Correspondence

A 5-MM Resonance Isolator*

The rectangular waveguide resonance isolator operating at frequencies from 3000 to 24,000 mc is a simple and compact device since the dc magnetic field requirements are relatively low. In the 5-mm range, however, resonance isolators are not practical if conventional ferrites are used because very high magnetic fields of about 20,000 oersteds are required to obtain resonance at these high frequencies. By using highly oriented Ferroxdure, resonance isolators in the millimeter range become feasible because of the high internal anisotropy field of 17,000 oersteds exhibited by this material.[1] Thus, with Ferroxdure a magnetic field of a few thousand oersteds is sufficient for resonance in the 5-mm region.

Such a 5-mm resonance isolator has been built and is shown in cross section in Fig. 1 and assembled in Fig. 2. A brief description of the assembly of this device might be of interest. A piece of highly oriented Ferroxdure was carefully ground to a thickness of 0.005 inch, a width of 0.021 inch, and a length of 2 inches. This material was then mounted on a strip of 0.020-inch thick laminated polystyrene using carbon tetrachloride and polystyrene as the adhesive. This strip served to space the ferrite from the waveguide wall by the proper amount. In addition, a strip of 0.010-inch thick laminated polystyrene was bonded to the other side of the ferrite in order to help concentrate the RF field in the ferrite.[2] The two strips of polystyrene also reinforced the fragile ferrite so that it could be handled without breakage. This composite sample was then placed in position against one wall of the waveguide and fastened to it, utilizing a long slim hypodermic needle to inject a mixture of carbon tetrachloride and polystyrene in the appropriate places.

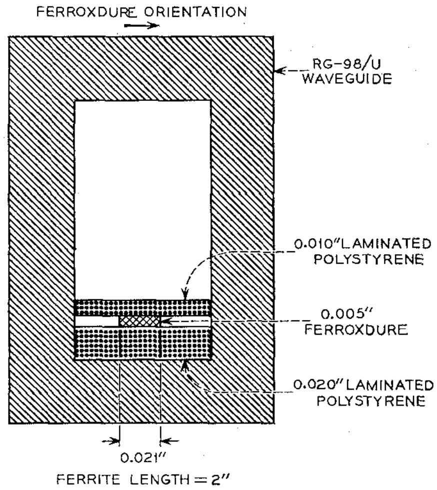

Fig. 1—Cross section of the 5-mm resonance isolator.

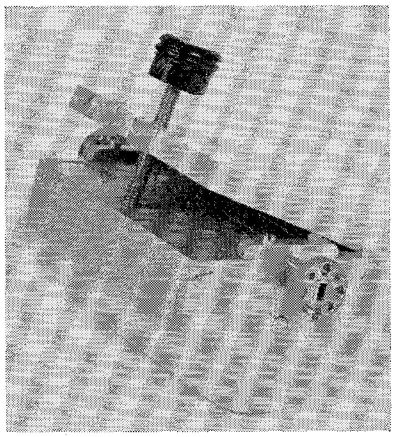

Fig. 2—Assembled 5-mm resonance isolator.

The performance of the isolator at three different frequencies is shown in Fig. 3. It can be seen that reverse-to-forward ratios of better than 20 to 1 in db can readily be obtained at a given frequency by a proper choice of dc magnetic field. The VSWR was measured to be less than 1.1 even though no effort was made to match the device.

In order to permit the operation of the isolator over a wide range of frequencies with a high reverse-to-forward ratio, it is evident from Fig. 3 that the dc field must be varied as the frequency is changed. This magnetic field variation is accomplished by means of a variable shunt placed on top of the magnet as shown in Fig. 2. The shunt is varied by means of the screw which permits one to change the field in the gap from 1200 to 4300 oersteds. This unit has been used in test bench setups with at least a 20 to 1 ratio in db over the frequency range from 53 kmc to 58 kmc.

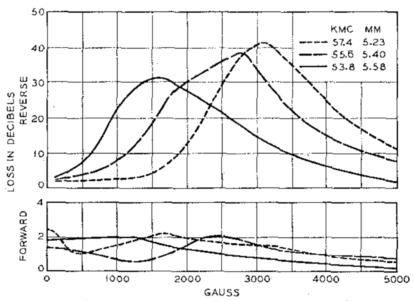

Fig. 3—Reverse and forward loss vs applied field at three frequencies for the 5-mm resonance isolator.

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[1] M. T. Weiss, "The behavior of ferroxdure at microwave frequencies," 1955 IRE Convention Record, pt. 8, pp. 95–99. Also see "Ferromagnetic resonance in ferroxdure," *Phys. Rev.*, vol. 98, pp. 925–926; May, 1955.

[2] M. T. Weiss, "Improved rectangular waveguide resonance isolators," IRE Trans. on Microwave Theory and Techniques, vol. MTT-4, pp. 240–243; October, 1956.

On Riblet's Theorem*

Riblet[1] presented the following theorem which is concerned with the synthesis of a quarter-wave impedance transformer: "The necessary and sufficient conditions that a rational function of p with real coefficients written in the form

$$Z(p) = \frac{m_1(p) - n_1(p)}{m_2(p) - n_2(p)} \qquad (1)$$

with m_1 and m_2 odd or even and n_1 and n_2 even or odd, be the input impedance of a cascade of n equal-length transmission line sections terminated in a resistance are: 1) $Z(p)$ must be a positive real function of p, and 2) $m_1(p)m_2(p) - n_1(p)n_2(p) = C(p^2-1)^n$."

These two conditions are surely necessary, but are not sufficient. To illustrate, consider the following function, which meets the two conditions but is not realizable as a circuit of this kind:

$$Z(p) = \frac{m_1(p) + n_1(p)}{m_2(p) + n_2(p)} = \frac{2p^2 + 2p + 4}{3p + 1} \qquad (2)$$

where $m_1(p) = 2p^2+4$, $n_1(p) = 2p$, $m_2(p) = 1$, $n_2(p) = 3p$. Clearly, $Z(p)$ is a positive real and

$$m_1(p)m_2(p) - n_1(p)n_2(p) = (2p^2 + 4) - 2p \cdot 3p = -4(p^2 - 1)^1.$$

Hence, $Z(p)$ satisfies the two conditions of the theorem. Let us try to realize $Z(p)$ through the use of Richards' theorem as indicated by Riblet.

$$Z_c = Z(1) = 2$$

$$Z_1(p) = Z_c \frac{pZ(p) - Z_c}{-Z(p) + pZ_c} = \frac{1}{2}(p + 1) = \frac{m_1'(p) + n_1'(p)}{m_2'(p) + n_2'(p)} \qquad (3)$$

$$m_1'(p) = 1/2, \quad n_1'(p) = p/2$$

$$m_2'(p) = 1, \quad n_2'(p) = 0.$$

$Z_1(p)$ is positive real and

$$m_1'(p)m_2' - n_1'(p)n_2'(p) = 1/2 = 1/2 \cdot (p^2 - 1)^0.$$

$Z_1(p)$ meets the two conditions, but cannot be realized as a cascaded network of equal-length transmission line sections terminated in a resistance. This function should be realized as shown in Fig. 1. The total circuit representation of $Z(p)$ in (2) is shown in Fig. 2.

The following restriction must be added: "3) Assuming that the numerator and denominator of $Z(p)$ in (1) are prime to each other, the degrees of both the numerator and denominator must be equal to n."

* Received by the PGMTT, February 28, 1958.

[1] H. J. Riblet, "General synthesis of quarter-wave impedance transformer," IRE Trans. on Microwave Theory and Techniques, vol. MTT-5, pp. 36–43; January, 1957.