Design of a Linear Array of Transverse Slots without Cross-polarization to any Directions on a Hollow Rectangular Waveguide

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***Abstract*-In this paper, we propose a linear array of transverse slots spaced with the half guided wavelength, which are fed by two hollow rectangular waveguides. No cross-polarization is radiated in any directions. The reflection is suppressed to below −14 dB in a wide frequency range and almost uniform illumination of all the slots is achieved in an eight-element array designed at 125 GHz.**

I. INTRODUCTION

The linear array of inclined slots on the narrow-wall is commonly used to radiate the polarization parallel to the waveguide axis [1]. As can be seen in Fig. 1, since slots with opposite inclination angles are alternatively placed with the separation of the half guided wavelength, it could radiate high cross-polarization at wide angles. In a transverse slot array on the broad-wall of a waveguide, grating lobes should be suppressed by filling dielectric material [2] or introducing transverse corrugations as slow-wave structures [3], because the slot spacing is one guided wavelength. In this paper, we propose a linear array of transverse slots with the half guided wavelength spacing fed by two rectangular waveguides. No cross-polarization is radiated in any directions.

II. ANTENNA CONFIGURATION

Fig. 2 shows the antenna configuration. The antenna consists of an E-plane T-junction, two feeding waveguides, and radiating slots. The two feeding waveguides are alternatively fed through the E-plane T-junction. The radiating slots are placed with the interval of the half guided wavelength. The odd-numbered and even-numbered slots are fed through the upper and lower waveguides, respectively, in order to excite all the slots in phase. All the slots are perpendicular to the direction of the array arrangement, so that no cross-polarization is radiated in any directions. The antenna will be fabricated by diffusion bonding of laminated thin metal plates [4] [5].

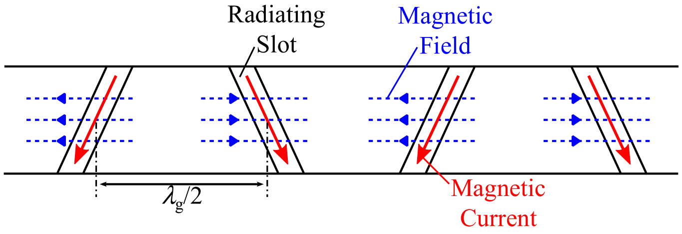

Fig. 1 A linear array of inclined slots on the narrow wall of a rectangular waveguide

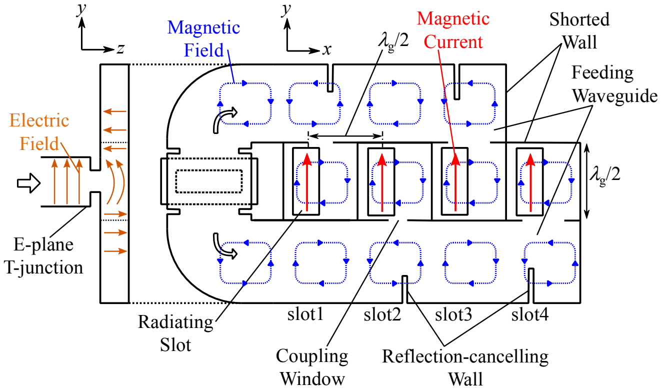

Fig. 2 Overall structure

III. DESIGN OF COMPONENTS

A. *Radiating elements*

Fig. 3 shows the design model of the radiating element. The radiation slot is placed on a cavity. The distance between the center of the slot and the shorted wall is the quarter guided wavelength.

Firstly, the resonant slot length is determined to have the reflection phase of 0 degree by analyzing it on a shorted waveguide. The same slot length is used for all the radiating elements. The coupling of the slots is controlled by the width of the coupling window. The reflection is suppressed by adjusting the length and the position of the reflection-canceling wall for the travelling wave excitation.

An array of eight slots is designed at 125 GHz. Four radiating elements are fed with each feeding waveguide. The radiating elements with the couplings of 25%, 33.3%, 50%, and 100% are designed for the uniform excitation. The radiating element with 100% coupling is realized by shorting the end of the feeding waveguide and its window width is same as that with 50% coupling.

Fig. 4 shows the reflection of the radiating element with 50% coupling for various slot widths. As can be seen in Fig. 4, the radiating element with 0.6mm slot width has the widest bandwidth. When the slot width is more than 0.6mm, the resonant condition is not satisfied. We adopt the slot width of 0.6mm to realize wideband operation.

