Investigation of a Printed Coaxial-to-Waveguide Transition

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1. Abstract

A S/C-band printed coaxial to rectangular waveguide transition component is investigated. Both simulation and measurement show a very good matching level in a bandwidth of more than 50%. Very good agreement between simulation and measurement was achieved. The performance of the transition element can be matched to the user's demands.

2. Introduction

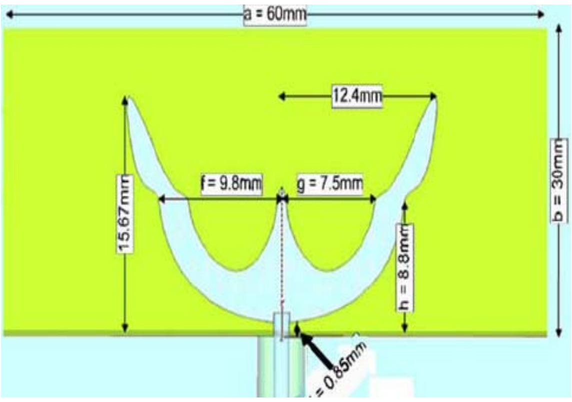
The usage of coaxial-to-waveguide transition components to transfer information is very common for low and medium power systems. Some radar systems and horn antennas require transitions between coaxial cables and rectangular waveguides. The main challenge is obtaining good impedance matching at most of the bandwidth of the rectangular waveguide basic mode (theoretical f:2f). Such components have existed for a long time, and their design methods are varied. Generally the electrical volume of the high quality components is not negligible. The common transitions are horn transitions, ridge transition [1], steps transitions [2], adjusting screws [3] and many other transitions based on very complicated geometrical shapes. Generally the prices of these components are high, and they are suitable to standard waveguides.

Our component is an improved version of the U-shaped transition element offered by [4]. The present research describes a compact, printed-circuit component which is easy to use and easy to change according to a systematic algorithm which we have developed.

The structure of the paper is as follows: Section 3 describes the geometry of the component. The main results of computer simulations are presented in section 4. The experimental validation of the simulation results are provided in section 5. Some examples of the parametric study are presented in section 6. The paper is concluded with a general discussion and some conclusions in section 7.

3. Geometry of the Transition Element

Fig 1.a shows the dimensions of the printed-circuit transition component, and its disposition within the cross-section of the waveguide (a = 60mm, b = 30mm). The conductor of the SMA connector (diameter 1.25mm) protrudes 1.5mm above the waveguide lower surface, and is integrated into a 4.1mm diameter Teflon holder. In addition, moving piston at the back wall of the waveguide is set at 16.9mm from the printed circuit conductor transmission, and is used for tuning the matching level as function of frequency for the parameter study. A side view of the printed transition element is shown in fig.1.b. The element is printed on 1.524mm thick Rogers RO4003C with ε_r = 3.38.



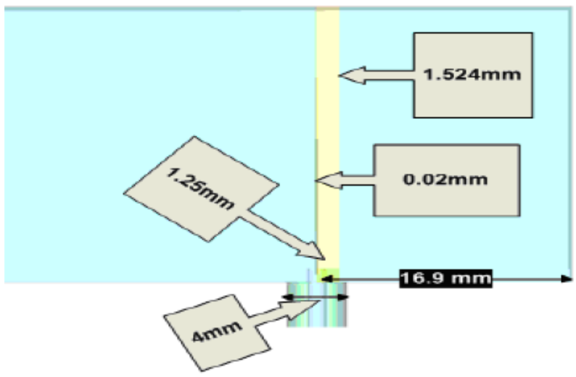
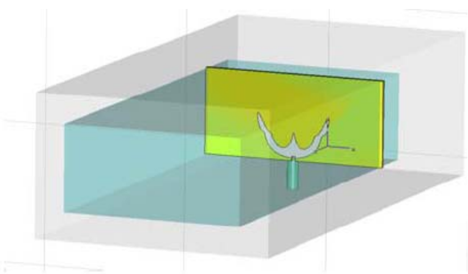


Fig. 1.a Front view of the transition element. b. Side view of the transition element.

4. Simulation

CST-Microwave Studio software was used during the design stage. Figure 2.a shows the element position inside the waveguide, and fig. 2.b shows the return loss of the element



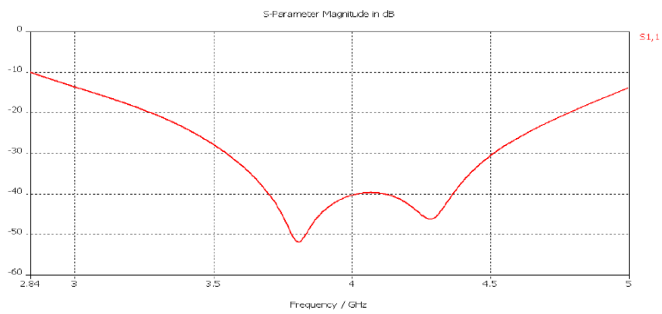
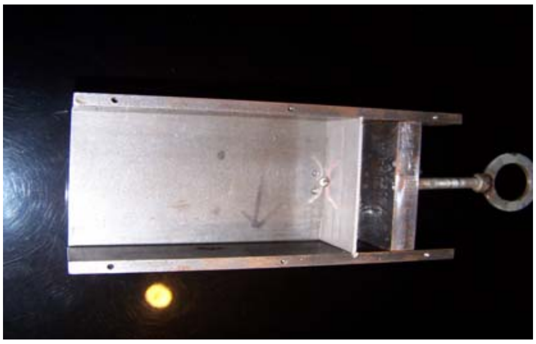


Fig. 2.a The transition elements inside the waveguide. b. Return loss of the element.

