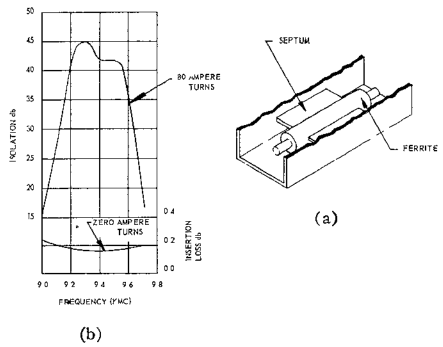

Fig. 3—Two-port reactive switch, normally on, utilizing mode-conversion properties of magnetized ferrite.

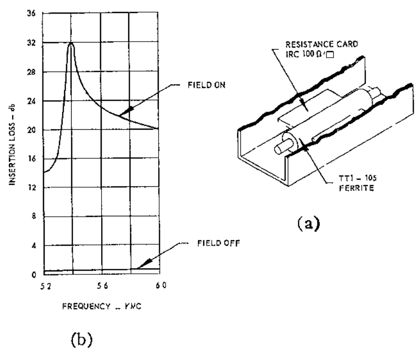

Fig. 4—*C*-band absorption switch, normally on.

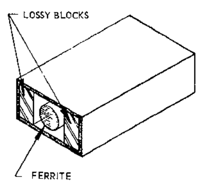

Fig. 5—Absorption switch, normally off. Field off, high insertion loss. Field on, low insertion loss.

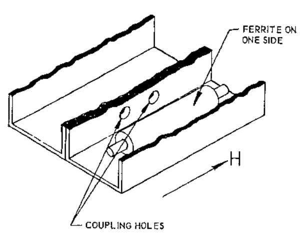

Fig. 6—Proposed variable coupler. With field applied, coupling to auxillary guide is reduced.

This indicates that there is a considerable field outside the ferrite even when saturated.

4) *Absorption Switch, Normally Off:* This configuration has not been fabricated as yet, but in principle should work well. The switch conception is illustrated in Fig. 5 and is similar to the reactive switch of Fig. 2. In this switch, the metal is replaced by lossy material so that, with zero field applied, most of the energy is absorbed. With an applied field, the RF energy is trapped to the ferrite and passes through the material with low insertion loss.

5) *Variable Coupling Devices:* A pair of coupled waveguides, one of which contains the phase-shifter geometry, is depicted in Fig. 6. When a field is applied, the energy is trapped in the ferrite and changes the coupling coefficient.

Conclusions

The suggested types of switches have a number of features which make them valuable. First, the magnetic field required is low, thus facilitating rapid switching. Second, they cannot be over-driven as in a Faraday rotation switch. Once saturated, additional field has little effect on the passage or reflection of RF energy. Excellent ratios of isolation to insertion loss can be obtained.

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Comments on "Stepped Transformers for Partially-Filled Transmission Lines"*

The use of a lumped equivalent circuit for the transverse section of a waveguide has been used to determine the cutoff frequency of ridged guide.[1,2] In essence, the transverse section of the guide is equated to an LC tank and the resonant frequency of the tank is determined by the usual formula. Sullivan and Parkes[3] have extended this method to the analysis of a ridged guide partially loaded with dielectric. They account for the additional capacitance introduced by the dielectric and include this capacitance as part of the LC tank to be analyzed for the resonant frequency. While the simplified lumped-network equivalents are always desirable in analyzing microwave networks, we should be wary of overgeneralizing them. In the case of dielectric slab loading in a waveguide, the location of the added capacitance as well as its magnitude has an effect in determining the cutoff frequency. (This can also be said of the discontinuity capacitance at the edge of a ridge.) Note how a dielectric slab when centered in a rectangular waveguide will lower the cutoff frequency far more than when flush with the sidewall.[4] This is not accounted for in the LC tank equivalent. The effect of each increment of capacitance due to each lamina of dielectric will be largely determined by the distance from the lamina to the short-circuit walls. Therefore, the author believes that the case of a partially dielectric-loaded guide can only be genuinely analyzed by the transverse resonance method or by some other method which accounts for the distributed parameters involved.

Another point for consideration in analyzing dielectric slab-loaded guide is the relationship between the guide wavelength and the cutoff wavelength—or rather the lack of relationship. Formulas for guide wavelength are based upon the right triangle relationship that exists between the propagation constants $k_{0,\kappa t,\kappa g}$. These are, respectively, the propagation constants for free space, for the waveguide transverse direction, and for the waveguide longitudinal direction.

$$k_0^2 = \kappa_t^2 + \kappa_g^2, \qquad (1)$$

where

$k_0 = 2\pi/\lambda_0$, λ_0 = wavelength of the traveling wave in free space,

$\kappa_t = 2\pi/\lambda_t$, λ_t = transverse resonant wavelength,

$\kappa_g = 2\pi/\lambda_g$, λ_g = guide wavelength.

* Received by the PGMTT, July 19, 1960.

[1] S. Ramo and J. R. Whinnery, "Fields and Waves in Modern Radio," John Wiley and Sons, Inc., New York, N. Y., 2nd ed., pp. 409–410; 1953.

