Wideband Design of a Circularly-polarized Plate-laminated Waveguide Slot Array Antenna

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***Abstract* – A conventional circularly-polarized plate-laminated waveguide slot array antenna achieved 3.3% bandwidth for antenna efficiency more than 80% and 4.2% bandwidth for axial ratio less than 3dB in 60-GHz band. In this paper, the radiating part is designed for wider bandwidth by genetic algorithm using fast analysis method by the method of moments. This design of the 2x2-element array is improved 14.6% bandwidth for less than -14dB reflection and 3dB axial ratio. The 16x16-element array is improved 16.6% bandwidth for the axial ratio and 17.2% bandwidth for the antenna efficiency.**

***Index Terms* — waveguide slot array, circularly polarization, wideband design, hexagon cavity**

I. Introduction

Previous research on a circularly-polarized plate-laminated waveguide slot array antenna[1] is shown in Fig.1 achieved 3.3% bandwidth for antenna efficiency more than 80% and 4.2% bandwidth for axial ratio less than 3dB in the 60-GHz band. In this paper, we design the 2x2-element array for wider bandwidth using fast analysis method[2] by the method of moments.

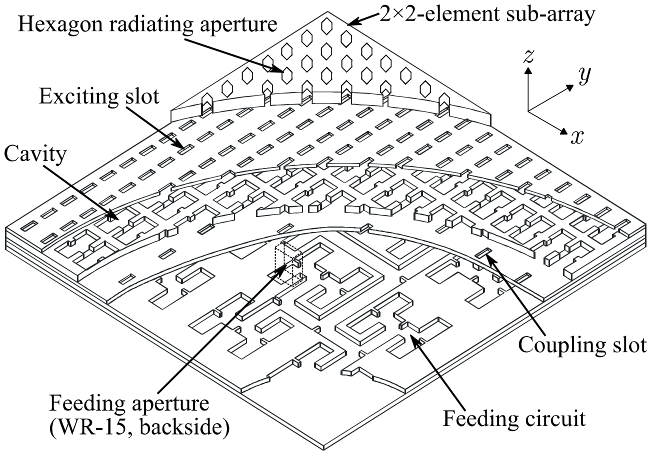

Fig.1 Circularly-polarized waveguide slot array antenna

The circularly-polarized slot array antenna consists of corporate feed waveguide in the lower layer and a radiating part in the upper layer. The antenna is fed through an aperture from its backside, and the coupling slot is located at each end of the feeding circuit in order to feed 2x2 exciting slots on a wall-inserted cavity. Finally, a circularly-polarized radiating aperture is fed through the exciting slot. The radiating aperture is square which is trimmed off two diagonal corners for the circular polarization. The radiating apertures are placed with constant spacing in the *x* and *y* directions.

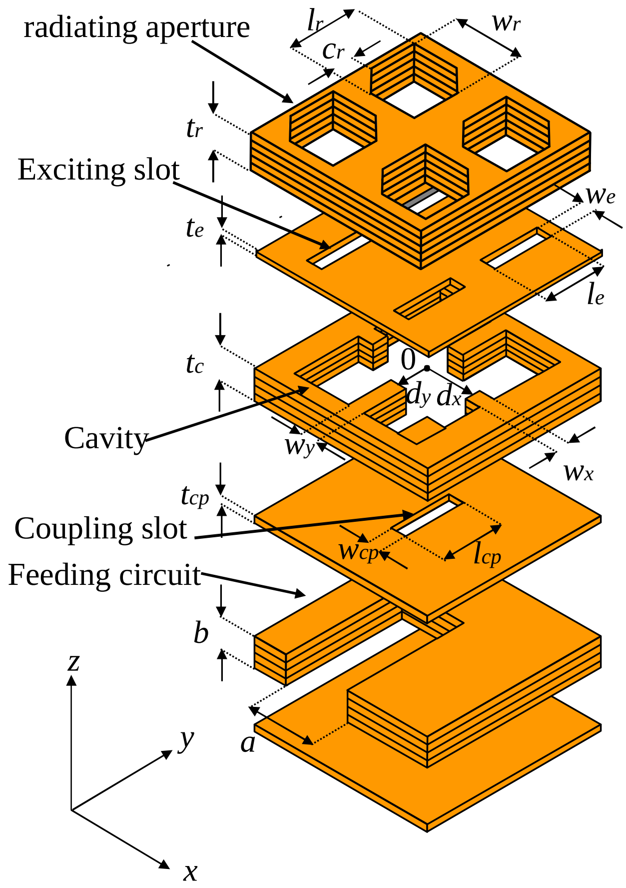

Fig.2 Bird's-eye view of the 2x2-element array

II. DESIGNING BY GENETIC ALGORITHM(GA)

The lower and upper bounds of the design parameters of the 2x2-element array are listed in Table 1. The bounds are determined by including the fabrication limitation of metal etching such as the minimum radius at the corners and the minimum width of the metal lines. The 2x2-element array is designed by GA for wider bandwidth.

The bandwidth for the axial ratio is defined as that for less than 3dB and the bandwidth for the reflection is defined as that for less than -14dB throughout this paper. The axial ratio depends on the shape of the radiating aperture and the radiating slot, and the reflection depends on all parts in the 2x2-element array. The design procedure is as follows. First, the bandwidth for axial ratio axial ratio is maximized. Second, the bandwidth for reflection is maximized. Finally, bandwidth for both of the reflection and axial ratio is maximized.

