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STUDY OF CORRUGATED COAXIAL WAVEGUIDE

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Corrugated waveguides have been of much interest in recent years. Properties of propagation in circular, square and elliptical corrugated waveguides have been investigated by many authors. When properly dimensioned they may have very low wall loss attenuation, and become attractive for use in low loss wave guide transmission systems. Circular corrugated waveguides are able to support fields with uniform transverse distribution when excited with their lowest hybrid mode. Such property is useful for the design of high efficiency feeds for parabolic reflector antennas.

In this paper the basic properties of propagation in corrugated coaxial waveguide are described. Because of the periodicity of the boundary, the field of each mode can be represented by an infinite number of spatial harmonics. However, when the number of corrugations per wavelength is made large enough the modal fields may be represented approximately by the fundamental components only. Study of the dispersion diagrams shows that the TEM mode can no longer be supported. Modes are hybrid only and appear in couples. as shown in Fig. 1. One of each mode couple has a cutoff frequency and field distribution that are similar to those of the corresponding TE mode in the conventional smooth wall cable. The other has a cutoff frequency that depends also on the corrugation depths. It is interesting to observe that the dipersion curves of the EH_{11} and HE_{11} modes couple together at a frequency below the cutoff of the next higher order mode. Over the frequency range in between no mode propagates and all the higher order modes are attenuated. One may, therefore, choose to operate the waveguide at a frequency above the cutoff of the EH_{12} mode thus having a single propagating mode. This may be taken as an advantage over the conventional coaxial waveguide, since the latter when driven at the same frequency supports the lower modes also, i.e. TEM, TE_{11}, ... Another interesting property of the present waveguide is that when the corrugation depths are so adjusted at a certain frequency, say $kb = 8$, as to make the tangential field at the boundaries vanish, all the evanescent modes disappear. This is a consequence of the assumption that the spatial harmonics are neglected, a case which becomes quite true when the corrugations width approaches zero.

The corrugated coaxial waveguide has also low wall loss attenuation compared to the conventional waveguide over certain frequency ranges. Numerical results show that a waveguide with inner radius a = 1 cm and outer radius b = 3 cm, may have attenuation as low as 10 db/km when operated in the X-band. Experimental results conform to theoretical predictions, but are consistently higher by some 50%. Such increase may be due to the effects of the neglected higher spatial harmonics and surface roughness. Fig. 2 shows typical results where the attenuation curves of the TEM, TE_{11} and TE_{12} modes in a comparable smooth wall waveguide have also been drawn.

Since most of the wall loss is generally caused by losses in the side walls of the corrugations, reduction of the slot depths and yet maintaining the same boundary conditions on the central region, can be achieved by dielectric loading. Assuming $_1$, $_2$ and $_3$ to be the relative dielectric constants in the central region, outer slots and inner slots, respectively, one may choose low loss dielectrics in the slots and proper values of $_2$, $_3$ to obtain a reduction of 50% or more in the attenuation. Fig. 3 shows typical results obtained for the EH_{12} mode in the same waveguide considered earlier and under different dielectric loading conditions. In each case the slot depths are assumed so adjusted as to keep the tangential E and H components zero at kb = 8.0

