

Low-sidelobe Design of a Waveguide Reflection-canceling Slot Array Antenna in the 60GHz Band

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Abstract – A series-feed waveguide reflection-canceling 16x28-slot array antenna is designed for 60 GHz band in order to suppress the sidelobe level. The simulation by HFSS gives low-sidelobe by excitation of Taylor distribution, reflection lower than -13dB and gain higher than 33dBi over 60-61GHz.

Index Terms —waveguide slot array, sidelobe suppression, reflection cancellation, 60GHz band.

1. Introduction

A series-feed waveguide reflection-canceling 16x28-slot array antenna in the 60GHz band is designed to suppress the sidelobe level by the excitation of Taylor distributions for both the feeding and the radiating waveguides.

2. Antenna Structure

Figure 1 shows the top view of the antenna. There are one 28 radiating waveguides with 16 longitudinal radiating slots each of which suppresses the reflection by a wall as shown in Fig.1A. A feed waveguide is placed on the bottom of the radiating waveguides. It has inclined coupling slots each of which suppresses the reflection by a wall as shown in Fig. 1B. An input waveguide is placed in the middle of the feeding waveguide.

3. Design of the Antenna

(1) Slot Elements

Excitation of Taylor distribution for sidelobe level of -30dB ($\bar{n} = 8$) in the H-plane and -20dB ($\bar{n} = 5$) in the E-plane is adopted as shown in Figure 2, The excitation of the radiating slot is controlled mainly by the offset while that of the coupling slot is changed mainly by the angle. The position and the length of each wall is designed to cancel reflection [1].

(2) Radiating Waveguide

The broad-wall and the narrow-wall widths of the radiating waveguide are 3.00mm and 1.20mm, respectively. Initially the spacing of all the radiating slots were $0.5 \lambda_g$ ($0.85 \lambda_0$). In Figure 3, the dotted line shows the initial H-plane pattern at the design frequency of 60.5 GHz using only the element design. The pattern has high shoulders around -5dB. This problem is solved by revising each spacing between adjacent slots according to Eq. (1) by P_n , the excitation phase of the n -th slot, in the simulation of the one-dimensional array model as shown in Figure 1A'.

$$s_{n,rev} = s_{n,ini} - (P_{n+1} - P_n) \frac{\lambda_g}{360} \quad (1)$$

where s_n is the spacing between slots the n -th and the $n+1$ -th slots. The solid line shows the revised H-plane pattern. The shoulder level becomes lower than -26dB.

