IMPEDANCE MEASUREMENT OF A WAVEGUIDE MOUNT

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Summary

A novel measurement technique is described, based upon the use of subminiature coaxial line, to gain electrical access to a terminal pair located inside the waveguide for driving point impedance measurements.

Introduction

The purpose of this work is to experimentally determine the driving-point impedance Z_R of a terminal pair, situated in a complex mounting structure which cannot be treated theoretically, thereby characterizing the impedance seen by a device mounted in such a structure. Determination of this information is necessary for realization of the theoretical design of components such as waveguide oscillators, amplifiers, mixers, frequency multipliers and converters. An example of such a structure is shown in Fig. 1 where a typical waveguide upconverter circuit is shown. The presence of the coaxial line with the low-pass filter, and the proximity of the waveguide filter elements precludes impedance determination by theoretical analysis, particularly for broadband applications.

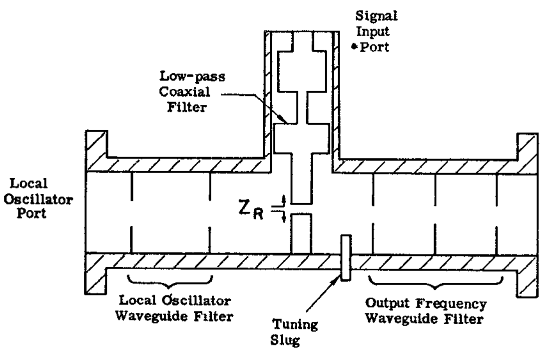

Figure 1. Typical Complex Waveguide Mount Configuration.

Z_R is defined as that impedance seen looking out through the cylindrical surface located at the edge of the gap between the mounting posts. Measurement of this terminal impedance would not normally be considered possible because of the inaccessibility of the terminals. This fact probably accounts for the lack of published material dealing with the problem. However, with the availability of subminiature coaxial cable and connectors, it is now possible to isolate the terminals electrically without affecting the surrounding field conditions, by running the measurement circuit cable inside the post. A versatile mount was designed incorporating this concept to allow impedance measurements for different gap position h, and post position s, described in Fig. 2.

Since broadband frequency measurements were desired, C-band waveguide was chosen for the mount. This resulted in a measurement range of 3-22 GHz which is consistent with equipment limitations.

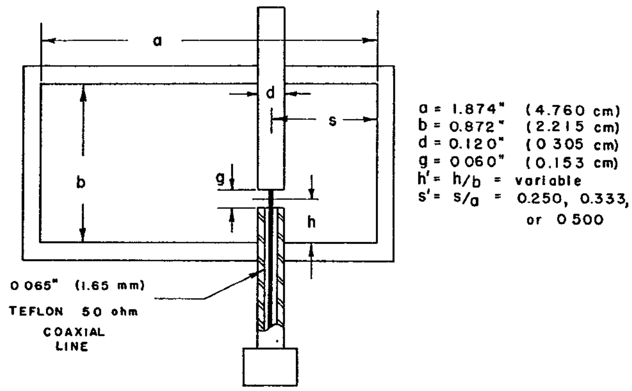

Figure 2. Measurement Mount.

Measurement Circuit Modeling

To measure the desired impedance Z_R it was necessary to provide connectors and adapters to get from the subminiature cable up to the standard 7 mm size. These elements introduced irregularities into the measurement line which, if ignored, would produce errors in the data interpretation. Additional difficulty was created by the necessary transmission-mode transformation from coaxial line to radial line at the gap. In order that a high degree of confidence could be put in the data and its interpretation, it was necessary to model these effects as an equivalent measurement circuit. A statistical comparison technique, briefly described below, was used to arrive at values defining the assumed lumped discontinuities and line lengths involved. The resulting equivalent circuit is shown in Fig. 3.

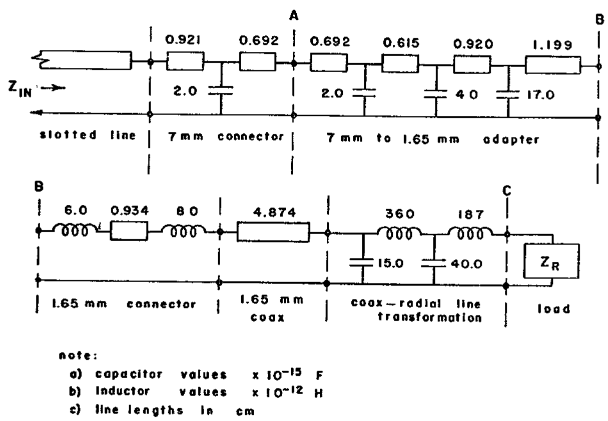

Figure 3. Measurement Circuit Equivalent Model.