It is seen in figure 2.b that the bandwidth is 2.84 - 5GHz for SWR = 2, which is about 57% of the theoretical bandwidth (f:2f). The level of the minimum points of the return loss, in this case at 3.8GHz and 4.28GHz is between -45dB and -50dB. The frequencies of the minimum points can be controlled by a parametric study, and will be shortly described later.

5. Measurement

A 15cm length box-shaped waveguide was assembled from four components. One component is the waveguide bottom surface with two sidewalls. On each sidewall there is a vertical small sized tunnel of 1.5mm wide and a depth of 1mm. The tunnel stabilizes the second element, which is the printed circuit's transition component, and allows quick and easy switching. The third component is the piston back of the waveguide's wall, which connects to a handle. This part of the waveguide allows tuning which fixes the bandwidth and frequency range (see Fig. 3.a). The waveguide's back wall functions as an energy barrier, which reflects the incoming waves at 90 degrees phase.



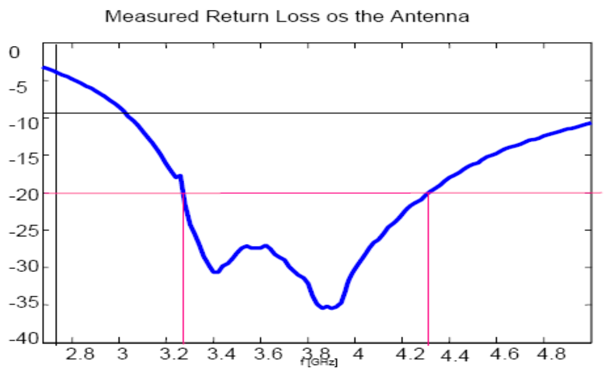


Fig. 3.a A picture of the transition element. b. Measured return loss of the transition element.

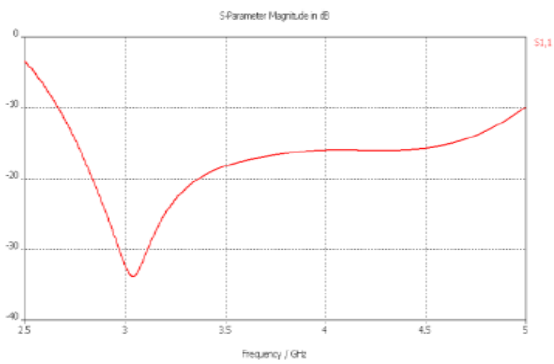
The last component is the upper wall, which is connected with screws and allowed the opening and closing of the printed circuit's switching. The waveguide is soldered to SMA connector of a standard coaxial cable. Measurements were performed using a Network Analyzer that was connected to the device via a coaxial cable. A highly absorbent material was set at the end of the waveguide to prevent reflectance, serving as an ideal port. The back wall was set as listed in chapter 3, which after much research proved to serve the average user most efficiently. The measurements of the returned loss wave are presented in figure 3.b. The minor changes between the simulated and the measured return loss is presented in table 1, and is due to construction deficiencies.

Table 1: Comparison of simulated and measured return loss performance of the component

	BW (SWR = 2)	BW (SWR = 1.2)	1st min.	2nd min.
Simulation	2.16 GHz (57%)	1.55 GHz (41%)	-51.8dB@3.8GHz	-46.2dB@4.3GHz
Measurement	2 GHz (53%)	1 GHz (27%)	-32dB@3.4GHz	-37dB@3.9GHz

6. Parametric Study

A comprehensive parametric study of the transition element was performed:



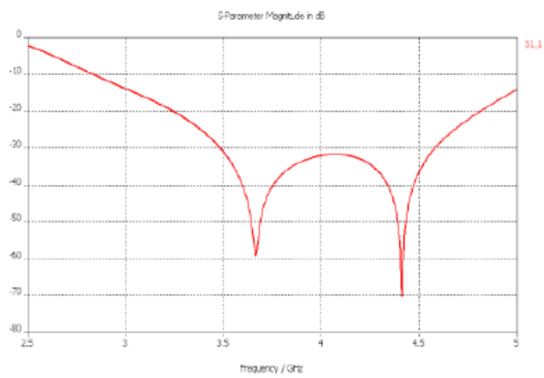


Fig. 4.a A wider SWR = 2 bandwidth. b. Wider distance between minima points.

Two examples are presented: a wider SWR = 2 bandwidth can be achieved by setting the distance between the element and the wall a little bit greater, to 21mm. The result is shown in fig. 4.a. In fig.

4.b the distance between the RL minima points is greater. This can be achieved by lowering by 0.5 mm the height of the element above the ground of the waveguide.

7. Conclusions

A novel low-cost, broadband coaxial-to-waveguide transition element having an excellent matching level has been presented. The agreement between simulation and measurement was very good. The device has a compact design, which allows a big improvement in the costs of manufacturing using a low cost printed circuit machine. This makes it inexpensive to manufacture. The parameter study allows the user changing the transition device easily because of the simple removal of the printed circuit and the systematic method of making the changes. The disadvantage of the component is in its limited power capability.

Future studies will involve an advanced optimization software combined with the parameter study algorithm guidelines and the 3D software..

References

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