New low-loss cables for mobile radio systems

New cables with low-loss foam dielectrics and combination foil-braid outer conductors represent the first important advance in low-loss cables in more than 10 years. Mobile radio system owners will appreciate the cost savings.

By Joe Lanoue and Robert Perelman

Low-loss coaxial cables are ideal for antenna feeders and interconnects in land mobile, cellular and paging systems. The traditional choices have been foam- or air-dielectric cables with corrugated-copper outer conductors and air-dielectric cables with combination foil-braid outer conductors.

Corrugated-copper cables are expensive. They require special connectors and are stiff, making them difficult to install. Recently, air-dielectric cables with foil-braid outer conductors have gained popularity because they are less expensive than corrugated-copper cables, they use inexpensive standard connectors, and they have good flexibility.

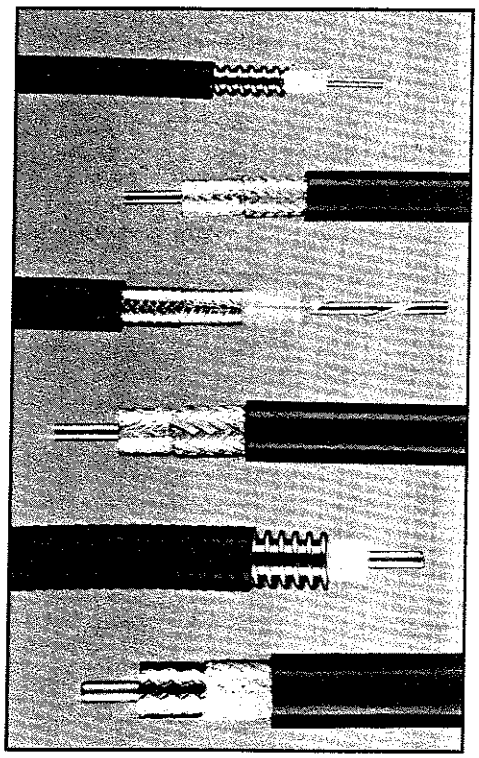

Photo 1. From top to bottom: Andrew FSJ1-50A cable , Times Microwave Systems LMR-400 cable, Belden 9913 cable, Times LMR-500 cable, Andrew FSJ4-50B cable, and Times LMR-600 cable.

Even so, air-dielectric cables have shortcomings. Their construction typically consists of a center conductor with a strand of polyethylene wound helically around it, a tube of polyethylene extruded over that combination, a bonded foil and braid outer conductor over that and, finally, a polyvinyl chloride (PVC) jacket, as shown in Photo 1 to the left (third from the top). Because the cable has a continuous air space along its length, moisture can accumulate inside and degrade the cable's electrical performance when it is installed outdoors. The center conductor is not bonded to the dielectric, so it can move toward the outer conductor when the cable is bent, changing the cable's electrical performance.

Temperature changes can cause the center conductor to protrude from the outer conductor, especially when the cable is outdoors. This protrusion can prevent the connector on the cable from making proper contact with its mating connector.

Air-dielectric cable is available in a 0.405" diameter with attenuation approaching that of a ½"-diameter corrugated-copper cable. For applications requiring lower loss, corrugated-copper cables were the only solution—until now.

A new series of cables fills the gap. Low-loss foam dielectrics and foil-braid outer conductors give the new cables losses comparable to corrugated-copper cables at a much lower cost. They use inexpensive connectors that are modified standard RG cable connectors. The cables are available in sizes ranging from 0.200" to 1.670" in diameter, but this article focuses on the LMR-400 0.405" and LMR-600 0.590" sizes, which were developed first.

The new cables avoid the problems of air-dielectric cables through the use of a proprietary, low-loss, polyethylene foam. The result is loss lower than for an air-dielectric cable of the same size and virtually identical to that of a corrugated-copper outer conductor cable of the same size. The foam materials and processing have been developed to maintain good strength so that the cable is rugged enough to withstand normal installation. The use of a foam instead of an air dielectric eliminates problems with moisture ingress. By bonding together all of the cable components, problems with differential expansion and conductor migration during bending are also avoided.