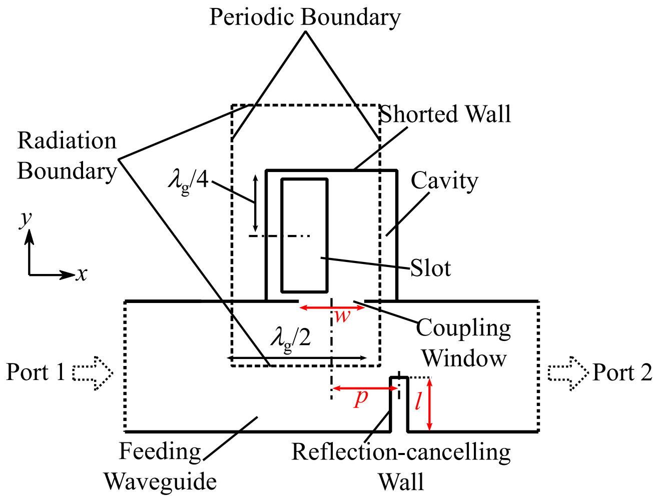

Fig. 3 Design model of the radiating element

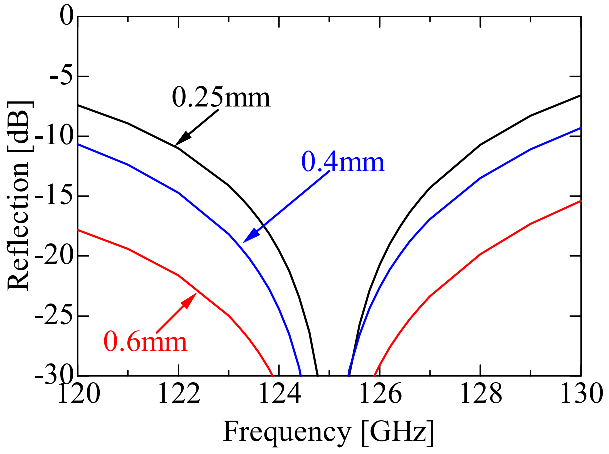

Fig. 4 The reflection of the radiating element with 50% coupling for various slot widths

B. Feeding part

Fig. 5 shows the design model of the feeding part. The feeding part consists of an E-plane T-junction and H-bends. The E-plane T-junction is fed by a standard rectangular waveguide in the 120-GHz band (WR-8). The dimensions of the feeding window, the length and the position of reflection-canceling walls are determined to minimize the reflection at 125 GHz. The E-plane T-junction is connected to the H-bends, and the radius of the rounded-edge of the H-bends is tuned to suppress the reflection.

The reflection of the overall feeding part is shown in Fig. 6. The reflection is below −20 dB in a broad bandwidth.

