X-Band Waveguide Step Transitions

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Two types of waveguide-to-waveguide transitions have been developed which permit accurate low-power laboratory tests on WR 125 waveguide components using more universally available WR 112 test equipment. A rather generally useful program for computer-aided analysis of tandem rectangular waveguide sections is being developed as a part of this effort.

I. Introduction

The X-band radar equipment requires transmission of a nominal 400-kW signal at 8.495 GHz. A study of the high-power problems associated with this requirement resulted in the choice of a new waveguide size, WR 125 (Ref. 1). This waveguide size is near optimum for both the radar frequency and anticipated frequency requirements for the DSIF (7.1 to 8.5 GHz).

The development of a well-matched waveguide-to-waveguide transition for adapting WR 125 components to WR 112 test equipment has been undertaken. Such a transition permits accurate low-power measurements using test equipment which is generally available to any microwave component manufacturer.

II. Design Considerations

The two waveguide sizes involved, WR 125 (3.175×1.588 cm) and WR 112 (2.850×1.262 cm), have relatively modest width-to-width and height-to-height ratios—1.114 and 1.258, respectively. It was decided that a carefully designed step transition would probably exhibit an acceptably low mismatch. The step type of transition has the advantage of compactness and ease of fabrication.

Two types of step transitions were designed and fabricated—a single-section and a two-section Chebyshev quarter-wave transformer. The design details were based upon the formulas and tables in Ref. 2, using the following assumptions:

(1) Waveguide characteristic impedance Z_0 is given by

$$Z_0 = \frac{377\pi b}{2a} \cdot \frac{\lambda_g}{\lambda_0}$$

where b and a are the waveguide height and width, respectively (Ref. 3).

(2) Junction discontinuity effects were neglected due to the small steps at each junction and the partial discontinuity cancellation resulting from simultaneous steps in both height and width (Ref. 4).

III. Results

The calculated geometry of the two transitions is given in Table 1. Samples of each transition have been fabricated and tested. The measured test data are given in Fig. 1. The single-section transition exhibits a voltage standing wave ratio (VSWR) under 1.010 over the frequency range of 8.3 to 8.6 GHz. The two-section transition exhibits an unexplained poor performance as shown in Fig. 1. However, the addition of a small capacitive tuning screw at the midpoint of the smaller section reduces the VSWR to a maximum of 1.020 over the range of 7.0 to 8.7 GHz.

An effort has been initiated to develop a computer-aided analytic technique applicable to an N-section array of tandem rectangular waveguide elements. This technique should prove useful in the improvement of the two-section filter and have general applicability to other waveguide computations. The mathematical model incorporates junction discontinuities at each step (Ref. 3) as well as lumped susceptances at any location.

IV. Conclusions

A single-section quarter-wave transformer has been designed and tested. This compact, easily reproducible transition can be used for low-power testing of WR 125 waveguide components using WR 112 test equipment. The resulting measurement accuracy is adequate for all but the most critical tests for the X-band radar frequency range.

Further improvements in the two-section transition will be investigated for future broadband applications (7.1 to 8.5 GHz). It is expected that the computer-aided analysis will be helpful in this effort. Progress on this technique and further test results will be reported at a later date.

References

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Table 1. Step transition dimensions

Dimensions	Input/Output		Single-section $F_0 = 8.45$ GHz	Two-section $F_0 = 7.80$ GHz, $wq = 0.2$	
	WR 112	WR 125		Section 1	Section 2
Height, cm	1.262	1.588	1.415	1.354	1.471
Width, cm	2.850	3.175	3.007	2.946	3.048
Length, cm	–	–	1.097	1.268	1.234

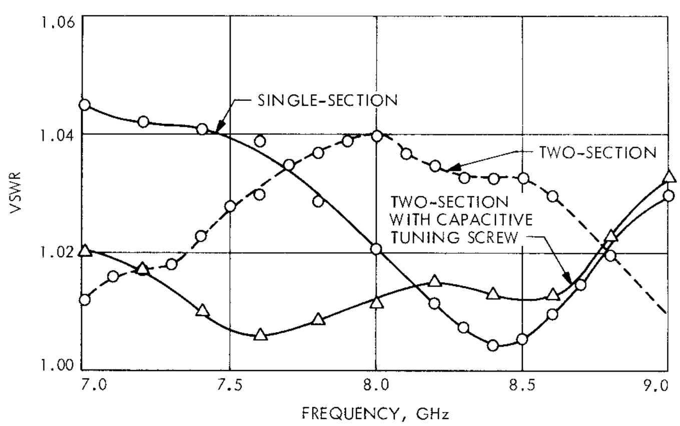

Fig. 1. Voltage standing wave ratio of step transitions