RADIO FREQUENCY SYSTEMS
The Clear Choice®

Radiating cable revealed

RFS Technical Team

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Executive Summary

Radiating cables, or 'leaky feeders', are one of the cornerstones of Wireless INdoor Solutions (WINS)–dedicated wireless infrastructure installed within a building, tunnel or complex, that provides wireless coverage where signals from outdoor base stations cannot penetrate. Essentially designed to 'leak' RF signal along the full length of the cable, radiating cable allows precise 'contouring' of RF coverage in areas with unique and/or confined geometries.

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In principle, radiating cable has identical construction to foam-dielectric transmission line, with an inner and outer conductor in coaxial configuration, separated by a low-loss foam-dielectric. However, the difference is in the inclusion of thousands of apertures (or slots) along the length of the outer conductor (**Figure 1**). These correspond to thousands of RF emission points, allowing the power output to be rationalized along the cable length, despite a single radio source.

In this way, distribution of the RF signal can be tailored. Radiating cable is therefore ideal in curved spaces where traditional antennas (requiring line-of-sight for coverage) are inappropriate. They also work well in constructions with a metal frame, or where the signal needs to be limited to a small radius (a few meters). The ability to tailor coverage also minimizes the risk of co-channel interference in larger systems by preventing overlap of coverage zones.

Since its inception in the 1970s, radiating cable has evolved to accommodate broadband communications that deliver advanced functionality, high network capacity and improved spectrum efficiency. Today's broadband radiating cable forms the backbone of a vast variety of wireless indoor communications systems; these include commercial second and third-generation networks, essential and emergency services communications networks, wireless local area networks (WLAN), *worldwide interoperability for microwave access* (WiMAX), and mobile TV.

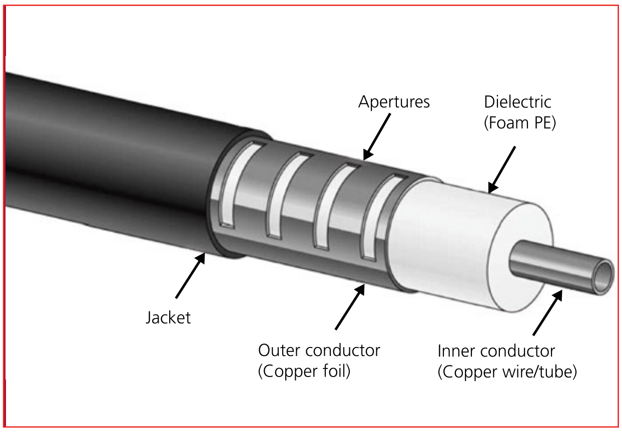

Figure 1 RADIAFLEX cable construction

Technical parameters

The most important parameters to consider when specifying radiating cable are:

- **Frequency range:** The operating frequency that a cable is optimized for is dependent on the design of the apertures in the cable's outer conductor. For this reason, radiating cables with various different aperture sizes and dimensions are typically available.
- **Coupling loss:** This is a measure of the signal loss between the cable and a test receiver at a distance of 2m (6.5ft), and is influenced by the transmission modes that are occurring. Generally two different physical modes carry the electromagnetic energy from the radiating cable into the air: the coupling mode and the radiating mode.
- **Longitudinal loss:** This is a measure of signal loss along a cable. Lower coupling loss usually results in higher longitudinal loss and vice versa. Both values are frequency dependent.

- System loss: This is the sum of longitudinal loss and coupling loss. Usually system loss increases down the length of the cable, but it is possible to design a cable where the coupling loss is decreased gradually to improve system loss performance and increase the service length.

Coupling loss measurement

As stated, coupling loss is derived from the ratio (in dB) between the signal in the cable and the signal received by a half-wavelength dipole antenna. Coupling loss, as well as longitudinal attenuation of radiating cables, is measured by the free space method according to the International Electrotechnical Commission (IEC) standard IEC 61 196-4, *Coaxial Communication Cables Part 4: Sectional Specification for Radiating Cables.*

This measurement of the radiated signal level involves moving a half-wavelength dipole antenna along the cable at a distance of 2m (6.5ft). The sampled values of coupling loss vary along the cable due to the superposition of signals of varying phase. They also vary depending upon the spatial orientation of the half-wavelength dipole antenna (orthogonal, radial, or parallel). According to IEC 61 196-4, coupling loss values are either spatially averaged data, or given for a specific antenna orientation.

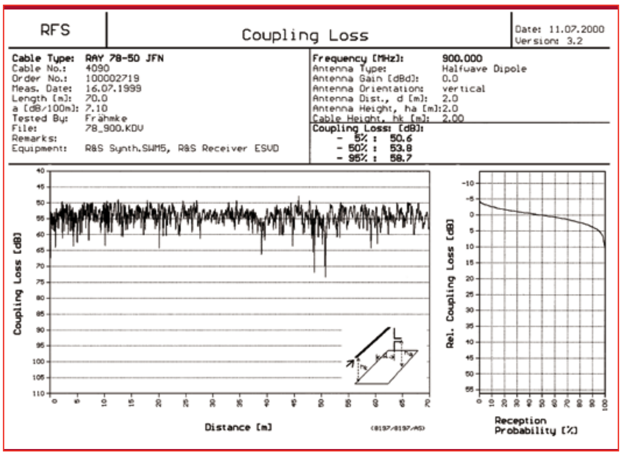

Figure 2 Test document for coupling loss measurements according to IEC 61 196-4

Typically, two coupling loss values are specified:

- **50 percent reception probability:** where 50 percent of all measured samples are better than the stated figure.
- **95 percent reception probability:** where 95 percent of all measured samples are better than the stated figure.