The antenna thickness should be an integral multiple of 0.2mm (plate thickness). The axial ratio is so sensitive to the thickness of the radiating aperture that the thickness varies 0.2mm steps for the axial ratio. The bandwidth for axial ratio maximized for each thickness. Fig. 3 shows the bandwidth as a function for the aperture thickness. The thickness for the bandwidth more than 16% is a range from 4.6mm to 5.4mm.

The bandwidth for both the axial ratio and the reflection is achieved 14.6% for the thickness of 4.6mm. The values of the parameters are listed in Table 1.

Table.1 Design parameters

		lower	upper	design
Coupling slot	lcp	2.500	2.800	2.650
	wcp	0.250	1.500	0.980
	tcp	0.200	1.600	0.200
Cavity	wcx	5.500	8.200	5.662
	wcz	6.000	8.200	7.607
	tc	0.200	1.600	0.800
Wall-inserted	wx	0.300	1.500	0.858
	wz	1.300	1.900	1.538
	dx	1.000	3.500	2.063
	dz	1.345	3.000	2.581
Exciting slot	le	2.500	3.000	2.792
	we	0.300	1.600	1.243
	te	0.200	1.600	0.800
Radiating slot	lr	3.500	3.950	3.946
	cr	0.000	1.970	1.607
	tr	0.200	6.000	4.600
Element spacing	se	3.940	4.253	4.249

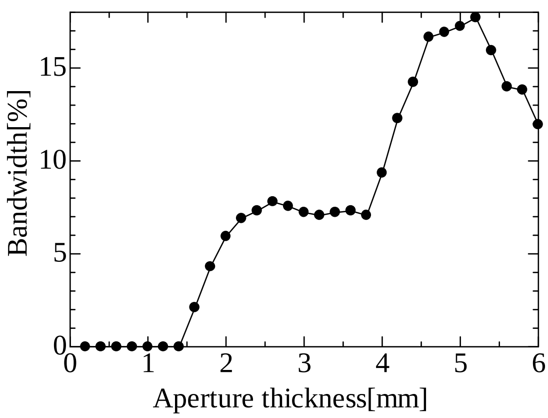

Fig.3 Axial ratio bandwidth for the aperture thickness

III. FULL STRUCTURE SIMULATION

The 16x16-element array consisting of the designed sub-arrays and the feeding circuit is simulated by HFSS. The axial ratio, directivity gain and realized gain are shown in Fig. 4. The bandwidth for antenna efficiency more than 80% is 17.2% and that for the axial ratio is 16.6%.

The radiation patterns at 61.2GHz are shown in Fig. 5. Good symmetrical patterns are obtained. The sidelobe level at 37 degrees is -17.4dB, which comes from imbalanced excitation in the 2x2-element array.

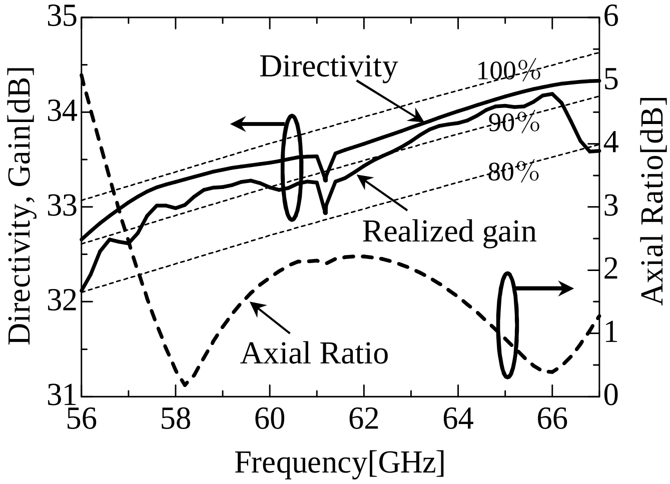

Fig.4 Frequency characteristic of the axial ratio, the directivity gain and the realized gain

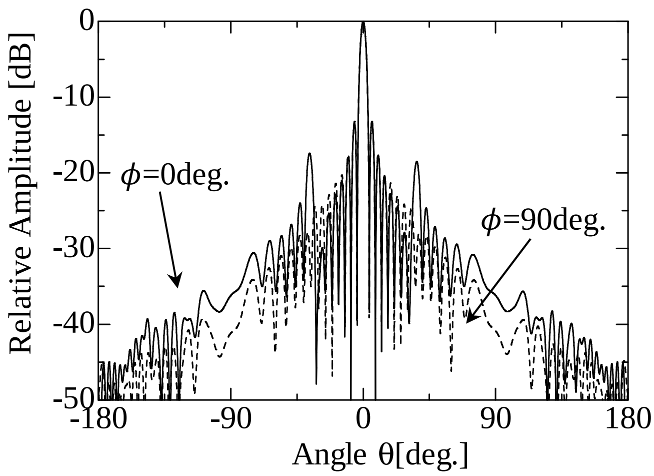

Fig.5 Radiation pattern at 61.2GHz

IV. CONCLUSION

We have discussed the design to increase the bandwidth in the circularly-polarized waveguide slot array. The bandwidth for the reflection and the axial ratio n the 2x2-element array is achieved 14.6%. The bandwidth in the 16x16-element array is 16.6% for the axial ratio and 17.2% for more than 80 % antenna efficiency.

References

[1] Y.Miura et al., IEICE Trans. Electron., vol.94, no.10, pp.1618-1625, Oct. 2011.
[2] T.Tomura, et al, IEICE, AP2013-100, 2013-11.