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Another Look at Combined Microwave-Optical Cables and Connectors

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New applications in microwave and optical communications may benefit from coaxial cables that combine an optical fiber with a conventional center conductor and outer conductor/shield

Cables that combine optical and microwave signal transmission have been available for several years, but it seems that this is a good time for a review. With so many new wide bandwidth communications systems, the ability to carry both types of signals on a single cable may have significant advantages.

Figure 1 shows the construction of these cables. At the center is an optical fiber, surrounded by its cladding, which is then metallized on the outside. The metallization layer becomes the inner conductor of a coaxial cable. A typical coaxial outer conductor and dielectric material completes the cable.

A number of design issues must be considered when manufacturing this specialized dual-mode cable:

- The optical fiber should be chosen for the application, whether single-mode, multi-mode with stepped index or multi-mode with graded index, with the desired wavelength and attenuation characteristics.
- To use standard coaxial cable materials and tooling, the outside diameter of the optical fiber, after metallization, should be the same as a standard coaxial cable inner conductor (e.g. 0.011 in. diameter for a 0.047 in. semi-rigid cable.)
- The physical strength of the clad and metallized fiber, as well as its bending behavior, must be included when determining cable specifications for pull strength, bending radius, repeated bending, etc. These characteristics can be significantly different from the typical copper center conductor.
- The metallization thickness and the choice of material must be appropriate for the skin depth at the operating frequency range of the coaxial cable.

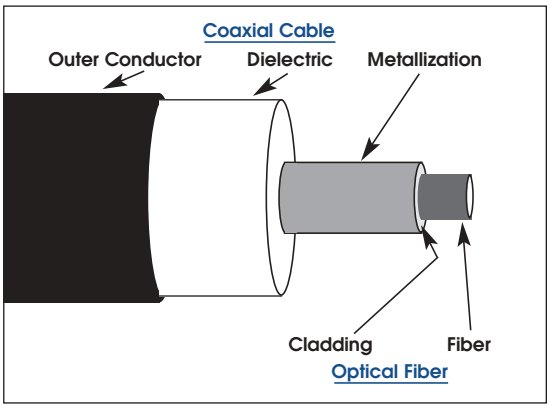

Figure 1 · Cutaway diagram of a combined coaxial and fiber optic cable.

Connectors

Connectors and launchers for microwave-optical cable are relatively simple in concept: The center pin of the connector is tubular, permitting the optical fiber to pass through to its termination at an optical source or detector (Figure 2). Although straightforward in concept, the mechanical alignment must be appropriate for an optical connector. In addition, the conductor dimensions and dielectric properties must be appropriate for the desired microwave characteristic impedance.

SMA connectors have dimensions that allow modification for use with this type of cable. The center conductor can be adapted for

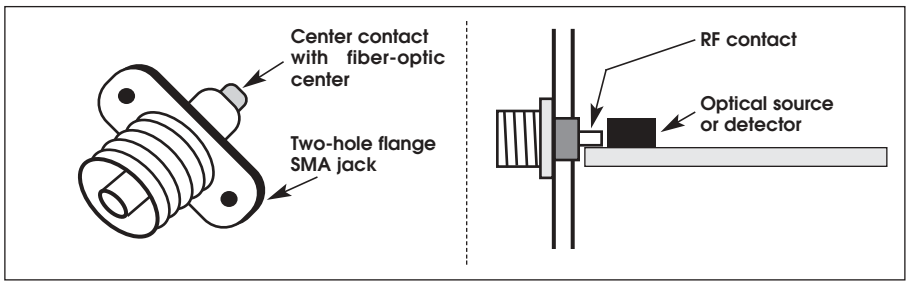

Figure 2 · Basic design of connectors and launchers for these cables.

an optical fiber to pass through, while providing an electrical connection to the metallization of the fiber's cladding. The connection to the outer conductor is unchanged from normal coaxial cable.

Performance

Measurements on the MOST (Microwave Optical Simultaneous Transmission) cable from Haverhill Cable & Manufacturing show that this design is practical as a microwave cable. The cable tested was compatible with standard 0.047 in. diameter semi-rigid coax. A multi mode step index fiber was used, with a core diameter of 183 µm, a clad diameter of 220 µm and a metallized diameter of 275 µm, which is equal to the normal inner conductor diameter of 0.011 inch.

An 18 inch long test cable with modified SMA connectors demonstrated a maximum VSWR of 1.28 from 0.5 to 18 GHz. Attenuation of the cable assembly at 1 GHz was equivalent to 58 dB/100 ft., rising to 260 dB/100 ft. at 20 GHz. To extend the frequency range of the cable, better connectors are required, and work has been done to develop 2.4 mm and 2.9 mm interfaces.

Applications

These MOST cable assemblies can be used in phased array antenna systems, signal processing networks, and systems that require extremely high isolation. The latter include remotely-located sensors or up- and downconverters that can be driven with one transmission mode, returning a signal on the other.

About the Author

After more than 30 years in the microwave industry, Foster Kneeland founded Haverhill Cable & Manufacturing Corp. in 1984. He studied Mechanical Engineering at Northeastern University and holds three US patents. Contact Haverhill Cable at 978-372-6386 or visit www.haverhillcable.com