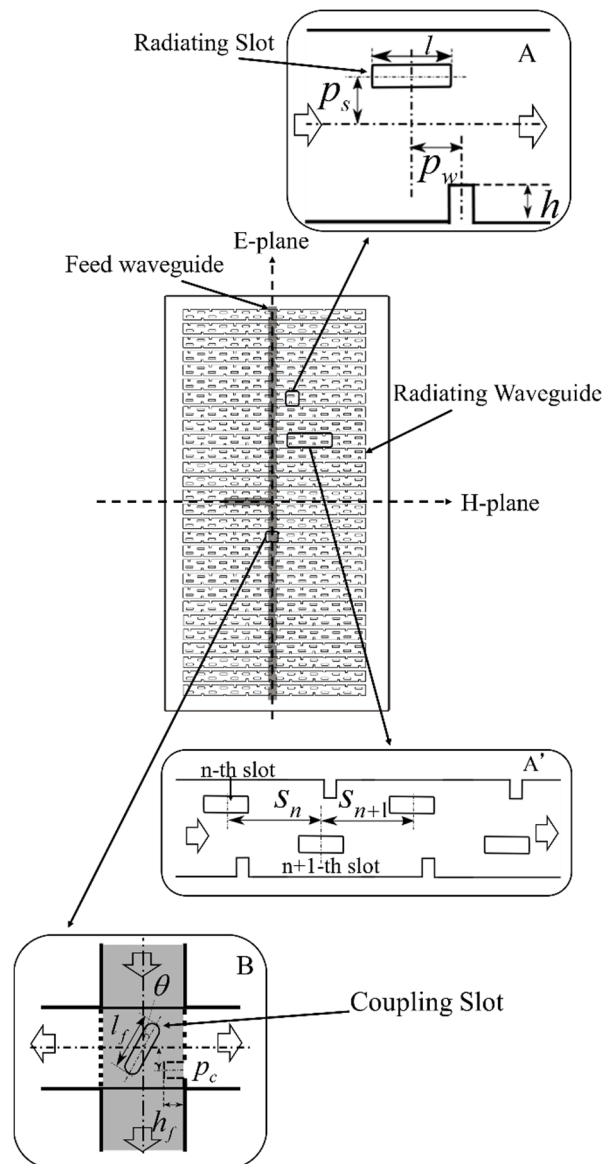


Figure 1 Top view of the antenna and the analysis models

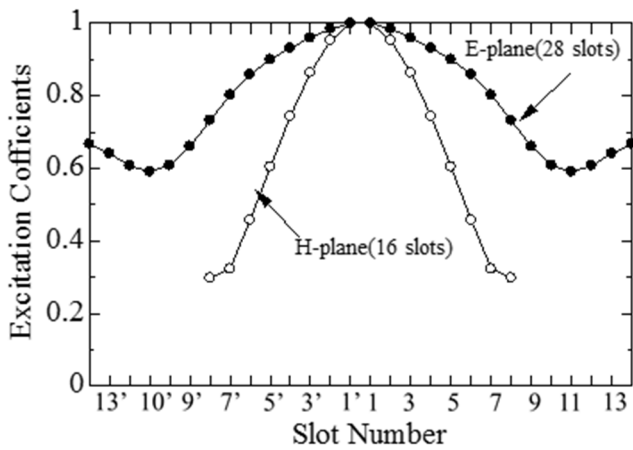


Figure 2 Excitation coefficients

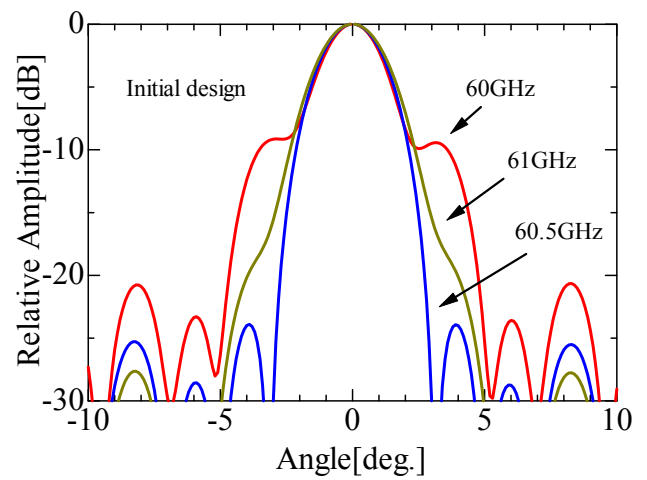


Figure 4 E-plane patterns of the full structure in the initial design

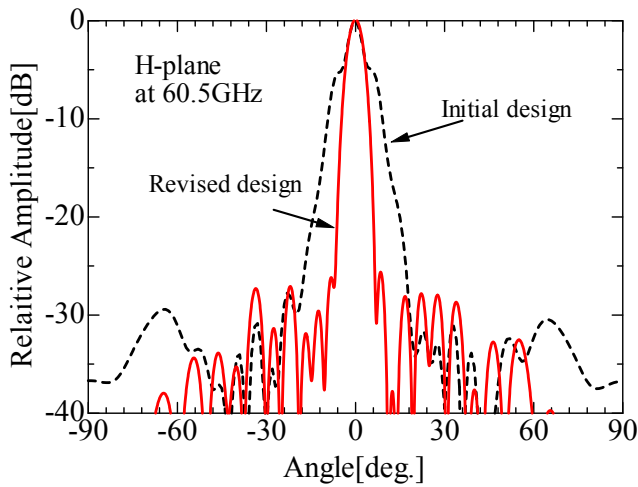


Figure 3 H-plane patterns at 60.5GHz

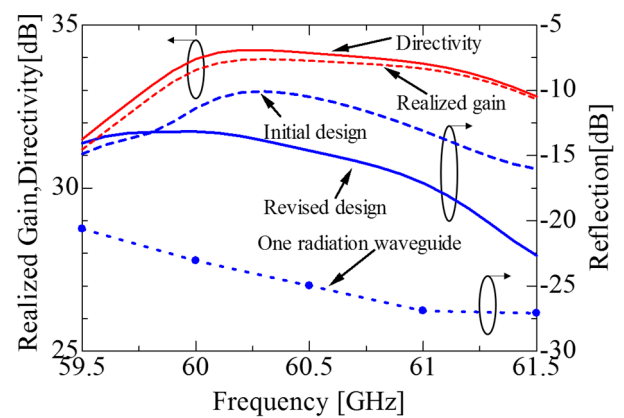


Figure 5 Reflection and gain of the full structure

(3) Full Structure

The full structure of the antenna is analyzed by HFSS. High shoulders of -10dB are observed in the E-plane pattern at 60GHz and the overall reflection is about -10dB at 60.5GHz as shown in Figures 4 and 5, respectively. The overall reflection gets worse by accumulating small reflections of all the slots. The positions of the all irises are moved outwards by 150 μ m and the broad-wall width increases by 25 μ m in the feed waveguide. Then the shoulders become smaller to about -25dB and the reflection reduces -13dB in the bandwidth from 60GHz to 61GHz as shown in Figures 5 and 6. Figure 4 includes the frequency characteristics of the realized gain and the directivity in simulation where the conductivity is assumed to be 5.8×10^7 S/m. The realized gain is 33.9dBi with the antenna efficiency of 64.1% is achieved at 60.5GHz.

4. Conclusion

A series-fed waveguide reflection-canceling 16x28-slot array antenna in the 60GHz band has been designed to suppress the sidelobe levels. As a result, the sidelobe levels in the H-plane can be suppressed sufficiently by use of the reflection canceling slots and the radiation pattern in the E-plane has small shoulder of about -25dB.

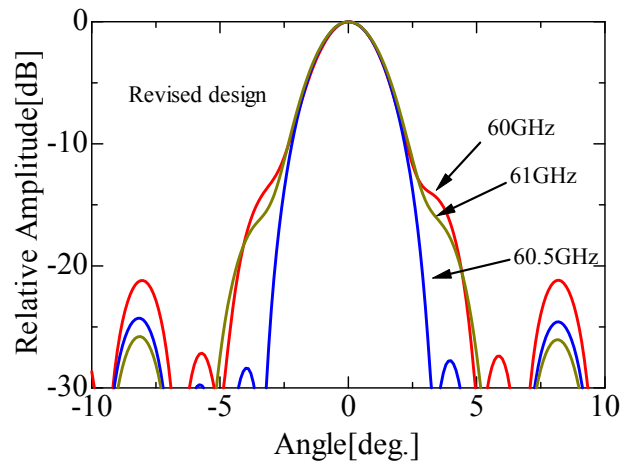


Figure 6 E-plane patterns of the full structure in the revised design

- [1] S.Park et al., "Simple Analysis of a Slot and a Reflection-Canceling Post in a Rectangular Waveguide Using only the Axial Uniform Currents on the Post Surface" IEICE Trans. Commun. vol.86, no.8, pp.2482-2487, Aug. 2003