COMMENTS ON A 2-GAP WAVEGUIDE MOUNT

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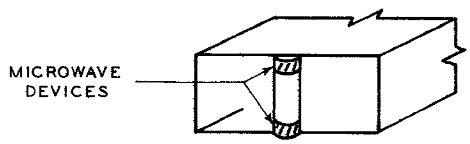
A recently developed analysis of a commonly used waveguide diode mount is discussed, with emphasis on usefulness and flexibility of application. Experimental confirmation is included for a variety of circuit configurations.

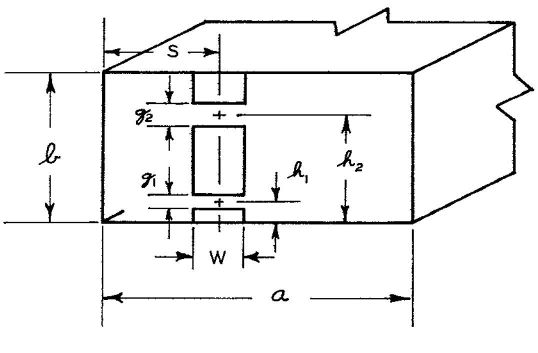
Introduction

The object of this discussion is to demonstrate the power and applicability of a recently completed analysis on a waveguide mounting structure, commonly used in the design of a variety of waveguide components. The general analysis and its resulting equivalent circuit are only reviewed briefly here because of the complexity involved; however, information will be available in the literature at a later date. In this discussion emphasis is placed on the usefulness and flexibility of the circuit.

Consider the common post-in-a-waveguide type mount having a single gap in the post for placement of a microwave device. This structure has been accurately analyzed[1] and is widely used as the basis for many applications including signal detection, amplification, generation, and control. As will become apparent later, it would be very worthwhile to have the option of including a second gap in the post, as shown in Figure 1a. This would, for example, allow placement of a varactor diode to electronically tune an oscillator diode. This "2-gap" configuration is the subject of the following discussion.



a. Typical mount with two devices



b. Parameter description for general mount

FIG. 1. Two-gap Waveguide Mount

Equivalent Circuit Review

Figure 1b shows the general 2-gap configuration, defining the eight dimensional parameters which, together with frequency, form the set of independent variables with which we must be concerned. There exists a double infinite set of waveguide modes that couple to some degree to those gap terminations. The dimensions of the waveguide determine the individual mode characteristics, while the post and gap dimensions establish the effect of the coupling to these modes from the gaps. The mathematics and equivalent circuit development follow closely Eisenhart and Khan[1] and result in the circuit shown in Figure 2. The driving point impedance (Z_R), i.e., the impedance seen looking out from one gap, is a function of the mount parameters and the impedance placed in the second gap (Z_{G2}). As expected, the circuit is symmetrical with respect to the two gaps, reducing to the single gap circuit if either of the gaps is shorted out. The values of the coupling coefficients, represented by the ideal transformers, are determined by the position parameters associated with each respective gap. These and the mode element values are specified by:

$$\alpha_n = \cos k_y h_1 \left(\frac{\sin \phi_{1n}}{\phi_{1n}}\right)$$

$$\beta_n = \cos k_y h_2 \left(\frac{\sin \phi_{2n}}{\phi_{2n}}\right)$$

where

$$\phi_{in} = \frac{n\pi g_i}{2b} \quad \text{for } i = 1 \text{ or } 2$$

and

$$Z_{Dn} = \sum_{m=1}^{M} Z_{mn} (K_{pm})^2 \quad \text{for } n = 0, 1, 2 \ldots N$$

$$Z_{G2} = \text{Loading impedance of the second gap}$$

All undefined symbols used here are defined in Eisenhart and Khan.[1]