[2] T. S. Chen, "Calculation of the parameters of ridge waveguides," IRE Trans. on Microwave Theory and Techniques, vol. MTT-5, pp. 12–17; January, 1957.

[3] D. J. Sullivan and D. A. Parkes, "Stepped transformers for partially filled transmission lines," IRE Trans. on Microwave Theory and Techniques, vol. MTT-8, pp. 212–217; March, 1960.

[4] N. Marcuvitz, "Waveguide Handbook," McGraw-Hill Book Co., Inc., New York, N. Y., p. 390; 1951.

$$\frac{1}{\lambda_0^2} = \frac{1}{\lambda_t^2} + \frac{1}{\lambda_g^2}; \quad (2)$$

$$\left(\frac{\lambda_0}{\lambda_g}\right)^2 = 1 - \left(\frac{\lambda_0}{\lambda_t}\right)^2; \quad (3)$$

$$\lambda_g = \frac{\lambda_0}{\sqrt{1 - \left(\frac{\lambda_0}{\lambda_t}\right)^2}}. \quad (4)$$

If the guide is completely filled with dielectric, (1) becomes

$$\epsilon_r k_0^2 = \kappa_t^2 + \kappa_g^2, \quad (5)$$

where ϵ_r is the dielectric constant of the medium relative to air.

Eq. (5) leads to

$$\lambda_? = \frac{\lambda_0}{\sqrt{\epsilon_r - \left(\frac{\lambda_0}{\lambda_t}\right)^2}}. \quad (6)$$

Usually when formulas (4) and (6) are presented λ_t is given as λ_c, the cutoff wavelength, because in the usual case where the guide has only one dielectric medium, λ_t is equal to λ_c. When the guide contains dissimilar dielectric media, however, λ_t is generally not equal to λ_c. Therefore, λ_c as well as f_c, the cutoff frequency, cannot be used to determine λ_g as in formulas like (4) and (6). This point is widely unappreciated. Sullivan and Parkes, for instance, have used the cutoff frequency in a formula akin to (6) attempting to determine λ_g for a dielectric slab-loaded guide.[5]

In a guide having one dielectric medium in the transverse plane, the transverse resonant wavelength for each mode is fixed and independent of the frequency of the traveling wave. In a guide having different dielectric media, however, the transverse resonant wavelength for each mode will vary as a function of the traveling-wave frequency as well as of the geometry of the system. Furthermore, each dielectric medium will contain a different transverse resonant wavelength.[6] In a dielectric slab-loaded guide, the air region and the dielectric region will each have a different transverse resonant wavelength, λ_{ta} in the air region and $\lambda_{t\epsilon}$ in the dielectric region. In all cases, λ_{ta} will be different from $\lambda_{t\epsilon}$, but both λ_{ta} and $\lambda_{t\epsilon}$ will yield the same λ_g when used in (4) and (6), respectively.

As the frequency increases, the *RF* tends to concentrate in the region of highest dielectric constant.[7] When the frequency is reached at which $\lambda_g = \lambda_0$, there is no longer any transverse propagation in the air region. λ_{ta} becomes imaginary, and in the transverse plane, the air region is a guide below cutoff. Nevertheless, (4) or (6) will still yield λ_g if we know λ_{ta} or $\lambda_{t\epsilon}$, respectively.

For the dielectric slab-loaded guide, (1) and (5) are modified respectively,

$$K_0^2 = \kappa_{ta} + \kappa_g^2 \quad (7)$$

$$\epsilon_r K_0^2 = \kappa_{t\epsilon} + \kappa_g^2 \quad (8)$$

where

$$\kappa_{ta} = 2\pi/\lambda_{ta}$$

$$\kappa_{t\epsilon} = 2\pi/\lambda_{t\epsilon}.$$

The determination of λ_g for this case is usually made by simultaneously solving (7), (8) and the transverse resonance equation of the given geometry.[6]

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[5] Sullivan and Parkes, *op. cit.*, see (13).

[6] C. G. Montgomery, R. H. Dicke, and E. M Purcell, "Principles of Microwave Circuits," McGraw-Hill Book Co., Inc., New York, N. Y., pp. 385–390; 1948.

[7] T. Moreno, "Microwave Transmission Design Data," Dover Publications, Inc., New York, N. Y., Fig. 11–2; 1958.

Authors' Comment[8]

The authors would like to thank Mr. Leibowitz for his comments on the article, "Stepped Transformers for Partially-Filled Transmission Lines."[3]

The analysis of a ridged waveguide partially loaded with dielectric is intended primarily to outline a means of designing dielectric stepped transitions in ridged waveguide. Because of the approximations that have been made in the analysis, it is not intended to be a precise treatment of guide wavelength as a function of the dielectric geometry for the double-ridged guide. However, we feel the design procedure will yield good results for most engineering component applications. Similar stepped dielectric transformers have also been employed successfully in the 4000- to 7000-Mc range.

Although not reported in the paper, the VSWR of a linear dielectric taper (of the same length as the stepped transition) had also been measured. The maximum recorded VSWR in the 2000- to 4000-Mc band was 1.44 as compared to a maximum VSWR of 1.10 for the stepped transition.

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[8] Received by the PGMTT, August 19, 1960.