1.3 BROADBAND ISOLATORS AND VARIABLE ATTENUATORS FOR MILLIMETER WAVELENGTHS

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A Faraday rotator has been developed which provides rotation independent of frequency in a band greater than 20% centered at 55 kmc. The loss characteristics plotted in Fig. 1 are typical for broadband variable attenuators incorporating this rotator. The minimum and maximum loss characteristics are for fixed fields of 0 and ~30 oe, respectively. Figure 2 contrasts the performance of a broadband isolator (solid curves) utilizing this rotator with a "conventional" Faraday rotation isolator (dashed curves). The broadband isolator has a forward to reverse loss ratio > 30 over a band 10 times as great as that for the "conventional" rotator and from 3 to 5 times greater than any other isolator known, to the author, to operate at these frequencies.

Unlike field displacement and gyromagnetic resonance devices which require magnetic fields proportional to the operating frequency, the Faraday rotator is a low field device with the field requirement determined by the composition and dimensions of the Ferromagnetic material. Contrast the 25-50 oe. field required by the above devices with the field of ~20,000 oe. required for resonance at these frequencies.

The principal problems associated with "conventional" millimeter wave rotators have been the bandwidth and the small dimensions of the ferrite rods. We obtain broadband rotation by utilizing a ferrite dielectric waveguide structure. Figure 3 from Southworth[1] shows that for the hybrid HE_{11} mode on a dielectric rod waveguide, there is a critical diameter for the rod $\left(\frac{2a}{\lambda_o} \approx .4 \text{ for } \epsilon = 10\right)$ above which the phase velocity, V, is approximately equal to the phase velocity in an infinite dielectric medium. When the dielectric rod is a longitudinally magnetized rod of ferrite of greater than critical diameter, the rotation obtained is characteristic of an infinite ferrite medium which was shown by Hogan[2] to be independent of frequency subject to the restriction that the field be much less than that required for resonance.

Dielectric waveguide rotators designed to operate about 55 kmc and utilizing common nickel-zinc ferrites of ~5000 gauss saturation magnetization require rods of .070 inches diameter which is about twice that of rods used in "conventional" rotators. Thus, the dielectric guide rotator offers not only increased bandwidth but the possibility of working at roughly twice the highest feasible frequency for the "conventional" rotator.

Since the dielectric waveguide rotator does not require a conducting cylinder around the ferrite element, its control field can be varied rapidly without the usual eddy-current losses. The fast response and low field requirement of these devices permits amplitude modulation of several hundred kc. This feature has been used to great advantage in an automatic level control system capable of removing variations of several kc frequency content from the swept frequency output of a millimeter wave BWO. Figure 4 shows the available power from a BWO swept from 50 to 60 kmc before and after leveling. The total variation was reduced from near 7 db to ~0.5 db.

This type of rotator may be designed for use at any frequency subject only to limitations on dimensions and the availability of suitable materials and should be readily incorporated into any of the many Faraday rotation devices such as circulators, multiport switches, and phase shifters.

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[1]Southworth, Principles and Applications of Waveguide Transmission, D. Van Nostrand Co., Inc., New York, pp. 130-131; 1950.

[2]Hogan, C. L., "The Ferromagnetic Faraday Effect at Microwave Frequencies and Its Applications," Review of Modern Physics, Vol. 25 No. 1, page 253; January 1953.