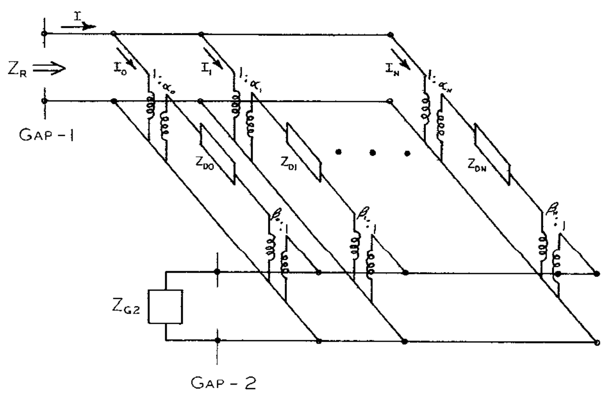


FIG. 2. Equivalent Circuit of the 2-gap Mount

Applications of the 2-Gap Circuit

This theoretical model can be used to describe the behavior of a variety of circuits, including perhaps a "single-gap" oscillator circuit which could, in fact, model the bias entry as a second gap. Of course, if the bias appears as a true microwave short, then it can be neglected; however, when modeled as a 2-gap circuit, the bias effects can be accounted for. Additional situations exist where the second gap impedance (Z_{G2}) is a sliding coaxial short, a stabilizing resistive load, or even a tuning varactor. Some of these examples will be demonstrated; however, first an aspect of an additional study[2] should be mentioned. An equivalence between a coaxial entry driving the waveguide and a gap as a driving port is demonstrated in Figure 3. The coaxial line is 50-ohm, 7-mm airline driving X-band waveguide. The results shown as the plotted points are for the measured driving point impedance. This is compared with a computer calculated plot for the gap configuration with an "equivalent gap" size (G_E) of 0.245 cm. (The required equivalent gap is, as expected, a function of the characteristic impedance and coaxial dimensions.) Utilizing this equivalence it is possible to study any of the various gap/coaxial combinations using the two-gap analysis.

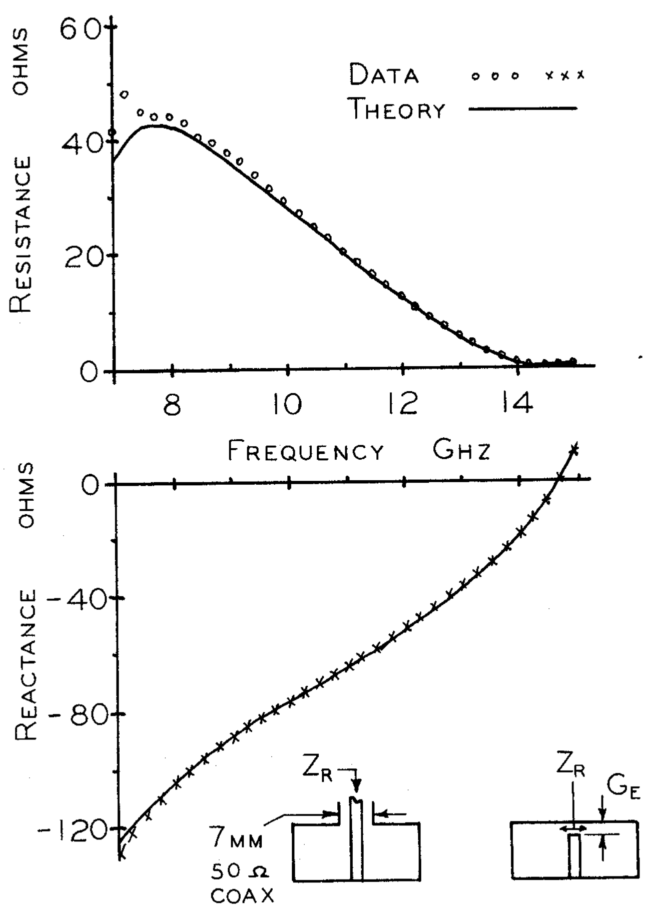


FIG. 3. Driving Point Impedance Comparison for a Coaxial Entry versus an Equivalent Gap (G_E)

The first two-gap example is that of a varactor mounted in the post a short distance from the bottom with a coaxial entry at the top of the waveguide. The driving point impedance is measured and plotted in Figure 4 at 0.0 and -30.0 volts bias. This is compared with the theory shown, using the "equivalent gap" (G_E) at the top of the guide and a standard packaged varactor model as Z_{G2}. Note the interesting effect at mid-band (10 GHz) where the reactance stays constant but the real part shifts from 17 to 31 ohms.