The 95 percent value, as well as the difference between the two values, helps the system designer in assessing and calculating the availability of the link (**Figure 2**).

System loss in practical environments

As stated, system loss is the sum of longitudinal loss (attenuation) and coupling loss. In practical environments (such as tunnels, buildings and underground garages), the influence of conducting, reflecting or 'lossy' surfaces has to be considered. This is done by employing the following two measures:

- Using stand-off clamps during installation to minimize the influence of lossy walls.
- Using a 10-15dB safety margin to cover the difference between the environment during factory measurement ('free space'), and in the actual situation (such as buildings and tunnels).

Normally, the coupling loss in tunnel installations differs from the free space loss, as more multi-path effects occur. They depend on the tunnel factors such as cross section and material. Radio Frequency Systems has been collecting data on the effects of various profiles, at various frequencies for more than 40 years, and can assist in quantifying these effects (**Figure 3**).

These studies have led to the development of a radiating cable that exhibits graded coupling loss. 'Steps' have been introduced into the coupling loss profile by means of specially designed aperture configurations. The result is a radiating cable that features longitudinal sections of decreasing coupling loss. The purpose of this is to compensate for longitudinal loss (attenuation) and yield an almost constant system loss along the length of the cable (Figure 4). This significantly increases the service length of the cable, since normally system loss increases with distance.

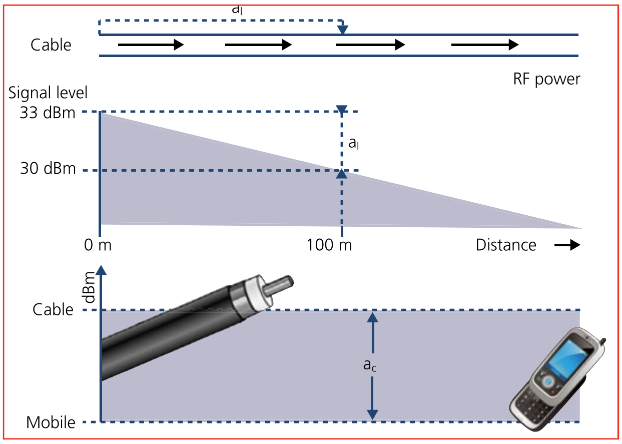

Figure 3 The sum of longitudinal loss (a_l) and coupling loss (a_c) defines the system loss.

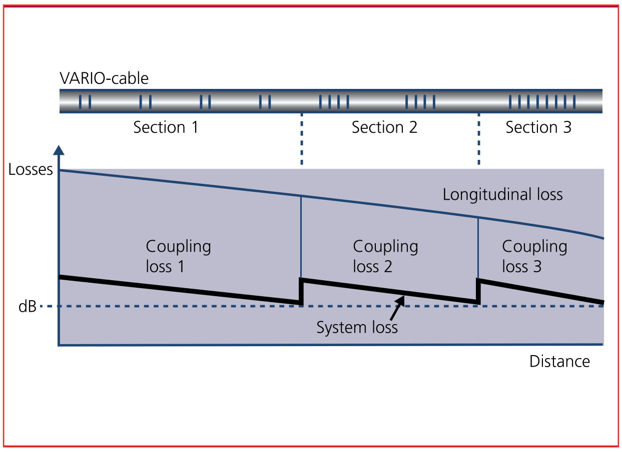

Figure 4 Example of a typical system loss measurement of an RFS Vario cable

A particularly attractive feature of this principle is the small dynamic range, which is only a fraction that of 'normal' radiating cables. An important system planning parameter, the dynamic range is limited by the performance of the active components. Since cable attenuation varies with frequency, the compensation is only precise for one given frequency range. However, the cable performs adequately at other frequencies as well, even when total compensation does not take place.

Introducing RADIAFLEX

RFS's foam-dielectric coaxial radiating cable, RADIAFLEX, is engineered to provide an optimized combination of advanced electrical and mechanical performance. It is comprised of an inner and outer conductor in coaxial configuration, separated by a low-loss foam dielectric. The outer conductors are made of either an overlapping copper foil (ALF, RLF, RLK, RLV, RAY models) or of seam-welded and corrugated copper (RCF, RSF models). One of the major advantages of radiating cable is its ability to transmit and distribute broadband RF. RFS categorizes its RADIAFLEX family of radiating cable into groups, according to common applications for mobile telecommunication:

- ALF, RLF series for heavy duty wideband applications
- RLK series for applications requiring low coupling loss variations
- RLV series ('Vario') for applications requiring graded coupling loss and near-constant system loss and low amplitude variation
- RAY series for high-frequency applications requiring low coupling loss variations
- RCF series for heavy-duty applications demanding small bending radii
- RSF series for installations in vehicles requiring sharp bending radii

The primary difference between these RADIAFLEX cable series is associated with the configuration of the outer conductor apertures, which determine the interaction between the inner coaxial system and the external environment. This influences all the important electrical parameters, such as frequency range, attenuation, coupling loss and susceptibility to environmental conditions.

Radiating cable revealed

Company profile

RFS serves OEM, distributors, system integrators, operators and installers in the broadcast, wireless communications, land-mobile and microwave market sectors.

As an ISO 9001 & 14001 compliant organization with manufacturing and customer service facilities that span the globe, RFS offers cutting-edge engineering capabilities, superior field support and innovative product design.

RFS is committed to globally fulfilling the most demanding worldwide environmental protection directives and integrating green-initiatives in all aspects of its business.