A New Coax to Troughguide Transition

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***Abstract*—This letter presents a new transition from coax to troughguide. The transition was developed using a combination of finite element method modeling and experimental validation. A frequency bandwidth of approximately 12% was achieved at a reflection coefficient of −20 dB. Detailed design parameters and a comparison between modeled and measured results are presented.**

***Index Terms*—Coax, guided wave, transition, troughguide.**

I. Introduction

TROUGHGUIDE consists of a rectangular trough containing a symmetrically located center fin. It can be viewed as a stripline operated in its first higher (a TE) mode [1]. In this higher order mode, an electric null runs along the center axis of the stripline trace and, hence, the strip may be bisected with an electrically conducting wall—resulting in troughguide. Radiation can be generated and controlled by deliberate asymmetries or periodic discontinuities along the length of the troughguide [2]–[4]. Its mechanical simplicity and the fact that it can be easily fabricated using metalized plastic make it an attractive candidate for low-cost communications antennas.

Although troughguide has seen only limited use since its introduction, several implementations have been reported in the literature. Rappaport presented the design and experimentation of a troughguide applicator for use in localized hyperthermia treatments for tumors [5]. More recently, Slattman presented a moment method analysis for asymmetrical troughguide antennas [6].

Two techniques have been presented in the literature to couple from other transmission line types into the troughguide. Fubini presented transitions from both coax and rectangular waveguide into troughguide [7], [8]. The common feature with these approaches is that they enter the troughguide through the end wall along the center axis of the trough. A new approach was desired, whereby a transition could be implemented through the rear wall of the trough. This approach effectively shortens the length of the antenna structure and shields the coaxial transition from the radiation direction.

II. Development of the New Transition

A combined approach of computer simulation and experimental verification was employed in the development of the new coax to troughguide transition. The design was optimized for use with an antenna for the communications band at 5.8 GHz. The starting point for this approach was selection of the troughguide cross section, with its resulting characteristic impedance and guided wavelength. Calculations were completed based on the formulas presented by Rotman [2] for the impedance and guided wavelength. The cross section for the troughguide at 5.8 GHz was as shown in Fig. 1. The propagation parameters for this configuration are presented in Table I.

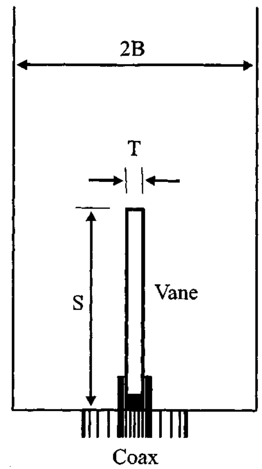

Fig. 1. Cross-sectional view of the coax to troughguide transition. For the design presented, $2B = 22.86$ mm, $T = 1.59$ mm, and $S = 19.05$ mm. The height inside the troughguide was 38.1 mm. The coax used was that of a Type N connector, with an outer diameter of 9.75 mm and a center pin diameter of 3.05 mm.

TABLE I
PROPAGATION CHARACTERISTICS OF THE SYMMETRIC TROUGHGUIDE

Freq.	Guided Wavelength	Cutoff Wavelength	Characteristic Impedance
5.8 GHz	60.66 mm	98.76 mm	116 Ω

Several assumptions were made regarding the basic approach for the transition. The connector was located approximately one quarter of a guided wavelength from the end wall of the troughguide, as is commonly used in traditional rectangular waveguide. Since the vane is inherently shorted to ground at its base, a resonant slot was added at the connection point on the vane to ensure that the center coax conductor was not electrically shorted.

And lastly, the vane width was tapered from a high impedance at the end wall to its full width and characteristic impedance at a point symmetrically beyond the coax feed. The coax to troughguide architecture is shown in Fig. 2.

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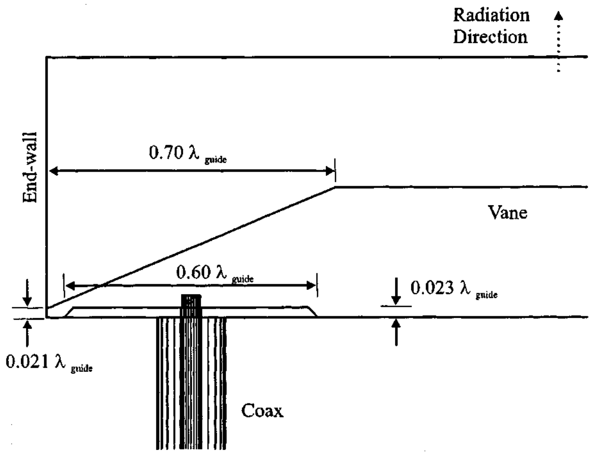

Fig. 2. Side view of the optimized coax to troughguide transition showing vane detail dimensions. The coax center pin extended 3.18 mm beyond the rear wall to permit a direct solder connection to the center vane. Note that the dimensions are shown relative to the guided wavelength in the symmetric troughguide at the center frequency.