The jacket on these cables is black, low-density polyethylene with 3% carbon black added for ultraviolet light protection. This is the same jacket material commonly provided on corrugated-copper cables, and it has proven to be durable for outdoor installations, with a life expectancy in excess of 20 years. Air-dielectric cables are commonly provided with PVC jackets of various types. These exhibit less weather resistance than polyethylene and, if not properly formulated, can result in degradation of electrical performance over time due to migration of the plasticizer into the dielectric.

The biggest difference between the new cables and the corrugated-copper cables is the outer conductors. Corrugated copper is a proven performer in outdoor applications. So is foil-braid—this basic construction has an excellent record of trouble-free

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service in millions of feet of cable TV (CATV) drop wire installed during the past 20 years. In the new cable's construction, the aluminum tape is bonded to the polyethylene dielectric. This bonding avoids the air gap found between the outer conductor and the dielectric on corrugated-copper products and provides a reliable moisture barrier to protect the dielectric. Extensive humidity testing has been done on these cable constructions to verify that there is virtually no change in their electrical performance over time in a harsh outdoor environment. A high-coverage tinned-copper braid is applied over the aluminum tape for mechanical protection and for connector attachment.

The construction results in excellent RF shielding and phase stability over temperature. The foil-braid outer conductor of the new cables and of air-dielectric cables provides better than 90dB of RF shielding, which is more than adequate for most applications. Corrugated-copper cables provide shielding well in excess of 120dB. When the highest possible shielding is required, corrugated-copper cables may be required.

Phase stability with temperature is mainly a function of the dielectric material used in the cable. Both the common corrugated-copper cables and the new cables use similar low-loss polyethylene foams and have excellent phase stability with temperature—typically better than 10 parts per million per degree Celsius.

When bent excessively, the corrugated copper cables kink easily, causing permanent damage. The new cables use a thicker jacket to provide strength and are virtually immune to kinking.

Crimp and clamp connectors are available for the new cables. The use of a high-coverage braid combined with an adhesive-backed shrink tube results in a high-strength, weather-proof interface between the cable and the connector. For the 0.590"-diameter cable, typical connector pull-off strength is in excess of 100 pounds.

Connectors for the 0.405"-diameter air-dielectric cables also will fit the new cable with the same diameter. These connectors are available from several manufacturers with different interface types and attachment methods. A sample of the types and part numbers is shown in Table 1 below. Connectors for the 0.240" diameter cable are also shown in the table. The 0.590"-diameter cable has a non-standard dielectric diameter, so our company has worked with several manufacturers to design connectors for it. The connector types available include N-male, N-female, UHF-male and 7/16 DIN male in both crimp and clamp-solder configurations. These connectors are

CONNECTOR	LMR-240		LMR-400	
	CLAMP	CRIMP	CLAMP	CRIMP
N (plug)	R. RFN-1004-NX R. RFN-1004-1SX	R. RFN-1007-SX R. RFN-1007-1SX	R. RFN-1002-1SI A. 82-202-1006 TP. 1005-1107-1	R. RFN-1006-3I
N (jack)	R. RFN-1026-X R. RFN1026-1X		R. RFN-1024-1SI	
N (rt. angle)				R. RFN-1009-3I
UHF (plug)	A. 83-59SP A. 83-750 A. 83-59SCP A. 83-168(adapter) R. RFU-500 R. RFU-501 R. RFU-531 (adapter) R. RFU-531S (adapter)	R. RFU-508-X	A. 83-8SP K. KU-51-07 K. KU-59-55 K. KU-59-22 K. KU-51-01 K. KU-51-02	R. RFU-507-SI A. 83-822 A. 83-1SP A. 83-1SPN A. 83-756 A. 83-851 K. KU-59-42 K. KU-59-52 K. KU-59-40 K. KU-59-82
UHF (rt. angle)			A. 83-67 A. 83-59	
Mini-UHF (plug)		A. 81-114		
Mini-UHF (jack)		A. 81-117		
BNC (plug)	R.RFB-1101-1X R.RFB-1101-X	R.RFB-1107-1P	R. RFB-1101-1SI	
TNC (plug)	R.RFT-1201-X	R.RFT-1203-1X		
TNC (jack)		R.RFT-1213-X		

