Analysis of the Circular Waveguide Feed for Prime-Focus Reflector Applications

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Abstract

A circular waveguide open end can be a good candidate for a feed of prime-focus reflector antennas. Detailed information has not been published on its characteristics over a wide frequency range. This paper presents the radiation pattern and input impedance matching characteristics of a circular waveguide open end over a wide range of frequencies. The analysis shows that a circular waveguide open end has symmetric radiation pattern with low cross polarization when its diameter is between 0.85 to 1.15 wavelengths (30% bandwidth), over which the gain varies from 9.1dBi to 10.8dBi and the 10-dB beamwidth from 104º to 128º.

Keywords: Antenna, reflector feed, circular waveguide, efficiency

I. INTRODUCTION

Shallow reflector antennas often employ a prime-focus feed of small cross section. A circular waveguide feed is a good candidate for a prime-focus reflector antenna feed [1]. A simple circular waveguide open end has good pattern characteristics when its diameter is properly chosen. Additive structures such as choke rings, dielectric lining, rim choke, and dual slits are employed to modify or to improve the performance [2].

II. ANALYSIS

In this paper we analyzed and summarized the performance of a circular waveguide open end radiator over a wide range of frequencies so that it can be used as a useful guideline for reflector antenna design. We employed Microwave StudioTM, a widely used EM simulation tool by CST for the analysis.

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Figure 2. Electric field distribution on the input plane (a) and on the aperture (b) of the circular waveguide

Figure 3. Current distribution of the waveguide surface

Figure 4 shows the electric field distribution on the input plane and on the aperture of the circular waveguide at 14GHz. The simulated cutoff frequency is 8.56GHz. One can observe that the electric field is predominantly in vertical polarization on the aperture as well as on the input plane. Figure 3 shows the current distribution on the surface of the waveguide. Currents on the waveguide outer surface are stronger in the E-plane and so are those in the H-plane.

Figure 4 shows the input reflection coefficient of the circular waveguide feed. Impedance matching is excellent even at 10GHz where the waveguide diameter is 0.69 wavelength. At 14GHz, the reflection coefficient is as low as -30dB.

Figure 5 shows the gain patterns of the circular waveguide feed at 10, 12, 14, 16, and 18GHz. The aperture plane is at $z = 60.00\text{mm}$ and the phase center $z_c = 59.75$, 59.97, 60.34, 59.99, and 60.14GHz at 10, 12, 14, 16, and 18GHz respectively. The phase center variation is remarkably small regarding the frequency. We can set the phase center at the aperture plane. In Figure 5, the phase patterns are obtained with this condition.

From Figure 5, it can be observed that the circular waveguide has excellent pattern symmetry, good phase pattern flatness, and low cross polarization from 12GHz to 16GHz (approximately 30%). With somewhat degraded performance, the feed can be used at 10-18GHz (approximately 60%).

Figure 6 shows the two-dimensional directivity patterns at 14GHz. One can observe symmetric co-polarized pattern and low cross polarization levels.
Table 1. Performance of the circular waveguide feed

<table>
<thead>
<tr>
<th>$f$ (GHz)</th>
<th>$G_{\text{max}}$ (co-pol) (dBi)</th>
<th>$G_{\text{max}}$ (X-pol) (dBi)</th>
<th>$\theta_E$ (deg) (at -10dB)</th>
<th>$\theta_H$ (deg) (at -10dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>8.9</td>
<td>-5.8</td>
<td>27.2</td>
<td>31.2</td>
</tr>
<tr>
<td>12</td>
<td>9.1</td>
<td>-6.5</td>
<td>27.8</td>
<td>30.5</td>
</tr>
<tr>
<td>14</td>
<td>10.0</td>
<td>-8.2</td>
<td>29.7</td>
<td>26.3</td>
</tr>
<tr>
<td>16</td>
<td>10.8</td>
<td>-9.6</td>
<td>29.4</td>
<td>27.3</td>
</tr>
<tr>
<td>18</td>
<td>11.8</td>
<td>-9.5</td>
<td>25.5</td>
<td>26.4</td>
</tr>
</tbody>
</table>

Table 1 summarizes the performance of the circular waveguide feed. The antenna gain varies from 8.9dBi to 11.8dBi, peak cross polarization from -9.6dBi to -5.8dBi, 10-dB beamwidth from 25.5° to 31.2°.

Figure 6. (a) Co- and (b) cross-polarized directivity circular waveguide

**III. CONCLUSION**

Wideband performance characteristics have been presented for the circular waveguide open end as a prime-focus reflector antenna feed. It has been shown that the circular waveguide feed has excellent characteristics over 30% bandwidth. With a little degraded performance, the circular waveguide feed can be used over 60% as a prime-focus reflector antenna feed.
REFERENCES


BIOGRAPHIES

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