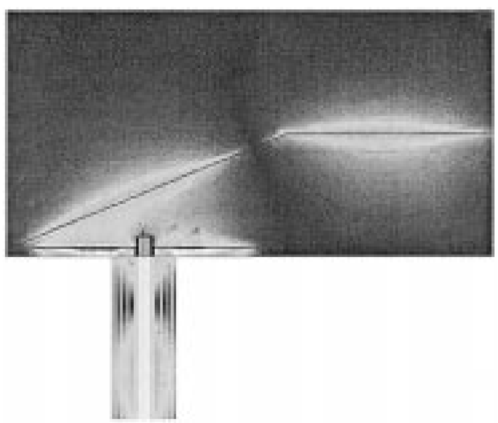

Fig. 3. Plot of the electric field distribution along the transition as shown from the side view. As expected, the electric fields go to zero at both the end wall (left) and bottom wall of the troughguide.

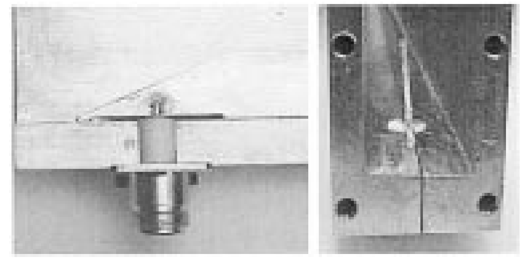

Fig. 4. Photographs of the coax to troughguide transition test fixture. Shown is the detail of (left) the Type N coax connector mounting and (right) the view down the fixture from the shorting end wall which was removed.

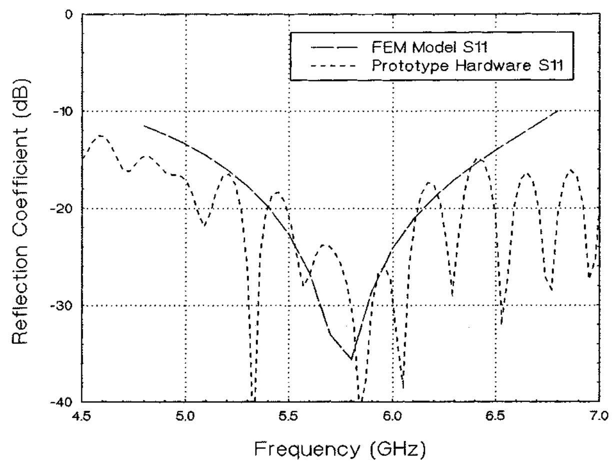

Fig. 5. Comparison of the measured and modeled reflection coefficient for the coax to troughguide transition.

TABLE II
PREDICTED REFLECTION COEFFICIENT BANDWIDTHS FOR THE 5.8 GHz COAX TO TROUGHGUIDE TRANSITION

S11 Level	Bandwidth (MHz)	Bandwidth %
-15 dB	1300	22.5
-20 dB	740	12.8

III. FINITE ELEMENT MODEL

A finite element model (FEM) was developed using the high frequency structure simulator by Agilent/EEsof. The coax cable and far end wall of the troughguide were defined as the two transmission ports and the upper surface of the structure was defined as a radiation boundary. The design was optimized through several iterations and the resulting architectural parameters are presented in Fig. 2. Fig. 3 presents a magnitude plot of the electric field within the transition. Fig. 3 also shows that, as expected, the distance between the coaxial feed point and the end wall appeared to be approximately one quarter of a guided wavelength (the predicted reflection coefficient performance is included in a comparison with the measured data).

IV. EXPERIMENTAL VALIDATION

In order to validate the predicted performance from the FEM analysis, a test fixture of the transition was fabricated. The fixture featured a fixed outer housing made from two parts which contained the Type N connector. The center vane and the shorting end wall were made replaceable, which permitted testing of several variants of the transition architecture. Photographs of internal views of the coax feed and center vane are shown in Fig. 4.

The test fixture was configured with only a single connector. The energy transiting down the troughguide was terminated by two conical ferrite absorbers inserted in the trough region, one on each side of the vane. The terminations employed were commercially available components designed for use in WR-90 rectangular waveguide loads.

V. RESULTS

The transition test fixture reflection coefficient performance was measured on a Hewlett-Packard 8510C Network Analyzer. A comparison between the measured and modeled reflection coefficients is presented in Fig. 5. The measured results indicate slightly wider frequency bandwidth at the −10 dB level, however, the performances at the −20-dB level agree well. A summary of the reflection coefficient bandwidths is presented in Table II.

VI. Conclusion

A new coax to troughguide transition was developed. An FEM model of the transition was used to optimize the design. The transition performance was validated via hardware testing. The architectural details of the design along with a comparison of computer-predicted and measured performance were presented.

References

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