R. = RF Industries A. = Amphenol K. = Kings TP. = Trompeter

CONNECTOR	LMR-400		LMR-500	LMR-600		LMR-1200	LMR-1700
	Clamp	Crimp	Clamp	Clamp	Crimp	Clamp	Clamp
N (plug)	TC-400-NMC	TC-400-NM	TC-500-NMC	TC-600-NMC	TC-600-NM	TC-1200-NMC	
N (jack)	TC-400-NFC	TC-400-NF	TC-500-NFC	TC-600-NFC		TC-1200-NFC	TC-1700-NFC

Note: All standard connectors have silver-plated bodies with gold-plated center pins.

Table 1 — Cable sizes and their corresponding connectors from various manufacturers.

available from distributors that handle the cables.

Applications for the new cables range from short jumpers between ports on a combiner, to longer jumpers between combiners and radios, to feeder runs up towers. Their combination of low-cost, excellent electrical and mechanical properties and ease of handling make them good choices for many applications where corrugated copper cables have been used.

For example, a large radio manufacturer has selected the new 0.590"-diameter foil-braid cable to replace a 10-foot jumper previously fabricated from ½"-diameter "superflexible" corrugated-copper cable in a 220MHz system. The 0.590" cable is nearly as flexible as the ½" "superflexible" corrugated-copper cable, but it has a loss of only 1.2dB/100ft at 220MHz compared to loss of 1.6dB/100 feet for the ½" corrugated-copper "superflexible" cable. The new cable's loss is almost as low as that of a ½" low-density foam-dielectric cable that has loss of 1.05dB/100 feet at 220MHz.

The list price of the 0.590"-diameter foil-braid cable is $1.20 per foot. The type-N male crimp connectors used on this assembly are $14.50 each (list price).

Several trunked radio system operators are planning to use the 0.590"-diameter cable for short antenna feeder runs at 900MHz in applications where they previously have used ½"-diameter, low-density foam-dielectric corrugated-copper cable. The attenuation of the 0.590" cable is slightly higher—2.5dB/100 feet at 900MHz—compared to 2.2dB/100 feet for the ½"-diameter corrugated-copper cable but the 0.590" foil-braid cable costs less ($1.20/foot, list) and is more flexible. The standard hangers and grounding straps sold for the ½"-diameter corrugated-copper cable also work with the 0.590" foil-braid cable.

A large manufacturer of paging equipment is evaluating the replacement of ¼"-diameter and ½"-diameter corrugated-copper "superflexible" cables with the new 0.405" and 0.590" cables, respectively. For a 20-foot assembly, the material cost is $5[illegible] for the foil-braid cable and connectors. At 450MHz, the 0.590"-diameter cable has 1.7dB/100 feet loss, compared to 2.3dB/100 feet for the ½"-diameter corrugated-copper cable.

The comparison is similar between the ¼"-diameter corrugated-copper cable and the 0.405"-diameter foil-braid cable. Loss at 450MHz is 2.7dB/100 feet for the 0.405" foil-braid cable, compared to 3.9dB for the ¼" corrugated-copper cable. Cost of materials for a 20-foot assembly is $35 for the foil-braid cable and connectors.

The development of the additional sizes of the new cables, including ⅞" diameter and 1¼" diameter, will provide additional choices in the selection of low-loss cables. These products have been introduced and are in field trials.

As technology has advanced, radio and antenna prices have decreased dramatically over the last few years, whereas the costs of low-loss cables have continued to escalate, and the cable technology has stalled. These new cables represent the first important advance in low-loss cables in more than 10 years. Cost-effective alternatives such as these will help to ensure the growth and the health of the mobile communications industry.