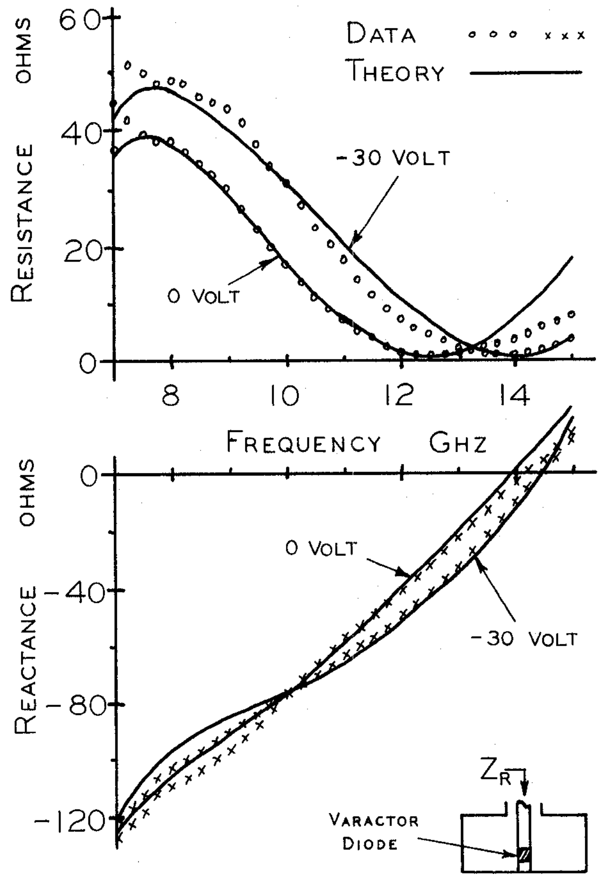


FIG. 4. Theory and Experimental Comparison for Varactor Tuning

The next mount example shown in Figure 5, uses the double coaxial configuration, requiring an "equivalent gap" representation at both ports. Three different loading conditions are established at Z_{G2} to demonstrate the versitility of this configuration. First a 50-ohm coaxial match is used to represent a lossy load. Then two different positions of a sliding short are used to represent widely varying reactive loading. The correlation between the measured data and the theory is excellent for all three conditions. These examples were chosen as typical and do not represent best cases.

Summary and Conclusions

An equivalent circuit for a 2-gap waveguide mount has been presented. Also, noting an equivalence between a coaxial entry an an "equivalent gap," the 2-gap circuit is applied to additional configurations. Using this information, theoretical curves for these configurations were generated and compared with measured data. Excellent correlation was observed, indicating the accuracy of the equivalent circuit modeling for use in microwave component design.

References

1. R.L. Eisenhart and P.J. Khan, "Theoretical and Experimental Analysis of a Waveguide Mounting Structure," IEEE Trans. on MTT, Vol. MTT-19, Aug. 1971, pp. 706-719.
2. R.L. Eisenhart, P.T. Greiling, L.K. Roberts, and R. Robertson, "A Useful Equivalence for a Coaxial-Waveguide Junction," to be published.

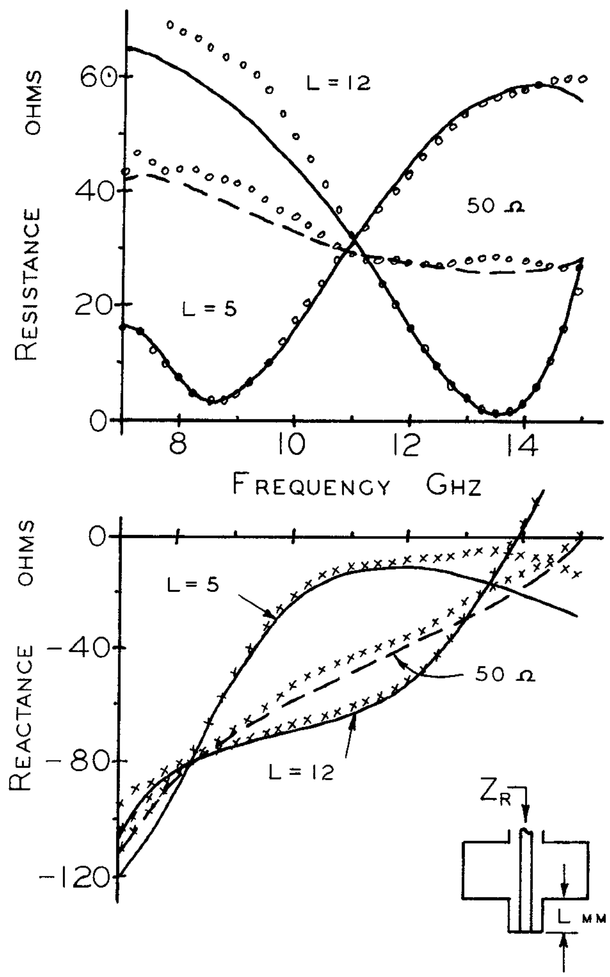


FIG. 5. Theory and experimental comparison for a 50-ohm load and a sliding short.

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