II-8. WIDEBAND POLARIZER IN CIRCULAR WAVEGUIDE LOADED WITH DIELECTRIC DISCS

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At last year's Symposium, it was shown that dielectric-disc loading could greatly increase the useful bandwidth of circular waveguide (Reference 1). Figure 1 is a sketch of a circular waveguide containing spaced high-k dielectric discs which strongly load the TE-11 (dominant) mode, but have little effect on the TM-01 mode which normally limits the single-mode bandwidth. Figure 2 shows the frequency range over which modes can propagate for disc loading and for uniform loading. Disc loading offers a much greater ratio of single-mode bandwidth, whose upper limit is then determined by the TE-21 cutoff. This wider frequency band is useful in the design of various components, particularly the polarization converter to be described.

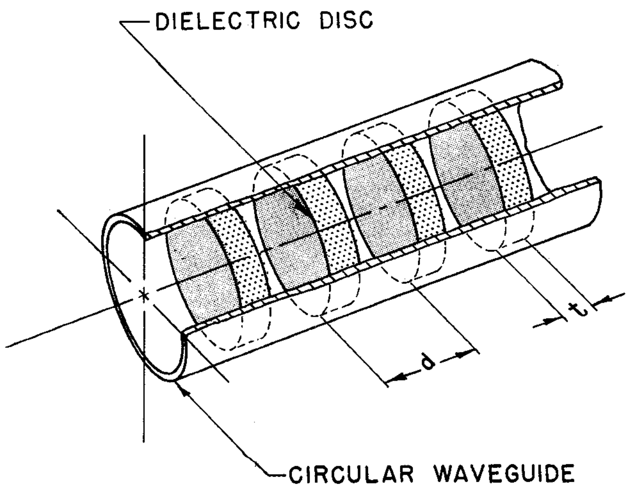

Figure 1. Dielectric-Disc-Loaded Circular Waveguide

It is well known that a conversion between linear and circular polarization can be accomplished in circular waveguide by providing differential loading for the two crossed TE-11 modes. An historic example of this is a dielectric slab located in one plane of polarization in air-filled waveguide (References 2 and 3). Unfortunately, this approach lowers the cutoff frequency of the next higher mode. Also, since the waveguide is air-filled, there is no opportunity to decrease the loading in the other plane of polarization.

