Investigation of Thick Coax-to-Waveguide Transitions

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Abstract—Thick transitions from coaxial transmission lines to rectangular waveguides are proposed. The coaxial SMA connector enters into the broad wall of the waveguide and continues to the bottom of the waveguide. Two types of transitions are described in the S-band with 40% bandwidth: the first type is based on a polygonal shape and the second type is based on a curved elliptical cylinder. Very good agreement between simulations and measurements was achieved.

Keywords — coaxial-to-waveguide transition, exciting waveguides by thick probes

I. INTRODUCTION

Coax-to-waveguide transitions are useful components, constructed in different geometries, mainly to feed horn antennas [1-3]. While the standard transitions use thin cylindrical pins, we propose two thick structures. In the first type the connector is connected to the broad wall of a rectangular waveguide with no metallic connection inside the waveguide. In the second type, called ‘end-launcher’, the connector enters to the end wall of the waveguide and then is fixed to the bottom wall of the waveguide. The main advantage of the proposed transitions is their mechanical stability and strength in respect to shocks and vibrations, while achieving high level of matching in a broad range of frequencies.

The structure of the paper is as follows: the geometry of the different transitions is presented in section II. Simulations are shown in section III, and measurements are shown in section IV. Finally, section V concludes the work.

II. GEOMETRY

A. Initial Trials and Final Polygonal Element

A side view of an optimized transition with a polygonal element is shown in figure 1.

Fig. 1. Side view of a transition with a polygonal element.

The SMA inner pin is connected to a short horizontal wire that passes through a hole in a thin wall and enters into a thick metallic polygon. The polygon is well fixed to the bottom of the waveguide.

The optimized structure in Figure 1 came after a series of investigations of different geometries. First we have simulated a triangular thick shape as shown in Figure 2 whose matching level was not good enough. Then we tried to change the element to a trapezoidal as seen in Figure 3.
The matching level of the trapezoid was also unsatisfactory so we have slightly changed the triangle to another polygon as shown in Figure 4.

![Fig. 2. Side view of a transition with a triangular element.](image1)

![Fig. 3. Side view of a transition with a trapezoidal element.](image2)

![Fig. 4. Side view of a transition with the final polygon.](image3)

The main geometrical parameters of the polygonal element are: waveguide inner dimensions $a = 60$ mm and $b = 25$ mm, polygon's height $h = 18.6$ mm, polygon's basis $L = 13$ mm, polygon's thickness $4$ mm, inner wall thickness $1.6$ mm, distance of the connector from the waveguide side wall $4.9$ mm, distance of the polygon from the waveguide side wall $Le = 19.1$ mm, distance of the inner wall from the waveguide side wall $6.7$ mm, height of the hole $10.6$ mm, radius of the hole $3.6$ mm and radius of the horizontal wire $1.9$ mm.

**B. Curved Elliptical Cylinder Type Element**

The geometry of the curved elliptical cylinder type element is shown in figure 5.

![Fig. 5. Side View of a transition with curved elliptical cylinder.](image4)

The main geometrical parameters of the curved elliptical element are: waveguide dimensions $a = 60$ mm and $b = 30$ mm, distance of the inner wall from the side wall of the waveguide $4.2$ mm, thickness of the inner wall $2.0$ mm, hole radius $4.4$ mm, height of the hole from the bottom of the waveguide $11.7$ mm, length of the horizontal wire $10.7$ mm and radius of the horizontal wire $1.1$ mm. Upper elliptical cylinder sizes are: horizontal radius $4.7$ mm, vertical radius $4.3$ mm, height above the bottom of the waveguide $19.1$ mm and thickness $2.0$ mm. Lower elliptical cylinder sizes are: horizontal radius $5.5$ mm, longitudinal radius $5.8$ mm, thickness $2.1$ mm, distance from the side wall of the waveguide $32$ mm.

**III. SIMULATION RESULTS.**

**A. The Polygonal Elements**

The return loss of the triangular element is shown in Figure 6 where we got return loss of $-12.8$ dB at $3.0 – 4.7$ GHz. The return loss of the trapezoid is shown in Figure 7 where we got return loss of $-12.6$ dB at $3.0 – 4.7$ GHz. The simulated return loss of the final polygonal element is presented in figure 8 with return loss of $-16$ dB or VSWR = 1.4 at $3.2 – 4.6$ GHz.

**B. The Curved Elliptical Cylinder Element**

The simulated return loss of the curved elliptical cylinder element is shown in figure 9, with return loss of $-18$ dB or VSWR = 1.3 at $3.0 – 4.8$ GHz. This structure is seen as the best choice for the desired transition.
IV. MEASUREMENTS

A picture of the prototype transition with a polygonal element is shown in Figure 10.

The measured return loss result of this element is shown in Figure 11, with a return loss of -15 dB or VSWR = 1.45 at 3.0 – 4.5 GHz (fractional bandwidth of 40%).
A summary of the results is shown in Table 1.

<table>
<thead>
<tr>
<th>Element</th>
<th>VSWR</th>
<th>Frequency Range [GHz]</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triangular</td>
<td>1.6</td>
<td>3.0 – 4.7</td>
<td>Simulated</td>
</tr>
<tr>
<td>Trapezoidal</td>
<td>1.6</td>
<td>3.0 – 4.7</td>
<td>Simulated</td>
</tr>
<tr>
<td>Polygonal</td>
<td>1.4</td>
<td>3.2 – 4.6</td>
<td>Simulated</td>
</tr>
<tr>
<td>Elliptical cylinder</td>
<td>1.3</td>
<td>3.0 – 4.8</td>
<td>Simulated</td>
</tr>
<tr>
<td>Polygonal</td>
<td>1.45</td>
<td>3.0 – 4.5</td>
<td>Measured</td>
</tr>
<tr>
<td>Commercial</td>
<td>1.25</td>
<td>3.3 – 4.9</td>
<td>Measured</td>
</tr>
</tbody>
</table>

V. CONCLUSIONS

Two types of novel transitions from coaxial transmission lines to rectangular waveguides were presented. The two components are relatively thick and firmly connected to the waveguide. The first type - a polygonal element was simulated and measured showing VSWR = 1.45 at fractional bandwidth of 40% in the S-band. The second type – an elliptical cylinder element was simulated showing even better level of matching (VSWR = 1.3) at a fractional bandwidth of 45%. These results are comparable with commercial component but they are fastened to the waveguide and therefore are less sensitive to shocks and vibrations.

REFERENCES