Statistical Comparison Technique

The analysis of the measurement circuit was based upon the concept that the sources of error or inconsistency in a set of data could be separated statistically into two groups. First is the inherent inaccuracy in the measurement equipment, which has hopefully been minimized by proper measurement technique. The second is the interpretation error due to improper assumptions about the circuit. If a simple transmission line assumption is made for the circuit, this is in effect a "model" which, if different from the true circuit, will introduce interpretation error. As more complex models are assumed, effectively providing better approximation to the true circuit, the error due to the modeling decreases. In theory then, if a perfectly true model is assumed for the circuit, the total error will be minimized and the remaining error is due solely to the equipment (e.g., frequency drift, mechanical tolerances, etc.).

Effects of Circuit Modeling

To determine the usefulness of the measurement circuit model, comparisons were made of the various circuit effects on the data interpretation for a mount which has been theoretically analyzed.[1] Three situations were considered: first, a simple transmission line was assumed between the load and the measurement equipment; second, the coaxial-radial line transformation was introduced; and third, the complete circuit model was used. Figure 4 indicates the differences in interpretation for the last two cases compared with the theoretical case for a typical data set. Lines are used to represent the trends in the data interpretation. The simple transmission line case is not shown because it bore so little resemblance to the other cases; its only characteristic in common with the others was the placement of zeros at 6.77 and 20.3 GHz. Very worthwhile improvement is noted by including the total circuit model, justifying the effort involved.

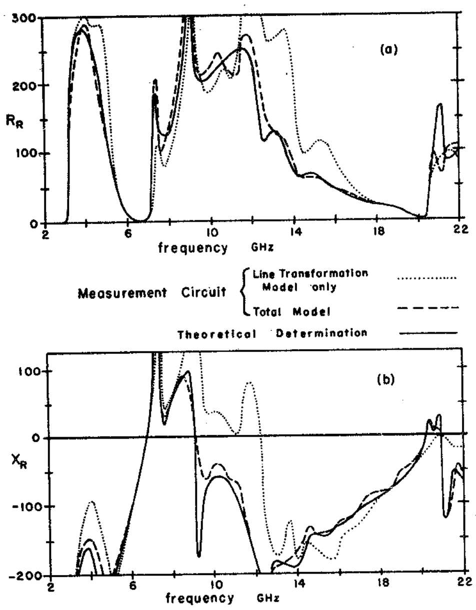

Figure 4. Measurement circuit modeling comparison for the driving point impedance.
(a) Resistive component.
(b) Reactive component.

Driving Point Impedance Measurements

The driving point impedance of the mount shown in Fig. 2 is a function of the six dimensional parameters a, b, s', h', d, and g. Only the two here referred to as the position parameters s' and h' are varied in these measurements. Relatively standard values were chosen for the others to conform to a typical mount, i.e., a, b represent C-band waveguide with d = 0.120" and g = 0.060", proper for mounting a "pill-type" device package.

Figure 5 represents the impedance for the most typical mounting configuration, with the post centered and the gap at the bottom. Theoretically-determined values are compared to those resulting from the measurements. The data clearly shows the zeros and damped poles predicted by the theory. This close correlation with the theoretical curves demonstrates the accuracy of the method of measurement. With this technique established, it is then possible to apply it to complex situations such as shown in Fig. 1.

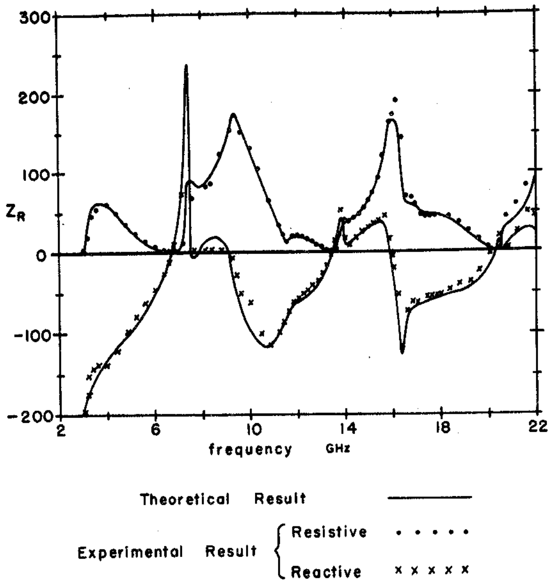

Figure 5. Driving point impedance comparison–theoretical and experimental s' = 0.500, h' = 0.035.

Conclusions

The experimental results reported here indicate the validity of this measurement technique, and its general applicability to impedance determination for configurations which are presently beyond the scope of theoretical analysis.

Reference

1. R. L. Eisenhart and P. J. Khan, "Theoretical Analysis of a Waveguide Mounting Structure," to be published in the IEEE Transactions on Microwave Theory and Techniques, August 1971.

Notes