A MATCHED COAXIAL-RADIAL TRANSMISSION LINE JUNCTION

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ABSTRACT

A broadband transition between coaxial and radial transmission lines was designed by means of an equivalent circuit developed for the junction. The design accuracy was substantiated by excellent correlation between measured and theoretical performance.

Introduction

The junction of coaxial and radial transmission lines was investigated toward establishment of an equivalent circuit that could be used for design purposes. The relationships between the physical dimensions and the equivalent circuit values were developed and then applied to the design of a junction at X-band. These relationships are presented and comparisons made between the theoretical and the measured results.

The junction has application in a power divider/combiner circuit. A similar configuration has been used in a reflection amplifier in which many active devices are paralleled by locating them around a radial transmission line. Another interesting application of this type of circuit can be seen in a recent issue of Microwaves,[1] in which the use of two radial line divider/combiners to parallel 12 GaAs FET amplifiers is discussed.

Background

Radial transmission line consists of two parallel conducting planes between which electromagnetic energy is propagated in a radial direction. An input impedance looking outward into the radial line at a given radius (r) reference plane can be derived.[2] Figure 1 shows the physical configuration, and Figure 2 shows a plot of the input impedance as a function of the input radius for frequencies of 8 and 12 GHz. The impedance has been normalized to a groundplane spacing of unity, and the radial line is assumed to be terminated at a large radius by its characteristic impedance at that radius.

As can be seen, the reactive components of the input impedance increases rapidly with decreasing input radius. Consequently, entering the radial line at a large radius would appear advantageous. However, while an increase in the input radius reduces the reactance, it also reduces the real part of the input impedance, although to a lesser degree. Because the input impedance is proportional to the groundplane spacing h, the impedance can be scaled by adjustment of h. But increasingly larger input radii would require increasingly larger groundplane spacings for the same impedance level to be maintained, and the introduction of higher order propagating modes would then become possible. Thus, a tradeoff exists between input radius and groundplane spacing.

Experimental Procedure

An experimental circuit was designed and built to demonstrate that, for a given frequency and coaxial line impedance, the height (h) and the tuning diameter (d) could be selected to give a matched junction. The circuit, shown in Figure 3, allowed variation of the groundplane spacing, the coaxial input dimension, and the entry probe geometry. It was terminated with microwave absorber. A 7-mm coaxial transmission line was selected for entry into the radial line because it was the largest coaxial line that could be used with the test equipment.

The geometry of the entry probe is shown in Figure 4 along with an equivalent circuit. This geometry was utilized because the parameters of the equivalent circuit could be estimated to first order

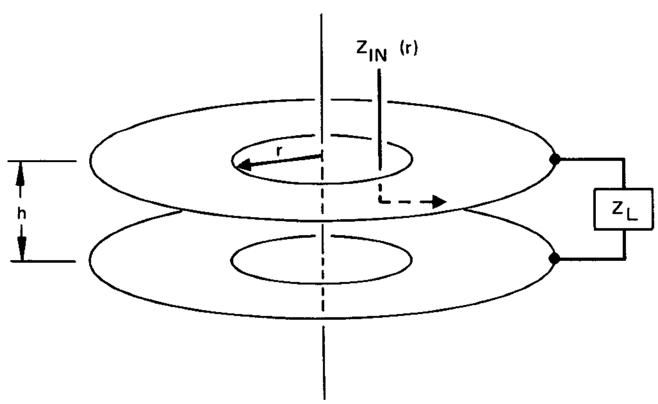

Figure 1. Radial transmission line.

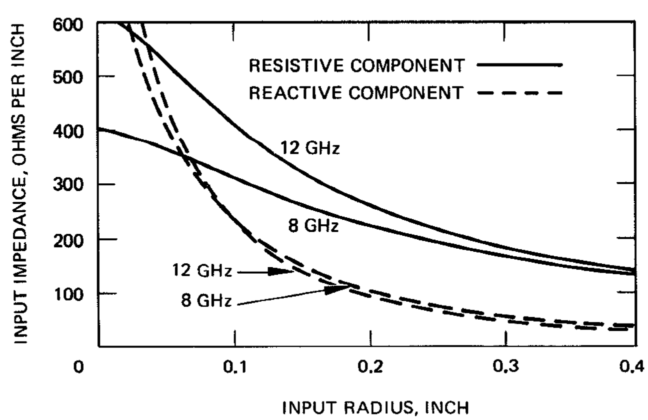

Figure 2. Effect on input impedance of input radius.

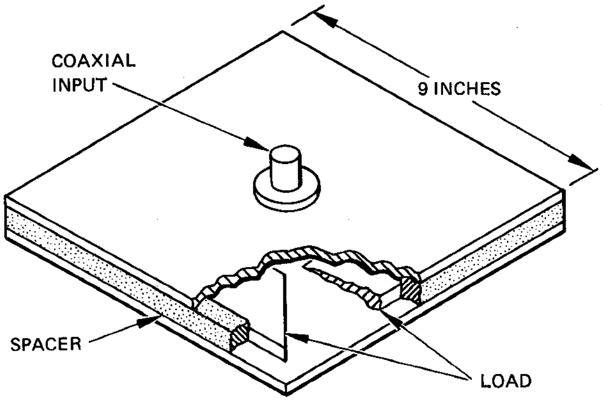

Figure 3. Test circuit.