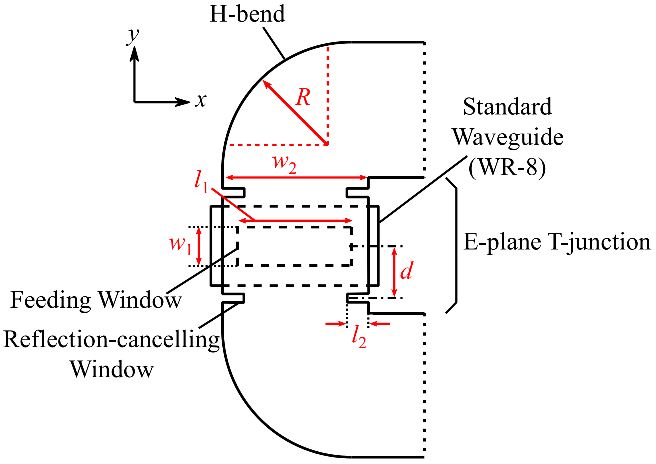

Fig. 5 Design model of the feeding part

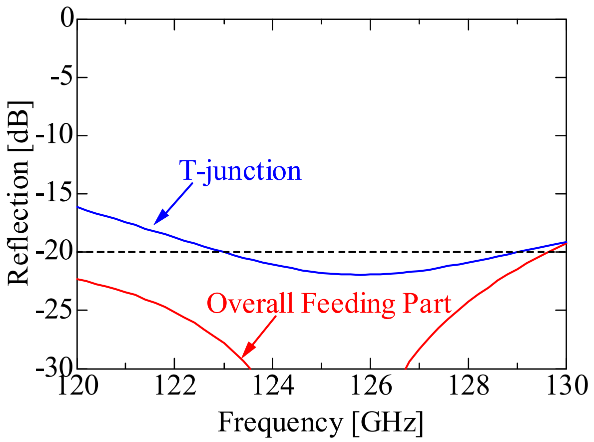

Fig. 6 Reflection of the feeding part

IV. OVERALL STRUCTURE

The radiating part is connected to the feeding part to form the 8-slot array antenna. The spacings between the slots are determined using the transmission phase and radiation phase to excite all the radiating elements in phase [6]. The overall antenna structure is analyzed using Ansoft HFSS.

The radiation patterns in the E-plane at 125GHz is shown in Fig. 7. The HPBW is about 9 degrees and the first sidelobe level is −13 dB. The cross-polarization is suppressed to below −35 dB even though the wide slots are used.

The amplitude and phase on each slot are shown in Fig. 8. The deviations of the amplitudes and phases are less than 0.5 dB and 4 degrees. Almost uniform illumination is achieved.

Fig. 9 shows the frequency characteristic of the reflection. The reflection is below −14 dB in 120-130 GHz. However, the center frequency is shifted to 124 GHz.

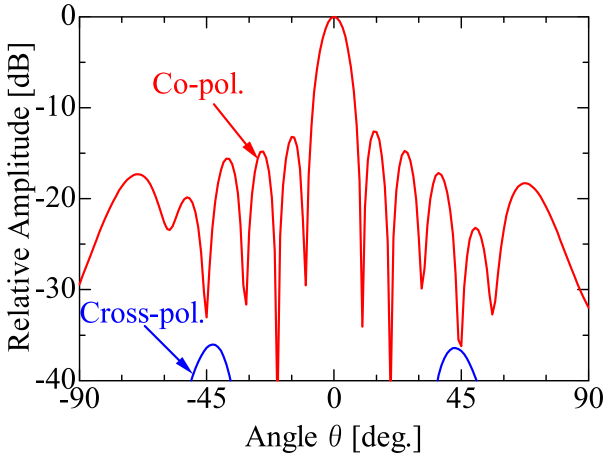

Fig. 7 Radiation patterns in the E-plane

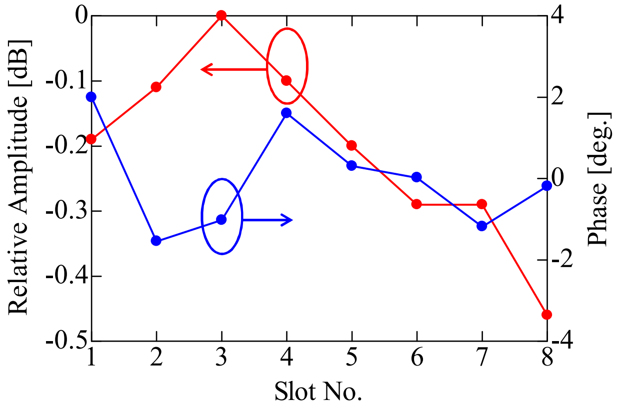

Fig. 8 Amplitude and phase on the slots

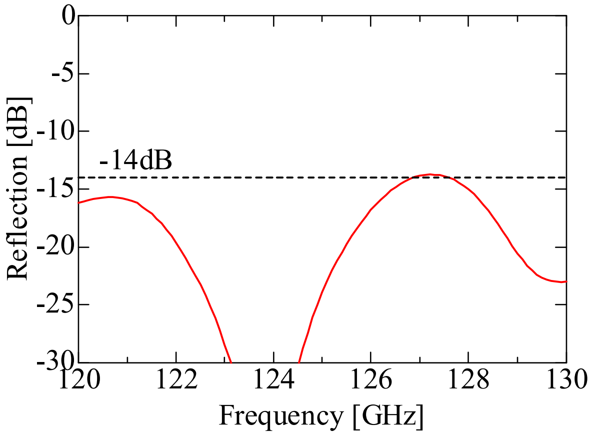

Fig. 9 Reflection of the overall structure

V. CONCLUSION

The authors have designed and analyzed a linear array of transverse slots spacing with the half guided wavelength, which are fed by two rectangular waveguides. The authors have designed an eight-element array and confirmed the uniform aperture illumination in the simulation. The measured results will be shown in the conference.

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