A Short Rugged Ferrite Half-Wave Plate for a Single-Sideband Modulator*

One type of microwave phase shifter consists of two quarter-wave plates between which is placed a half-wave plate whose principal axis is rotatable.[1] The phase shift introduced is directly proportional to the angular displacement of the principal axis of the half-wave plate. Continuous rotation of the principal axis causes continuous advancement or retardation of the phase of the signal traversing the phase shifter. This causes a frequency shift of the signal and the device can thus be used as a single-sideband modulator.[2]

A ferrite half-wave plate in reduced guide has been described by Karayianis and Cacheris.[3] The direction of the applied transverse magnetic field forms the principal axis of the half-wave plate. The advantage of working in reduced guide is that since the guide is more dispersive, a higher differential phase shift per applied field can be obtained. The major disadvantage is the increased difficulties associated with matching the ferrite loaded reduced guide to the normal waveguide run. Matching was attempted by Cacheris and Karayianis by using two 2-inch dielectric tapers. These are difficult to manufacture and are lengthy for some applications.

A certain amount of work has been carried out using a tube of ferrite in reduced guide. The ferrite used was an experimental ferrite Type MM3 supplied by Marconi's Wireless Telegraph Company, Ltd. The dimensions of the tube are 0.7 inch O.D. ×0.5 inch I.D.×2 inches long. The ferrite tube was loaded with distrene tubes of 0.5 inch O.D. and various I.D. dimensions. The final half-wave plate arrangement is shown in Fig. 1.

Fig. 2 shows a typical phase shift characteristic obtained. The kinks associated with the ordinary wave phase characteristic are a function of the ferrite tube dielectric loading and the input matching arrangement. The input circuit consisted of a single "quarter wavelength" transformer, which was a distrene tube of 0.70 inch O.D. and the I.D. was determined experimentally for any particular frequency range. A typical value was 0.312 inch I.D. The minimum length of the transformer is determined by the winding overlay (Fig. 1). A typical performance curve for this transformer is shown in Fig. 3. It is evident that the insertion loss of the half-wave plate is extremely mismatch sensitive. Where the mismatch is small the insertion loss is approximately 1 db. An impedance plot of this arrangement would not yield a simple theoretical broadband match.

The over-all length of the half-wave plate and matching assembly is less than 3 inches. It could be useful in a single-sideband modulator where a rugged and compact design is desirable, and where narrow band operation is satisfactory.

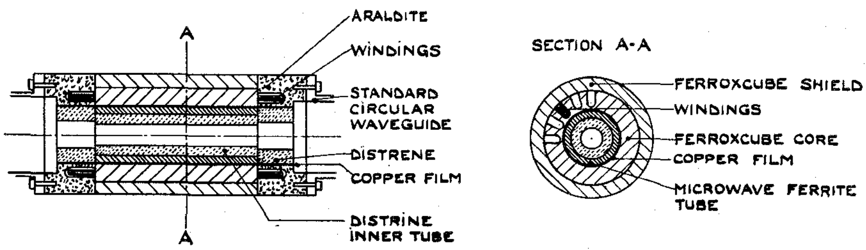

Fig. 1—Cross section of ferrite half-wave plate.

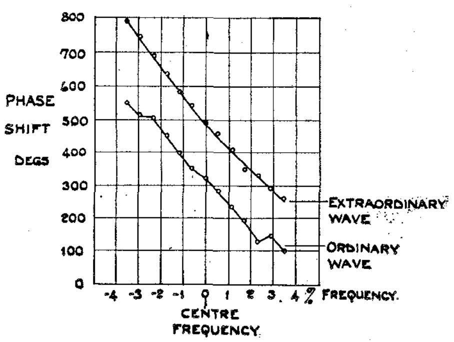

Fig. 2—Phase shift vs frequency characteristic or ordinary and extraordinary wave propagation.

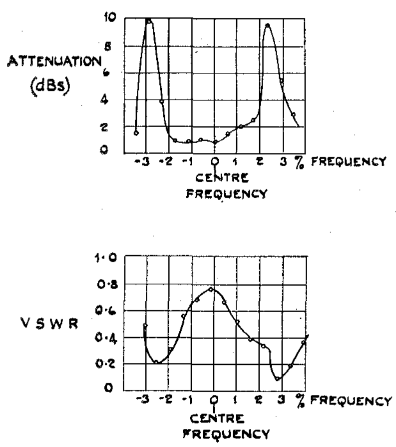

Fig. 3—Attenuation and VSWR vs frequency characteristic of the ferrite half wave plate.

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* Received by the PGMTT, October 9, 1958.

[1] A. G. Fox, "An adjustable wave-guide phase changer," Proc. IRE, vol. 35, pp. 1489–1498; December, 1947.

[2] J. Cacheris, "Microwave single-sideband modulator using ferrites," Proc. IRE, vol. 42, pp. 1242–1247; August, 1954.

[3] N. Karayianis and J. Cacheris, "Birefringence of ferrites in circular waveguide," Proc. IRE, vol. 44, pp. 1414–1421; October, 1956.

A Technique for Minimizing Hysteresis in a 35-DB Ferrite Variable Attenuator*

A requirement arose for a low-power microwave transmitter, the output power of which could be controlled over 40 db with a reset accuracy of 0.5 db for single frequency operation.

The experimental arrangement used is shown in Fig. 1.

The electronically variable short circuit is shown in Fig. 2. This has been described by Scharfman.[1]

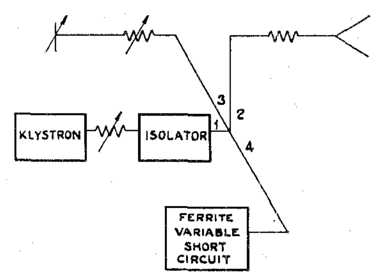

Fig. 1—Variable attenuator.

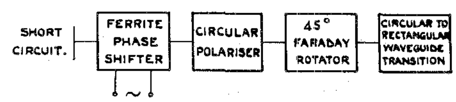

Fig. 2—Electronically variable short circuit.

For one sense of circular polarization the slope of the phase shift vs field curve becomes zero as the ferrite saturates, but for the other sense this is not so marked. This is shown in Fig. 3. Fig. 4 shows the attenuation between arms 1 and 2 vs relative phase difference between arms 3 and 4 of the magic T. It can be seen that the slope of the attenuation vs relative phase shift characteristic curve is extremely steep at the maximum attenuation point. Consider a negatively circularly polarized wave fed into a ferrite loaded section which is subjected to a field sufficiently large to saturate the ferrite. This corresponds to the point P in Fig. 3. The attenuator and short circuit in arm 3 can now be adjusted to give maximum attenuation between arms 1 and 2. This

* Received by the PGMTT, October 9, 1958.

[1] H. Scharfman, "Three new ferrite phase shifters," Proc. IRE, vol. 44, pp. 1456–1459; October, 1956.