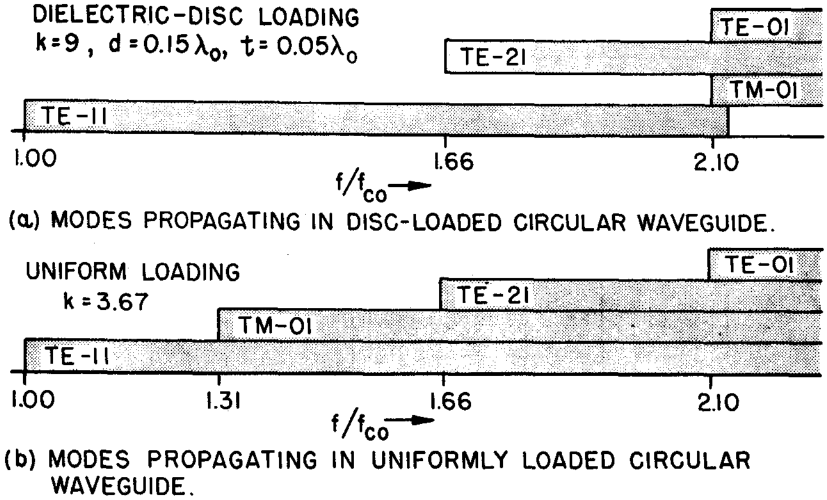

Figure 2. Relative Cutoff Frequencies

Differential loading can be achieved in disc-loaded waveguide by oblong discs which present different "equivalent dielectric constants" in orthogonal planes of polarization. Such a polarizer does not proportionately load the next higher mode. Moreover, the loading may be increased in one plane and decreased in the orthogonal plane, thus minimizing the departure from the "normal" loading in the abutting waveguide. As two component waves with space-quadrature polarization propagate through the anisotropic discs, a 90 degree difference in time phase may be obtained, this being the requirement for conversion between linear and circular polarization. The phase difference can be maintained very close to 90 degrees over a wide band of frequencies. This principle is illustrated in Figure 3, where the variation of transmission phase with frequency is plotted for 3 degrees of dielectric loading. The center curve is for a medium value of "effective dielectric constant" (k) and corresponds to the loading in the waveguide which abuts the polarizer. The other two curves are for greater and lesser values of k, effective in the orthogonal planes of polarization. It is noted that there is a bandwidth over which there is nearly constant phase difference between the high-k and low-k channels. Exact time-quadrature may be achieved at two frequencies in the band.

A polarizer has been designed with four oblong discs as shown in Figure 4. For reference, one iterative section of the abutting waveguide is shown at the rear in the photograph. In the polarizer region, the effective k is decreased along the vertical axis, which includes series air gaps. Along the horizontal axis, the effective k is increased, because the polarizer discs are thickened and air gaps are avoided. The partial filling that is characteristic of disc-loaded waveguide allows flexibility for these adjustments in the design of the polarizer.

As previously stated, the TE-21 cutoff frequency imposes the upper limit on the useful bandwidth in disc-loaded waveguide. One might wonder if the thicker discs in the polarizer region would give a lower cutoff frequency in the TE-21 mode. This does not happen, since the average loading of the TE-21 mode is not increased. The single-mode feature of simple disc loading is preserved.

