V-6. OVERSIZE WAVEGUIDE QUASIOPTICAL FERRITE DEVICES*

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Oversize waveguide quasioptical techniques, which have been used in the past to develop many components (Reference 1 and 2) have not been used to design nonreciprocal ferrite devices at wavelengths as low as 1 mm. These Faraday rotation devices include an isolator, four-port circulator, and modulator. Initial experiments have demonstrated the rotation phenomena and yielded information on ferrite properties at these small wavelengths. In this paper, devices will be described and experimental data will be given. Previous work on millimeter Faraday rotation devices has been at longer wavelengths and used standard sized waveguide (Reference 3).

In oversize waveguide, ferrite configurations that are used in conventional size guide are inadequate because they generate propagating higher-order modes. Optical structures such as slabs and gratings over the complete cross section of the guide are necessary.

Figure 1 shows an oversize waveguide isolator. It requires an oversize waveguide tee-junction, two gratings, and a ferrite section. A wave incident at port 1 is reflected to the left, rotated in polarization by 45 degrees, and coupled to port 2. Power reflected from port 2 is rotated another 45 degrees and coupled to a dummy load. Thus, power couples from port 1 to port 2, but is isolated from port 2 to port 1.

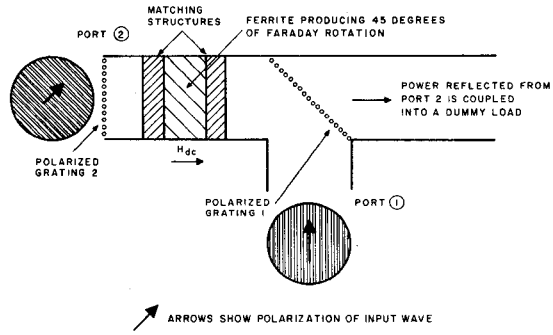


Figure 1. Oversize Waveguide Isolator

*The work described here was supported in part by the Rome Air Development Center under Contract AF30(602)-3343.

Figure 2 shows an oversize waveguide circulator with four ports. A wave arriving from port 1 is reflected toward port 2 by the center grating. The wave is rotated 45 degrees by the ferrite section in port 2, and then coupled to the output of port 2 since its new polarization is normal to grating 2. A wave arriving at port 2 is rotated an additional 45 degrees and then has a polarization normal to grating 1. It therefore propagates into port 3. The ferrite in arm 3 rotates the polarization another 45 degrees, and the wave couples through grating 3 into port 3 output. Similarly, a wave from port 3 goes to port 4, and a wave at port 4 goes to port 1

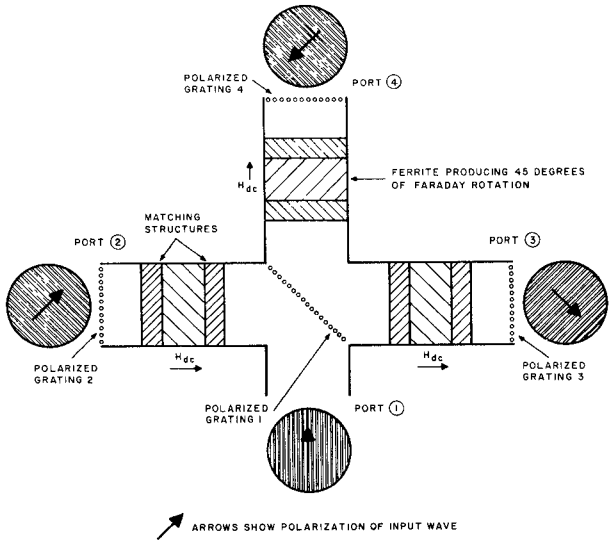
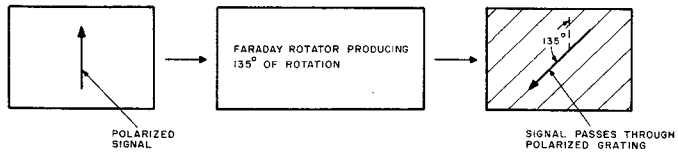


Figure 2 Oversize Waveguide Circulator

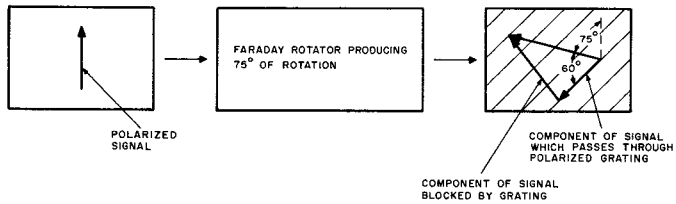
Figure 3 shows an oversize waveguide ferrite modulator. A rotated wave, for example 135 degrees, is made to pass through a grating. If, however, the rotation is time varying between 45 and 135 degrees, then only the component of field favorably oriented to the polarizer will be passed, thus producing modulation. A modulation index from 0 to 100 percent can be obtained for a time varying rotation from 45 to 135 degrees.

Experiments to demonstrate the phenomena of Faraday rotation in oversize waveguide at 2 and 1 mm have been performed in oversize circular waveguides. Rotation angles up to 60 degrees have been obtained with the same magnetic field strength over the band (Reference 4) from 135 to 155 gc and 285 to 315 gc. Losses due to undesired modes were kept to 0.2 and 0.4 db over these bands. Magnetic losses were of the same magnitude. An estimate of dielectric constant for the ferrite used (R-6, a Mg-Mn-Al material) was made (ϵ_r = 9.5) at 2 mm. We also estimate the loss tangent to be tan δ = 0.003. Figures 4 and 5 show some of the data obtained at 2 and 1 mm wavelengths.

