Matching of Waveguide Slot Antenna by Evolutionary Method

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Abstract

The impedance-matching is needed to improve the transmission efficiency of a waveguide slot array antenna with the small spherical dielectric lens. This paper reports the design method of the tuning screw for the impedance-matching by using the computational approach which consists of the FDTD method and the evolutionary method. From the optimized results, the VSWR in the frequency range from 11.8 to 12.2 GHz is decreased to less than 1.18.

Keywords – μGA, FDTD method, waveguide slot antenna, impedance matching

1 Introduction

To develop the high gain planer antenna, we propose a waveguide slot antenna with the small spherical dielectric lens[1]. For the array antenna case, it is desirable to design the proposed antenna with higher transmission efficiency. Therefore, the impedance matching is needed to improve the transmission efficiency. The use of a tuning screw is one of the impedance matching methods of the waveguide slot antenna. However, in the experimental approach, it is difficult to adjust the plural tuning screws individually. This paper reports the computational approach for the matching of the antenna by using both the FDTD method and the evolutionary method.

2 Analysis Condition

For the matching of the 8-slot waveguide antenna as shown in Fig.1, it is necessary to minimize the reflection wave in the input port. To evaluate the influence of the reflection wave, the voltage standing wave ratio (VSWR) in the input port is generally used. For the impedance matching over the frequency bandwidth from 11.8 to 12.2 GHz, the VSWR needs to be calculated as the function of the frequency \( f \). Namely, the matching of the antenna becomes the minimization problem of \( \text{VSWR}(f) \).

Fig.2 shows the analysis condition of the tuning screws which are inserted into top of the waveguide. The diameter and the length of the tuning screw are 2.0 mm and 3.0 mm, respectively. The design parameters of the tuning screw are shown in Table 1. The analysis object is approximately modelled by the rectangular parallelepiped cell whose size is 0.5 mm in the FDTD simulation.

Table 1. Design parameters of tuning screw.

<table>
<thead>
<tr>
<th>Design parameters</th>
<th>Search space</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insertion depth (BZ)</td>
<td>0.5 to 1.5 mm</td>
</tr>
<tr>
<td>Insertion location (BC)</td>
<td>5.0 to 15.0 mm</td>
</tr>
</tbody>
</table>

3 Optimization Results

To search the optimal design parameters of minimizing the worst value of \( \text{VSWR}(\theta) \), the micro genetic algorithm (μGA) is adopted as the evolutionary method[2]. The number of the population and the generation of the μGA are set to 5 and 1,000, respectively. An example of the optimization results are shown in Table 2 and Fig.3. The VSWR is confirmed to be decreased to less than 1.18 over the frequency bandwidth.

Table 2. Optimal parameters.

<table>
<thead>
<tr>
<th>Screw No.</th>
<th>#1</th>
<th>#2</th>
<th>#3</th>
<th>#4</th>
<th>#5</th>
<th>#6</th>
<th>#7</th>
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</thead>
<tbody>
<tr>
<td>BC [mm]</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>0.5</td>
<td>1.0</td>
<td>1.5</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>BZ [mm]</td>
<td>11.5</td>
<td>12.0</td>
<td>12.5</td>
<td>10.0</td>
<td>12.0</td>
<td>13.0</td>
<td>13.0</td>
<td>13.5</td>
</tr>
</tbody>
</table>

Fig. 1. Waveguide slot array antenna with dielectric lens.

Fig. 2. Design parameters of tuning screw.

Fig. 3. Frequency characteristics of VSWR.

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References