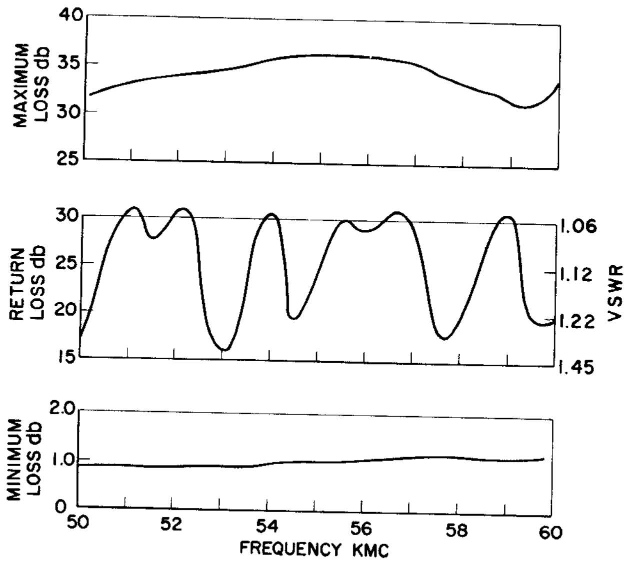

Figure 1 - Broadband Variable Attenuator Performance.

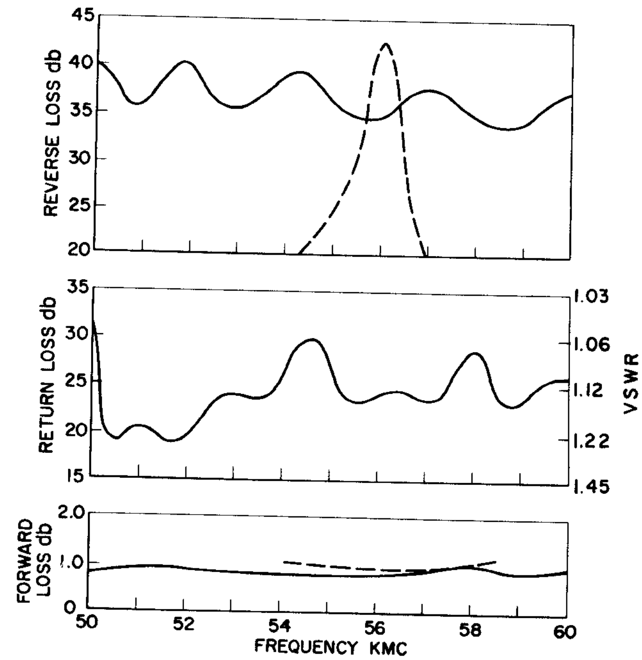

Figure 2 - Broadband Isolator Performance.

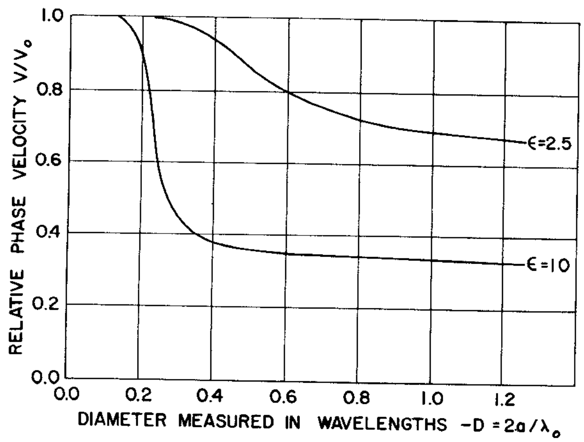

Figure 3 - Phase Velocity for A Dielectric Rod Waveguide From Southworth

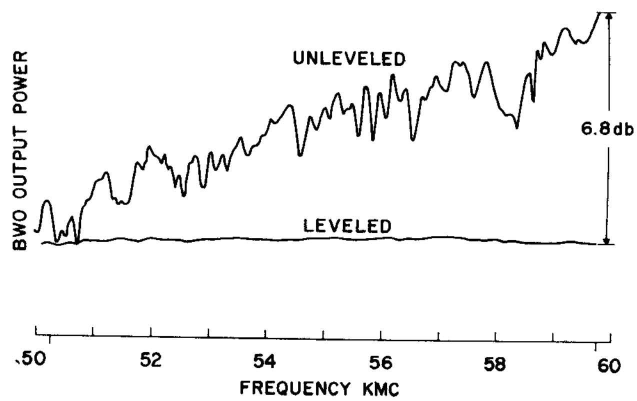

Figure 4 - MM Wave Power Leveling.