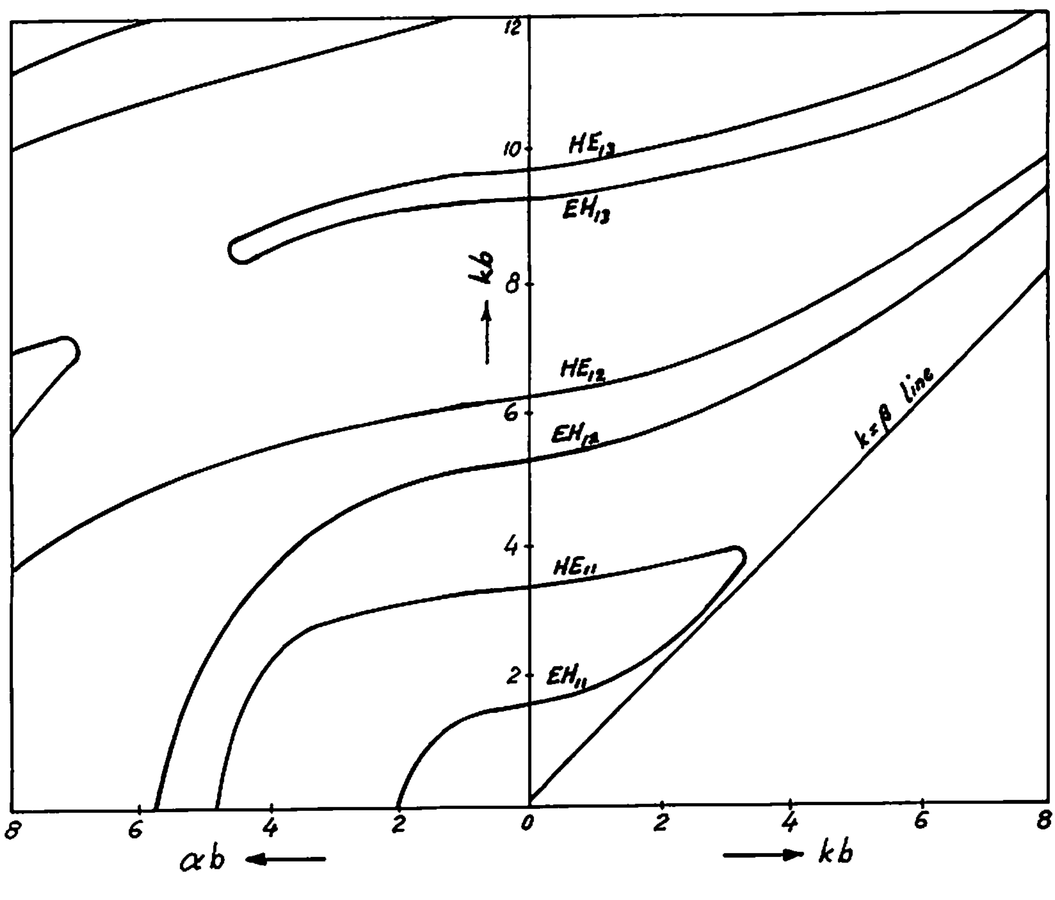

Fig. 1 Dispersion Diagram of a Corrugated Coaxil Waveguide

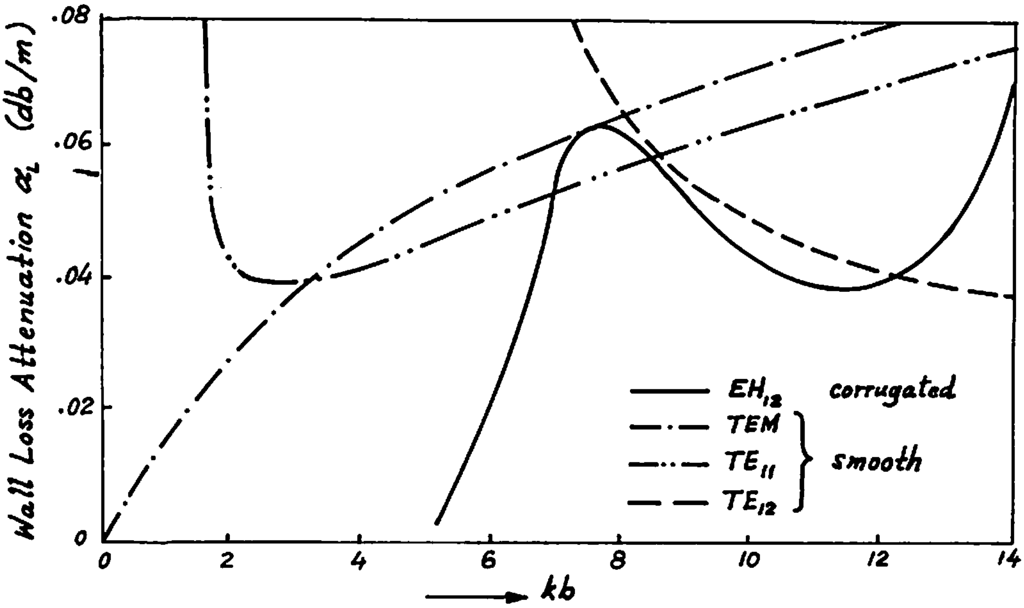

Fig. 2 Wall Loss Attenuation for Several Modes in a Coaxial Waveguide with a = 1 cm and b = 3 cm.

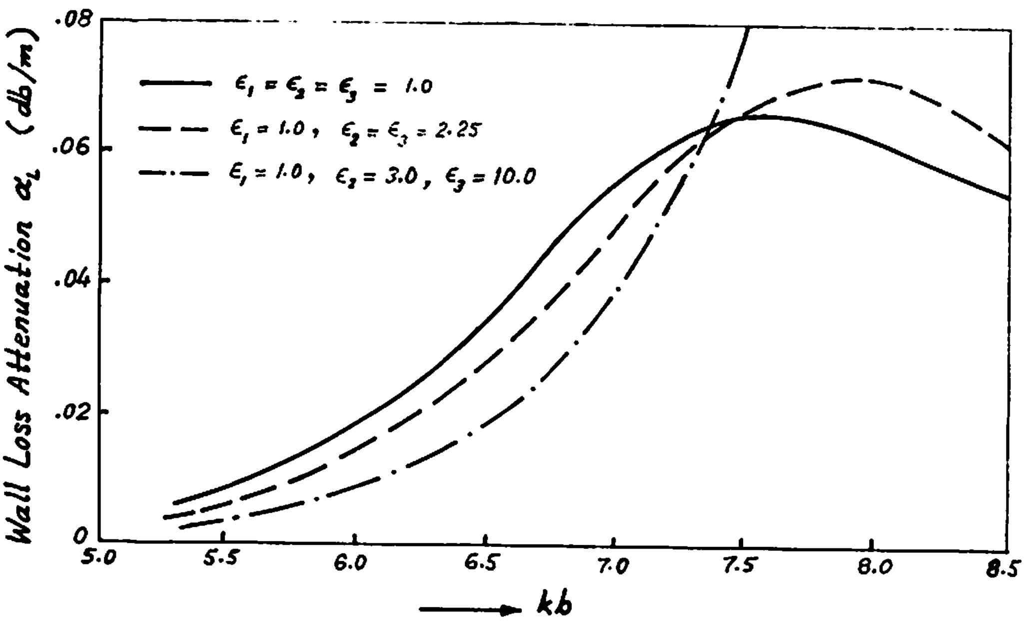

Fig. 3 Effect of Dielectric Loading on Attenuation in a Coaxial Waveguide with a = 1 cm and b = 3 cm.