Merix Corporation

High-Frequency Construction Techniques for RF Applications: Methods to Reduce Complexity, Size and Improve Performance

Historically, RF (radio frequency) assemblies were highly complex electro-mechanical structures, that were large and hard to manufacture. Competitive requirements and consumer expectations have put the same cost/performance pressures on RF designs as the computer industry has been facing for years. Reducing component count and assembly size is a must.

To better address the mounting pressures on RF designs, new construction techniques have been developed to combine multiple functional activities in a single interconnect product. These methods have been used, for example, to eliminate coaxial cables, combine multiple amplification steps into single units, or integrate antennas with driving circuitry. This type of consolidation has been effective in reducing component count, assembly size, tuning activity, and in improving quality.

Outlined below are some construction methods that have been successfully used to meet these goals. When these methods are used, all components are made at the same time so performance is uniform over an entire assembly. In addition, by reducing the number of interconnect interfaces, assembly is much less complex. Basically, every time the need for an interconnect is eliminated, the margin for error is reduced. Quality goes up and connnectivity issues go down.

RF Stripline/Digital

RF Stripline/Digital construction is primarily intended for multi-module interconnections -- transmission lines, or splitter-combiner circuits, and often replaces coaxial cables. It contains high-performance material in the center of the board with conventional materials on the outside. This technique offers substantial uniformity and control (with Teflon materials, in particular) and has very good electrical properties. Digital control and power circuitry can also be embedded in the same unit, eliminating the need for separate boards. RF Stripline/Digital is principally used in backplanes and amplifier modules. This is an exceptional mechanical construction and very robust.

Microstrip/RF Stripline

The Microstrip design is the most common design type used in RF. The Microstrip RF Stripline is an extension of this design, adding additional layers that enable the combination of, and therefore the reduction of, several different modules. These bottom layers contain the connection between individual processing areas, power distribution, and in some cases, have other RF functions. These layers provide support for activities that previously could only be achieved by adding extra modules. Primary functions, however, are still performed on the surface.

Dissimilar materials are common in this construction. An example is the use of material with a high dielectric constant for the microstrip layer to reduce circuit size, while the stripline regions use low dielectric constant materials. This flexibility allows the designer to "tune" the performance of a circuit layer to the specific requirements of that layer. Differing materials, when used in an unbalanced construction, (see Designing Balanced PCBs) will have a tendency to warp. That's why it's usually necessary to build a prototype of the design. However, experience and knowledge of materials can minimize problems. To meet electrical performance requirements, the top material is often Teflon-based (a very soft material). Therefore, handling and assembly-care are very important. Common drawbacks to this design include: less control of conductor size on the top layers, as compared to the inner layers, due to variations in plating thickness; and the need to shield the modules.

Double Board Construction/Double Blind Via Board
A double board construction takes two relatively independent multilayer boards and connects them by vias. The purpose of this construction lies in the fact that RF modules are noise sensitive and need shielding. In order to get enough room to shield the modules, a large board is essentially cut in half with the pieces placed on top of each other, allowing shielding in between. The result is increased functionality from two single units covering a much smaller area.

While these are very complicated boards, the benefits are distinct: 1) board-count reduction in assemblies, 2) mixed RF and digital processing on a single board, 3)size reductions in systems, and 4) assembly simplification.

RF Microstrip/RF Microstrip
As the name implies, this technique is back-to-back microstrips connected together. RF Microstrip/RF Microstrip can be built with every possible type of material and thickness variation available. Normally, one side is thick and has very high performance. The other side simply needs to be compatible. The main application for RF Microstrip/RF Microstrip is antenna send/receive units. The high-performance side is a solid-state antenna (instead of wire loop) attached to the other side by vias or coupling, where there are normally additional electronic functions like antenna drives and receivers. Because the materials used can differ, this construction technique is also subject to warping (like Microstrip/RF Stripline).

Each of the designs, or construction techniques discussed, results in smaller, less complicated, better performing products. Here are three tips for using them:

These are often complex interconnect systems. In order to get the desired results, the designer has to approach the project aggressively. Generally, the more features incorporated into the board design, the more cost-effective the overall product. This is referred to as "the best use of the technology."

Supplier experience is critical to the proper execution of these types of products. Merix has been a pioneer in the use of these technologies. It is important to note that performance variations are common among suppliers. So, carefully investigate capabilities, particularly prototyping.

Use these technologies when needed. They are elegant solutions, but can easily be overused. You don't need a Ferrari just to get across town.