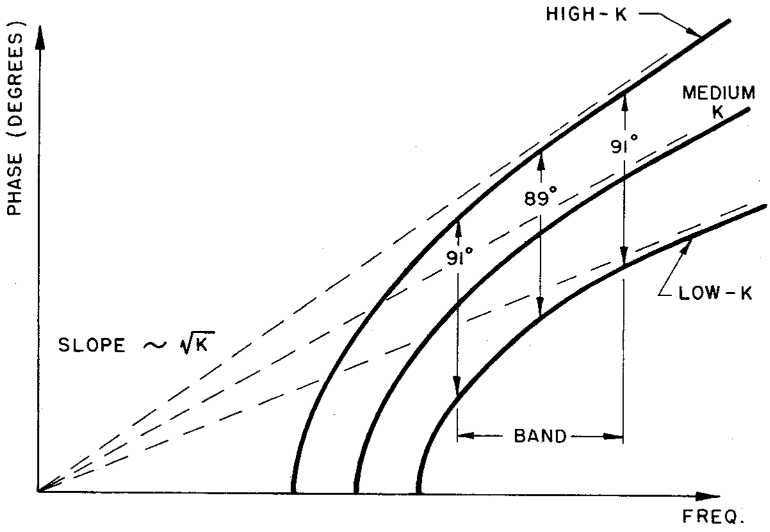

Figure 3. Phase versus Frequency for Differential Loading

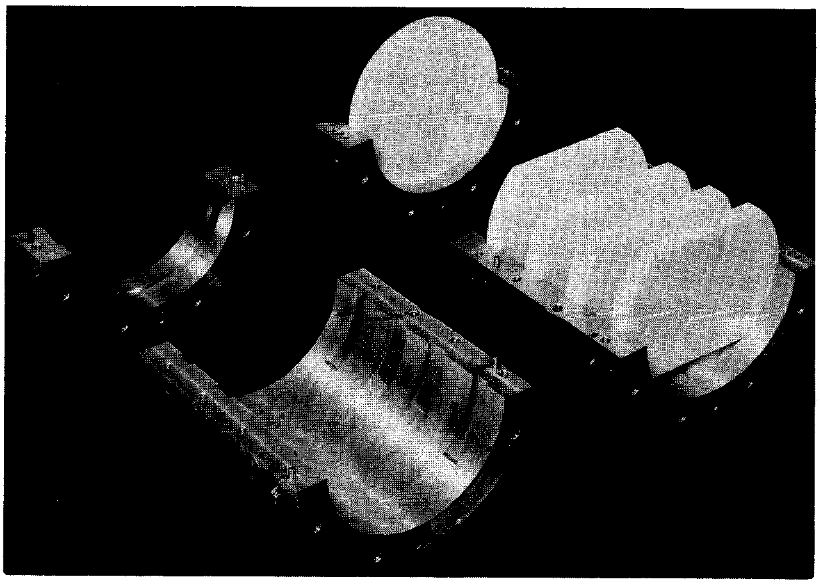

Figure 4. Development Model

The dimensions of the developmental model were determined empirically by slotted-line measurements. The transmission phase through the polarizer was measured for linear polarization in the respective high-k, and low-k planes. Impedance matching in both planes was accomplished by tapering the change of loading from the center to either end of the polarizer. The reflection measured in each channel of the polarizer is plotted in Figure 5. The SWR is within 1.5 db over a bandwidth of about 15 percent. Figure 6 shows the phase difference between channels over the same bandwidth, the variation is within ±1 degree from the average, and within 2 degrees from the objective (90 degrees). From these properties, the axial ratio of polarization is computed to be within 0.3 db over this bandwidth This performance qualifies the dielectric-disc polarizer for applications where wideband conversion between linear and circular polarization is required. Such a polarizer may be used in the feed of a reflector-type antenna, in the radiating element of a phased array, or in a two-channel rotary joint employing waves with opposite circular polarization.

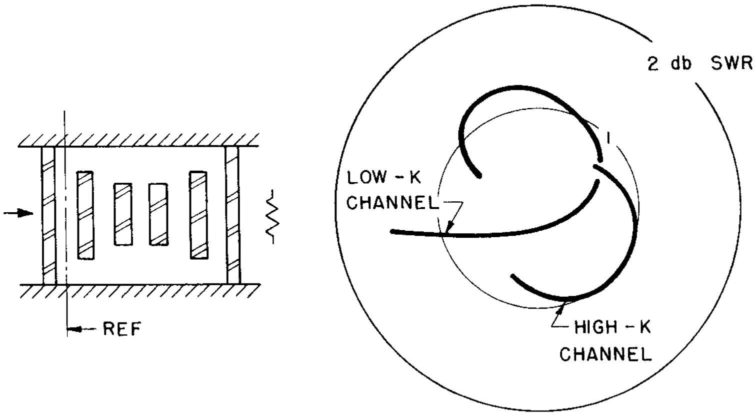

Figure 5. Polarizer Reflection Across Approximately 15 Percent Band

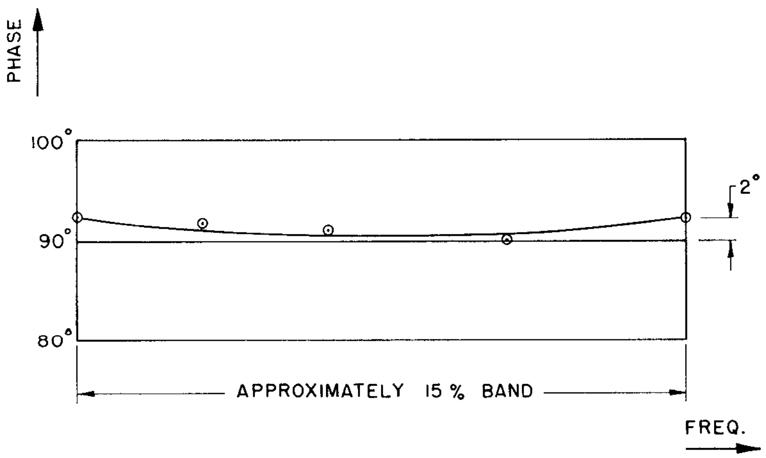

Figure 6. Phase Shift versus Frequency

ACKNOWLEDGMENT

The direction and encouragement provided by R. L. Mattingly, P. H. Smith, and others at Bell Telephone Laboratories, are gratefully acknowledged.

REFERENCES

1. Meier, P. J., Balfour, M. A. and Wheeler, H. A., "Circular Waveguide Loaded with Dielectric Discs for Increased Usable Bandwidth," Digest of the 1964 PTGMTT International Symposium, pp. 33-36.

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