3.2 A FIELD DISPLACEMENT ISOLATOR AT 57 KMC

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Ferrite devices employing the field displacement principle or ferromagnetic resonance are difficult to build in the millimeter wavelength region because of the high magnetic fields usually required for biasing the ferrite. In conventional ferrites, the upper limit of the saturation magnetization, $4\pi M_S$, is about 6000 gauss. For resonance with the most favorable ferrite shape, namely, a thin slab magnetized in the direction of one of its longer dimensions, the Kittel relation for resonance becomes, $f = \gamma\sqrt{H_A(H_A + 4\pi M_S)}$. Here f is the frequency of operation, γ is the gyromagnetic ratio of the electron, and H_A is the applied biasing field. Using a 6000 gauss ferrite, for resonance at 55 kmc, the required biasing field, H_A, is about 17,000 oersteds. This field is obviously difficult to obtain in a device of convenient size.

The field displacement isolator offers some advantage in the biasing field requirement, since the ferrite, instead of operating at resonance, operates in the region of a small negative effective permeability, $\mu_e = \frac{\mu^2 - k^2}{\mu} = -0.5$ to -1.0, where μ and k are the diagonal and off-diagonal components of the Polder permeability tensor respectively. However, in this case with a 6000 gauss ferrite, the required field at 55 kmc is still 15,000 oersteds.

Oriented polycrystalline materials having very high anisotropy fields, such as barium ferrite ($BaO.6Fe_2O_3$), have been found to relieve the high field requirement[1,2]. When properly magnetized, a thin slab of this material will make a resonance isolator at approximately 50 kmc without any external field applied. By applying a nominal field, approximately 360 oersteds per additional kmc, the resonance can be brought to higher frequencies. This same high anisotropy material may also be used for a field displacement isolator. In the latter case, the best shape for the ferrite seems to be a slab of rectangular cross section spaced away from the waveguide walls.

The field displacement isolator described here was made from oriented barium ferrite sold under the trade name of Indox V by the Indiana Steel Products Company. No resistance sheet was used on the face of the ferrite as in the usual field displacement isolator. The ferrite slab was cut with the direction of orientation of the material parallel to the smaller dimension of the waveguide, and it was magnetized in this direction after cutting. No external magnet was necessary, thus, the entire device is contained in a 3/4 inch length of RG98/U waveguide. The assembly is shown in Fig. 1.

The performance of this isolator over the 56 to 58 kmc range is approximately 1 db insertion loss and 60 db isolation as shown in Fig. 2. This is the best ratio at these frequencies known to us. While this isolator operates over a rather narrow band, and its performance is critically dependent on the properties of the ferrite material, it does serve to point out the usefulness of the highly anisotropic materials for field displacement devices at millimeter wavelengths.

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[1] M. T. Weiss and F. A. Dunn, "A 5 MM Resonance Isolator," Trans. IRE, on Microwave Theory and Techniques, MTT6, p. 331, July, 1958.

[2] D. J. DeBitetto, F. K. duPre and F. G. Brockman, "Highly Anisotropic Magnetic Materials for Millimeter Wave Applications," Proc. Symposium on Millimeter Waves, Polytechnic Press, Polytechnic Inst. Brooklyn, N. Y., pp. 95–108, 1960.

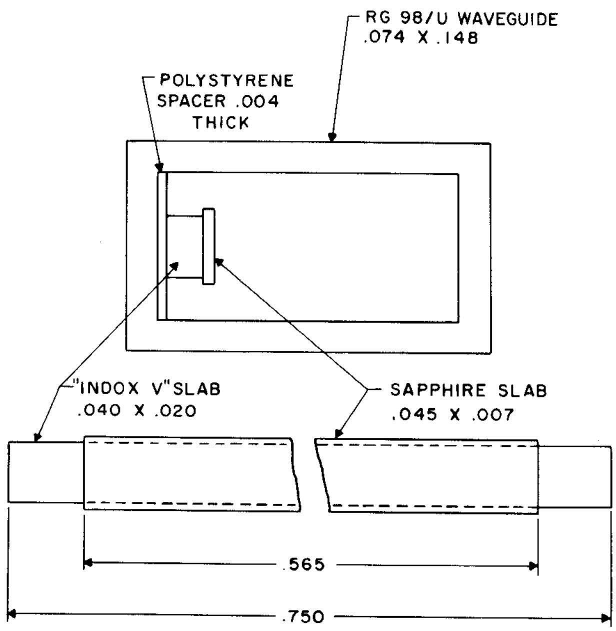

Figure 1 - Dimensions of the Isolator.

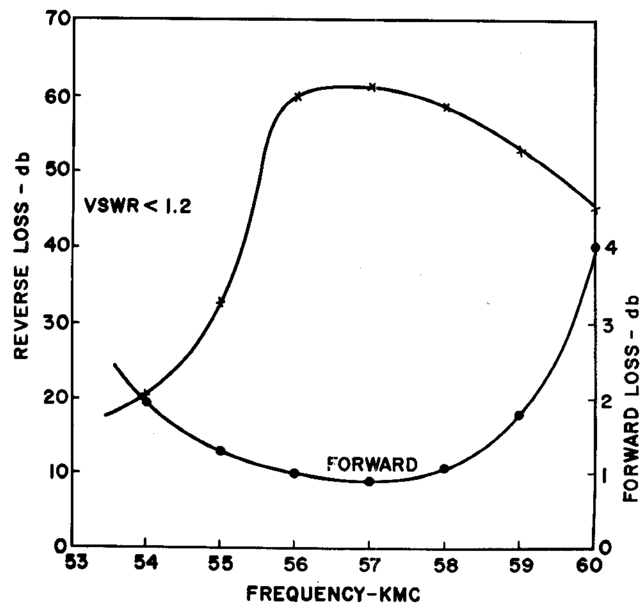

Figure 2 - Performance of the Isolator.