A Four-Corner-Fed Slotted Waveguide Sparse Array for Near-Field Focusing

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***Abstract*—Recently more and more people are developing the near-field antennas for various applications of wireless power transfer, security inspection, and medical care. Based to the concept of suppressing intersymbol interference in the near field of the transmitting antenna, a double-layer near-field-focused slotted waveguide array antenna is designed in the X-band. The sparse array antenna has low side-lobe level and narrow focal spot, which can be widely applied in the above-mentioned near-field applications. In addition, the antenna also exhibits good performance in terms of communication quality because the delay occurring in the four-corner feeding circuit naturally realize the phase difference necessary for the near-field focusing.**

Keywords—near-field focusing; slotted waveguide array; intersymbol interference; four-corner feed; sparse array;

I. INTRODUCTION

In recent years, more and more people are developing the near-field-focused antennas [1] due to their various applications such as wireless power transfer, security inspection, and medical care. The basic idea to design a near-field-focused antenna is to properly control the phase of the radiation sources on the antenna aperture for focusing the electromagnetic field at the focal point in the near-field region. In this study, a novel X-band double-layer four-corner-fed slotted waveguide sparse array antenna was developed for the near-field focusing at 50 mm. The overall structure of the array antenna is illustrated in Fig. 1.

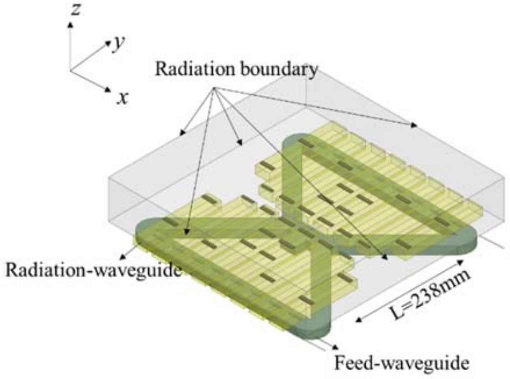

Fig. 1. Overall stucture of the proposed near-field-focused antenna.

II. DETERMINATION OF WAVEGUIDE DIMENSIONS

First of all, the center frequency of designed array antenna is assumed at 10 GHz, and the free space wavelength λ_0 equals 30 mm. Under the condition of the dominant TE_{10} mode propagation, guided wavelength λ_g is related to the broad wall width of the hollow rectangular waveguide as follows:

$$\lambda_g = \lambda_0/\sqrt{1-(\lambda_0/2a)^2} \tag{1}$$

Here, a denotes the broadwall width of the hollow rectangular waveguide. Moreover, both the feeding waveguide and the radiating waveguide have the same dimensions in cross sections.

III. 3. ANTENNA ANALYSIS AND DESIGN

As illustrated in Fig. 1, the whole antenna composes of two parts: the feeding circuit in the bottom layer and the radiating waveguides in the top layer.

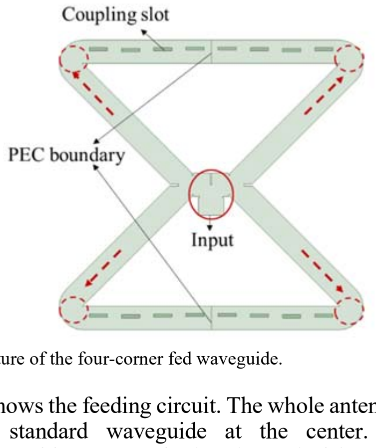

Fig. 2. Structure of the four-corner fed waveguide.

Fig. 2 shows the feeding circuit. The whole antenna is fed by a X-band standard waveguide at the center. A unique configuration of four-corner feed [2] instead of the conventional center feed structure is introduced in this study as illustrated in Fig. 2. The circle in solid line indicates the position of antenna input, whereas the four circles in dashed lines indicate the artificial feeding points at the four corners. It should be emphasized here that the delay occurring in the four-corner feeding circuit naturally realize the phase difference necessary for the near-field focusing at 50 mm.

The radiating waveguides in the top layer are fed through the coupling slots cut in their broad faces in common. Both the lengths and offsets of those coupling slots are adjusted to control the coupling power and phase.

During the design of radiating slots, we adopts the sparse array which has the advantages of reducing the sidelobe levels around the focus and improving the focusing performance. Fig. 3 shows the structure of radiation waveguide.

The transverse slot array realized in a hollow waveguide always generates the unwanted grating lobes in far-field region, since the slot spacing identical to λ_g is larger than λ_0. However, this transverse slot array antenna has suppressed sidelobes in its near-field region because the slots don't radiate in-phase.

The overall reflection of the designed waveguide slot array antenna is shown in Fig. 4. It is suppressed below -10 dB over the frequency ranging from 9.72 GHz to 10.24 GHz. The present bandwidth is wide enough for the near-field-focused application.

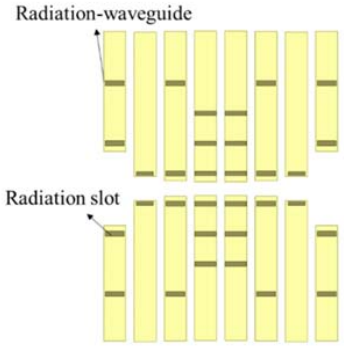

Fig. 3. Radiating waveguide with sparse slot arrangement.

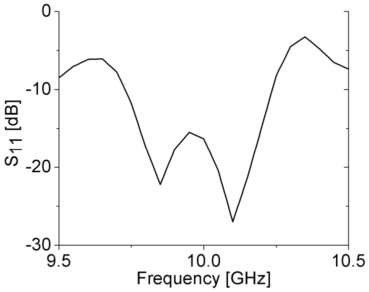

Fig. 4. Two-dimensional distribution of the electric-field intensity.

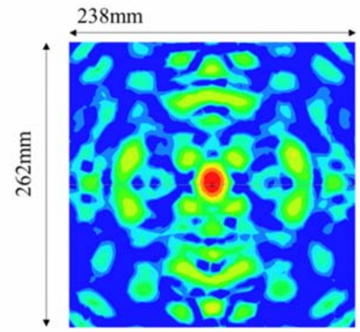

Fig. 5. Two-dimensional distribution of the electric-field intensity.

Fig. 5 shows the two-dimensional distribution of the electric-field intensity in a parallel plane crossing the focal point, which is at a distance of 50 mm from the antenna aperture. The maximum power intensity is realized at the focal point. It is clearly observed that the 3-dB focal spot occupies an area of 14 mm × 18.5 mm.

IV. CONCLUSION

A four-corner-fed near-field-focused slotted waveguide sparse array antenna is proposed. The bandwidth of 5.2% for $S_{11} < -10$ dB is achieved in the X-band. In addition, the antenna has low sidelobes and small focal spot, and it can be successfully applied in the fields of wireless power transfer, imaging, medical, near-field communication and others.

ACKNOWLEDGMENT

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