parasitic effects associated with it. One interesting case study even showed the cost of the PCB actually increasing due to the fine width demands of the printed inductor. In many cases it is much more efficient to choose the thin-film inductor.

It is also important to note that thin-film inductors offer designers a miniature intermediate-to-high Q inductor that is electrically repeatable on a lot-to-lot basis and, most importantly, thin-film inductors offer extremely tight tolerance options for designers. This is significant and solves many problems for designers.

Thin-film inductors usage is dramatically increasing due to frequency spectrum crowding, narrow band circuit needs and maximum useable frequency band increases. Further, significant progress is being made with increasing the Q factor and maximum value range of the part, making it more and more often the necessary solution for design engineers in the wireless field.

AMERICAS

AVX Myrtle Beach, SC
Corporate Offices
Tel: 843-448-9411
FAX: 843-448-1943

AVX Northwest, WA
Tel: 360-699-8746
FAX: 360-699-8751

AVX North Central, IN
Tel: 317-848-7153
FAX: 317-844-9314

AVX Midwest, MN
Tel: 952-974-9155
FAX: 952-974-9179

AVX Mid/Pacific, CA
Tel: 510-661-4100
FAX: 510-661-4101

AVX Southwest, AZ
Tel: 602-678-0384
FAX: 602-678-0385

AVX South Central, TX
Tel: 972-669-1223
FAX: 972-669-2090

AVX Southeast, GA
Tel: 404-608-8151
FAX: 770-972-0766

AVX Canada
Tel: 905-238-3151
FAX: 905-238-0319

AVX South America
Tel: ++55-11-2193-7200
FAX: ++55-11-2193-7210

EUROPE

AVX Limited, England
European Headquarters
Tel: ++44 (0) 1252-770000
FAX: ++44 (0) 1252-770001

AVX/ELCO, England
Tel: ++44 (0) 1638-675000
FAX: ++44 (0) 1638-675002

AVX S.A., France
Tel: ++33 (1) 69-18-46-00
FAX: ++33 (1) 69-28-73-87

AVX GmbH, Germany
Tel: ++49 (0) 8131-9004-0
FAX: ++49 (0) 8131-9004-44

AVX srl, Italy
Tel: ++390 (0)2 614-571
FAX: ++390 (0)2 614-2576

AVX Czech Republic
Tel: ++420 57 57 57 521
FAX: ++420 57 57 57 109

ASIA-PACIFIC

AVX/Kyocera, Singapore
Asia-Pacific Headquarters
Tel: (65) 6286-7555
FAX: (65) 6488-9880

AVX/Kyocera, Hong Kong
Tel: (852) 2-363-3303
FAX: (852) 2-765-8185

AVX/Kyocera, Korea
Tel: (82) 2-785-6504
FAX: (82) 2-784-5411

AVX/Kyocera, Taiwan
Tel: (886) 2-2698-8778
FAX: (886) 2-2698-8777

AVX/Kyocera, Malaysia
Tel: (60) 4-228-1190
FAX: (60) 4-228-1196

Elco, Japan
Tel: 045-943-2906/7
FAX: 045-943-2910

Kyocera, Japan - AVX
Tel: (81) 75-604-3426
FAX: (81) 75-604-3425

Kyocera, Japan - KDP
Tel: (81) 75-604-3424
FAX: (81) 75-604-3425

AVX/Kyocera, Shanghai, China
Tel: 86-21 6341 0300
FAX: 86-21 6341 0330

AVX/Kyocera, Beijing, China
Tel: 86-10 8458 3385
Fax: 86-10 8458 3382

ASIA-KED

KED, Hong Kong
Tel: (852) 2305 1080
FAX: (852) 2305 1405

KED, Shanghai
Tel: (86) 21 6859 9898
FAX: (86) 21 5887 2542

KED, Beijing
Tel: (86) 10 5869 4655
FAX: (86) 10 5869 4677

KED, South Korea
Tel: (82) 2 783 3288
FAX: (82) 2 783 3207

KED, Taiwan
Tel: (886) 2 2950 0268
FAX: (886) 2 2950 0520

KED, Singapore
Tel: (65) 6255 3122
FAX: (65) 6255 5092

Contact:

AVX
A KYOCERA GROUP COMPANY

http://www.avx.com