

Modern Coaxial Cables Emphasize Precision and High Reliability

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This month's tutorial reviews the current areas of attention in the design, manufacture and application of today's coaxial cables

Coaxial cables have been used since the early days of radio communications, becoming the most common means for connection to antennas and

between modules and subsystem equipment. The materials and manufacturing techniques used to make coaxial cables have evolved continually, in response to changing performance needs. This tutorial highlights some of the recent developments in coaxial cables and is intended to help readers make appropriate choices when specifying cables for their next design assignment.

Coaxial Cable Construction

Figure 1 is a cross-section diagram of three common types of coaxial cables. The primary difference in these types is the shield—foil/braid, solid conductor or corrugated conductor. Proceeding from the outside to inside, here is a discussion of each element in the construction of a coaxial cable:

Jacket—The expected environmental conditions determine the jacket material. For many cables, particularly with solid or corrugated shield cable types, having no jacket may be appropriate for installations that are protected, or when the minimum weight and volume is a requirement.

Various formulations of PVC, polyethylene, polyurethane, neoprene and other materials are used for jackets, depending on the requirements for resistance to heat, abrasion, UV (sunlight), chemicals, water, etc. Cables intended for outdoor use, or for direct burial, may include a semi-liquid sealant between the

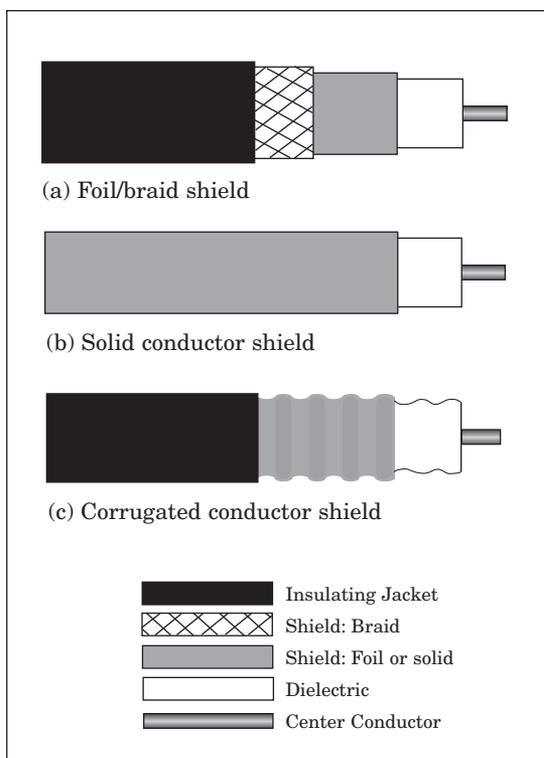


Figure 1 · The main construction methods for coaxial cables. See text for descriptions and variations in these methods.

jacket and outer shield to automatically seal any cuts or nicks and avoid water infiltration that can speed corrosion of the shield conductors. This is most important with the thin wires of a braided shield, but may also be desirable to keep water from flowing or migrating along the length of any cable.

Shielding—The need for flexure is the primary mechanical criterion for selection of a particular shield type, while shielding effec-

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tiveness is the main electrical performance specification.

For example, permanent installation of interconnections between modules often is done with unjacketed, solid shield coax. A soft copper shield allows relatively easy one-time bending to route the cables. Although unjacketed, these cables are sometimes tinned to obtain a measure of corrosion resistance. Solid aluminum shielding is used in cables for CATV distribution and as a lower-cost alternative to corrugated copper shielded cables in communication systems.

Corrugated conductor shielding allows some repeated bending and a tighter bend radius than solid conductor cables. These cables are common in high power communication systems, as well some signal-level installations with extremely long cable runs, where the lower loss of a large cable is required.

Relatively recent developments in corrugated cables include finer pitch corrugations for better performance with repeated flexing, and improved dielectric formulation for greater phase stability over temperature and repeated flexure.

The greatest amount of recent work has occurred with flexible cables using foil and braid shielding in various configurations, including cables designed for both communication systems and test systems.

For the past several years, companies like Times Microwave, Semflex, Micro-Coax and others have developed better methods for constructing flexible cables. Much of this work involves the foil shield. For the highest performance test cables, the foil may be wound around the dielectric in a tight spiral, or braided like wide, flat "wires." Much work has been done in the development of manufac-

turing techniques that lay the foil in a manner that remains intact and stable during the repeated flexing of connecting, disconnecting and re-connecting production test cables for high performance equipment.

In communication systems, foil/braid cables have become competitive with, or even preferred to, the well-established corrugated shield cables. Because foil/braid cables contain less copper, materials cost is lower. Manufacturing tooling is readily scaled for these cables, allowing a wide range of sizes to match the cost, weight and loss tradeoffs of almost any system. Like test cables, optimal foil placement maintains high shielding effectiveness.

The braided shield has an important role in both mechanical and electrical properties. It helps hold the foil shield in place during flexing, as well as adding to the overall shielding



Figure 2 · An example of current flexible cable technology is Semflex's LA Cable, which uses silver-plated inner and outer conductors, microporous PTFE dielectric, helically served flat braid plus 97% coverage round braid, and either PTFE or polyurethane jacket.

effectiveness. Recent work includes improved braiding machinery to achieve precise control of the pitch and tightness of the weave. The size, shape and composition (e.g., plating) of the braid strands has been explored, including the use of flat wires that offer very high percentage shield coverage.

Dielectric—This is another area of significant development work in the manufacture of coaxial cables. Solid dielectrics of PTFE and polyethylene (PE) remain common, especially where high impact resistance and other mechanical strength properties are important.

Most R&D has been directed toward achieving a lower dielectric constant while maintaining good mechanical performance, especially under flexing conditions. The lower dielectric constant lowers the loss by making the cable electrically shorter for a given actual length, augmented by the lower loss of a slightly larger center conductor for a given characteristic impedance. Methods developed include micro-porous foam PTFE, and a variety of spiral and cel-

lular PE structures with high air content, as well as improvements to the density and stability of common expanded foam PE.

Center conductor—Best electrical performance is achieved with a solid center conductor, which is how the highest performance cables are constructed. However, stranded conductors offer the greatest flexibility and reliability, and methods have been refined to make use of those characteristics in “ultra-flexible” cables.

Work also continues on alloys, plating and other metallurgical options that affect the conductivity, mechanical strength and cost of manufacture.

Cable “Usability”

In recent years, cable manufacturers, together with their connector manufacturer colleagues, have greatly improved the ability to install connectors quickly, with repeatable high performance. In many cases, the greatest improvements have been achieved with innovative installation tools that prepare the cable precisely, then allow the connector to be placed, tightened and sealed with accurate, repeatable results. Additional improvements to the cable/connector assembly include new strain relief configurations, as well as improvements to the connectors themselves to better handle side stresses, mating/unmating forces, and other typical “wear-and-tear” issues.

As with most other parts of electronics, customer support from cable manufacturers is part of the process. That support includes training, specialized packaging and shipping, and pre-assembly services.

Summary

Coaxial cables continue to be improved in response to customer requirements. Engineers selecting cables for new systems need to understand what performance features are currently available and what type of support may be useful.