REPORT 880-2 *

SHORT DISTANCE RADIO-WAVE PROPAGATION IN SPECIAL ENVIRONMENTS

Buildings, tunnels, mines, etc.

(1982-1986-1990)

1. Introduction

There is an increasing need for knowledge of propagation within confined spaces such as buildings, tunnels and mines. Increased knowledge of propagation in buildings is required to assist in the implementation of cordless communication. The present understanding of radio-wave propagation in tunnels and mines can be applied to communications in the transportation and mining industries. (Information on propagation into and within buildings for the frequency range 30 MHz to 3 GHz may be found in Report 567.)

2. Radio-wave propagation within buildings

Measurements at 60 GHz [Huish and Pugliese, 1983] have revealed a ray-like mode of propagation with little evidence of diffraction around obstacles. The attenuation and reflectivity of a number of building materials have been measured at this frequency and the results used to interpret the results of propagation tests in three different types of building.

3. Propagation mechanisms in tunnels and mines

The propagation of radio signals in tunnels and mines (see also Report 902) depends primarily on the geometry of the walls and, to a lesser degree, on the electrical characteristics of these walls. Two propagation mechanisms are of practical importance. These two mechanisms have a complex theoretical basis, but they are now well understood [Delogne, 1980].

The first mechanism has been described as a natural propagation mode in which the tunnel or mine shaft behaves like a multimoded waveguide with lossy walls. This mechanism favours the use of frequencies above the equivalent waveguide cut-off frequency. This mechanism has the disadvantages of poor coupling of the waveguide modes to the usual type of antennas and of high losses around corners.

The second mechanism, described as guided propagation modes, requires the use of a radiating cable suspended near the roof of the tunnel. Single wires, balanced open-wire transmission lines, and coaxial cables with a controlled degradation in their shielding (leaky feeders) are used. At frequencies below the waveguide cut-off, the tunnel and cable support two TEM-like modes (transverse electromagnetic). At higher frequencies many waveguide-like modes can propagate [Seidel and Wait, 1978]. One TEM-like mode is the normal transmission line mode. The other mode is supported by currents on the outside of the cable or by common mode currents when a balanced transmission-line is used. There is a continuous conversion of energy between the two modes caused by leakage of the cable shield or by devices, known as mode converters, which introduce a deliberate discontinuity in the shield.

Both mechanisms are characterized by an exponential propagation loss with distance which is expressed in dB/m. In guided propagation modes, the transmission loss between the transmitter and receiver can be separated into the normal cable loss (dB/km) and a coupling loss. This coupling loss may show a periodic variation with distance due to standing waves on the shield [Martin, 1982].

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* This report is brought to the attention of Study Group 8.

4. Other applications of leaky feeders

A leaky feeder system for railway communications has been successfully developed in Japan at 400 MHz [Okada *et al.*, 1975]. A notable feature of this system is a special antenna on the side of the train. The radiation pattern of this antenna matches the field of the cable, and the variations in coupling loss with distance are very small in comparison with a simple dipole.

It has been suggested that leaky feeder systems may be used as a spectrum conservation measure in those cases where radio communications are normally difficult such as in large buildings and in dense vegetation.

The leaky feeder principle also explains a possible interference mechanism between normal communications systems and coaxial cable distribution systems for television and audio broadcasting.

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