The isolator (Figure 6) and circulator have been constructed in oversize circular guide and are being evaluated The modulator is under construction. Data will be presented on the overall operation of these devices. The data to date indicates that nonreciprocal components may indeed be made to operate in oversize waveguide at 2 and 1 mm. The use of these components along with others that have been developed will make it easier to assemble RF systems at these short wavelengths.



A. OPERATION OF FARADAY ROTATOR WITHOUT MODULATION



B. OPERATION OF FARADAY ROTATOR USED AS A MODULATOR

Figure 3. Oversize Waveguide Modulator

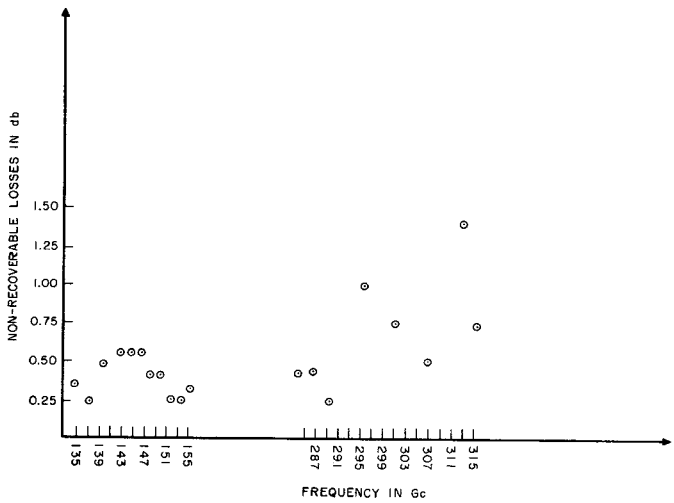


Figure 4. Nonrecoverable Losses with Magnetic Field Set for 45-Degree Rotation at 2 and 1 mm.

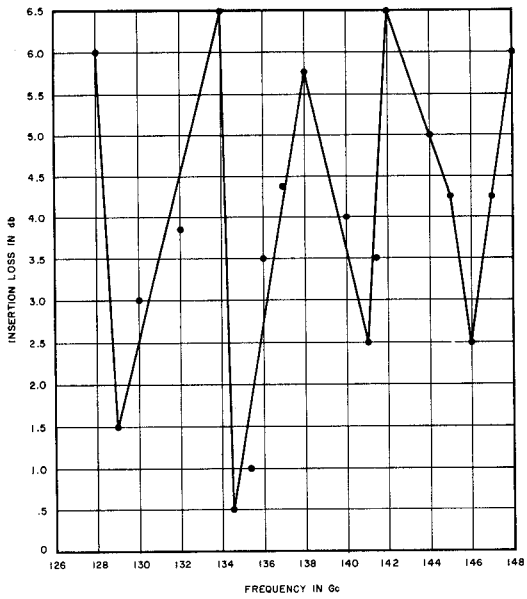


Figure 5. Cyclical Insertion Loss of R-6 Ferrite at 2 mm Showing Mismatch Effect. Dielectric Constant and Loss Tangent are Determined from this Data

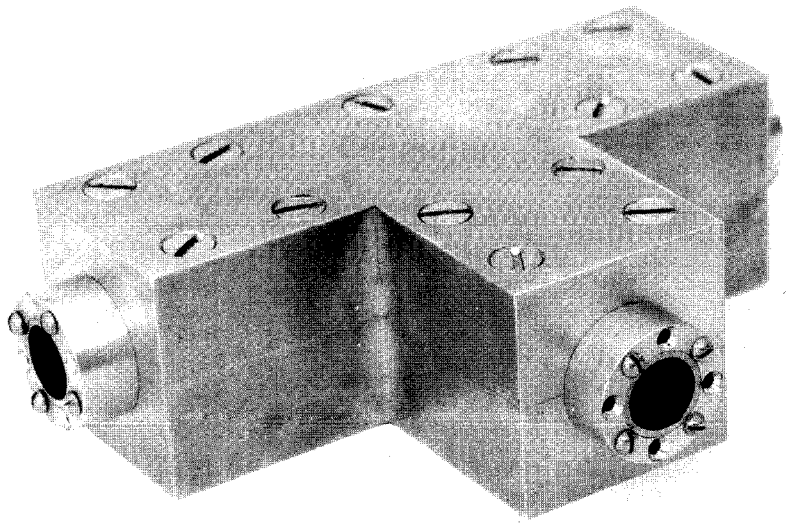


Figure 6. Oversize Isolator

ACKNOWLEDGEMENTS

Mr. J LoMascolo of RADC furnished the 1-mm test setup and participated in the experimental work. His cooperation is gratefully acknowledged.

REFERENCES

1. Taub, J. J., Hindin, H. J., Hinckelmann, O. F. and Wright, M L., "Submillimeter Components Using Oversize Quasi-Optical Waveguide," IEE Transactions on MTT, Volume MTT-11, September 1963.

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4. Taub, J J., Cohen, J., Hindin, J. H., Kurpis, G., Arams, F. R. and Peyton, B., "First Quarterly Report on Millimeter and Submillimeter Component Development," RADC-TDR-64, Contract AF30(602)-3343, June 1964.