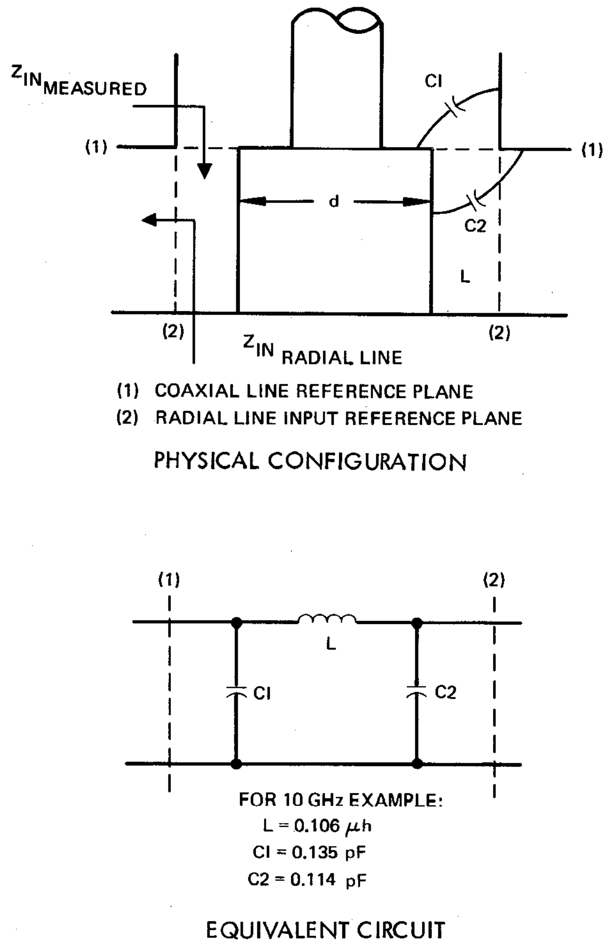

Figure 4. Modeling of junction.

with some confidence and it offered considerable flexibility for adjustment of the parameters by variation of the diameter.

The equivalent circuit values were measured from 2 to 18 GHz with the use of an automatic network analyzer. The procedure consisted of six steps:

1. Calculation of the radial line input impedance
2. Estimation of the circuit values
3. Measurement of the test circuit
4. Interpretation of the measured data
5. Comparison of measured data with total theoretical behavior
6. Adjustment of the element values and iteration of the procedure.

A de-embedding program that calculated the radial line input impedance from the measured data transformed through the equivalent circuit was utilized for interpretation of the measured data. Equivalent circuit element values were iterated around the initially estimated values until the interpreted results corresponded closely with the predicted radial line input impedance. Finally, the equivalent circuit values determined by interpretation were used for calculation of the total theoretical response of the circuit.

On the basis of all the data gathered on the radial line and the equivalent circuit of the junction, physical dimensions (h, d) were found that resulted in zero reactance and a resistive component of approximately 50 ohms at 10 GHz. The calculations predicted a total band of 4 GHz with a VSWR of less than 1.3:1.

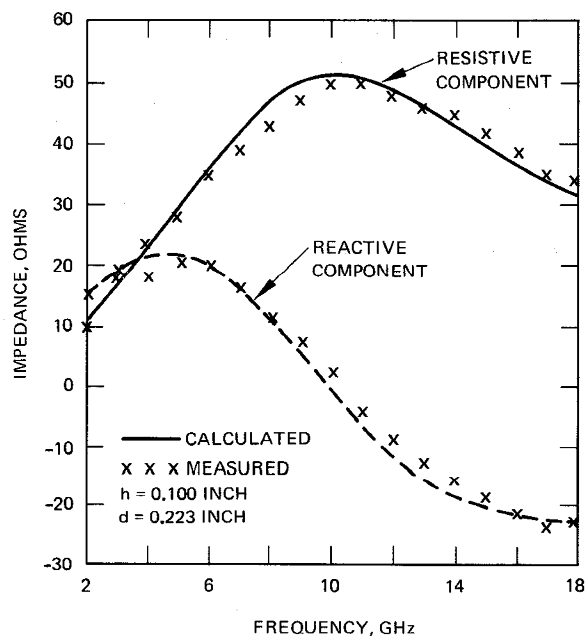

Figure 5. Total input impedance of circuit.

Results

The calculated and measured responses of the circuit are presented in Figure 5. As can be seen, the correlation is excellent. This result confirmed the choice of the equivalent circuit representation and demonstrated that a matched junction could, in fact, be designed. The measured 1.3:1 VSWR bandwidth (see Figure 6) of close to 5 GHz demonstrates the wideband characteristics inherent in this design. It is felt that the techniques utilized in this experiment could be applied to other frequencies and dimensions with similar success.

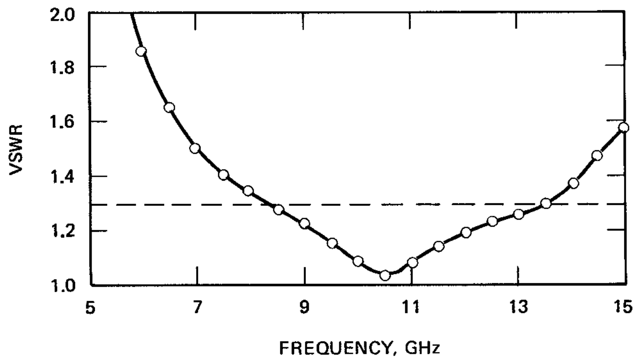

Figure 6. Measured VSWR of matched circuit.

References

[1] S. V. Bearse, "Compact Radial Power Combiner Teams Up a Dozen Power GaAs FETS," Microwaves, Vol. 16, No. 10, p. 9, (October 1977).

[2] S. Ramo and J. R. Whinnery, Fields and Waves in Modern Radio, John Wiley and Sons, Inc., New York (1953), p. 395.