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GRATING LOBE SUPPRESSION OF NARROW WALL SLOTTED WAVEGUIDE ARRAY ANTENNA USING POST

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1 Introduction

High gain and high angular resolution sensors and high speed wireless communication systems have been developed in the millimeter-wave band recently. Slotted waveguide planar array antennas have advantages of low loss and compact size which are suitable for low profile systems in high frequency. In the design of slotted waveguide broadside array antennas with 45° inclined polarization for such as automotive radar systems, slot spacing becomes one guide wavelength which is larger than a wavelength in free space. Consequently, grating lobes appear in the array pattern. Open ended cavity is set on the slot to reduce the level of the grating lobes with the effect of element radiation pattern [1]. It works effectively when the grating lobes appear in far angle from the broadside.

We propose a narrow wall slotted waveguide array antenna using post in order to prevent gain reduction due to the grating lobes. We discuss the design of a proposed slot element. The simulated performances of both single element and array antenna are indicated in this paper.

2 Design of the array antenna

A planar array antenna is composed of several slotted waveguides excited by a feeding waveguide as shown in Fig.1(a). In order to suppress the grating lobes of a linear array in xz-plane, adjacent waveguides are fed in alternating phase and slot arrangement shifts a half guide wavelength in x-direction to excite all the slots in phase. Since slot spacings in x-direction become half, the grating lobes do not appear in the xz-plane. A maximum slot spacing is in the K-K' direction because of the triangular lattice arrangement of slots as shown in Fig.1(a). So, the grating lobes can appear in the plane including K-K' line and perpendicular to the xy-plane.

There exist two ways to reduce the slot spacing in K-K' direction. One is to reduce the spacing of the waveguides. If slots are cut on the broad wall, width of the broad wall is limited to be narrow for small spacing between the waveguides. Therefore, the slot spacings in x-direction are much larger than that in the case of large broad wall width. On the othe hand, a narrow wall slotted waveguide array antennas are advantageous since broad wall width can

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be independently chosen to control the guide wavelength for the other way to reduce the slot spacing in K-K' direction. Slot spacing can be short by increasing the broad wall width a of the waveguide because the guide wavelength becomes short for large a. However, it is a serious problem that radiation from the slot decreases significantly for large a.

Then, we propose to locate a post on the opposite side of the slot in the waveguide as shown in Fig.1(b). Slots are inclined 45° from the guide axis(x-axis) for polarization requirement. Since input power distributes over the cross section of the waveguide, coupling power from the slot decreases for thick waveguide. On the other hand, in the case that post is located in the waveguide, since the size of the cross section of the waveguide becomes small above the post, power density increases around the slot. Consequently, radiation from the slot increases depending on the height of the post. Furthermore, reflection from the slot and that from the post can be canceled out of phase by optimization of the spacing between the slot and the post. It is not necessary to use the beam tilting technique which is general way to improve return loss characteristic because the reflection from each element has already been small due to the post.

3 Simulation results

A 13-element array is designed at 76.5GHz. Required variety of radiation from slots is 3%∼55% for Taylor distribution for side lobe level lower than -20dB. Major parameters of the proposed element are shown in Fig.2. They are optimized to minimize the reflection for required radiation of the array element.

The radiation P and scattering coefficients S_{11} and S_{21} of the typical antenna elements with post and without post are compared in Fig.3. Length S_l (2.0mm), width S_w (0.4mm) and broad wall width a (3.6mm) are common parameters of the both models. The parameters of post are optimized for the model with post as height h of post is 1.3mm, the spacing between the post and the slot d is 0.7mm. Reflection is lower than -20dB at the design frequency. Radiation from the slot with post was approximately 45% of the input power, which is almost three times as large as that without the post.

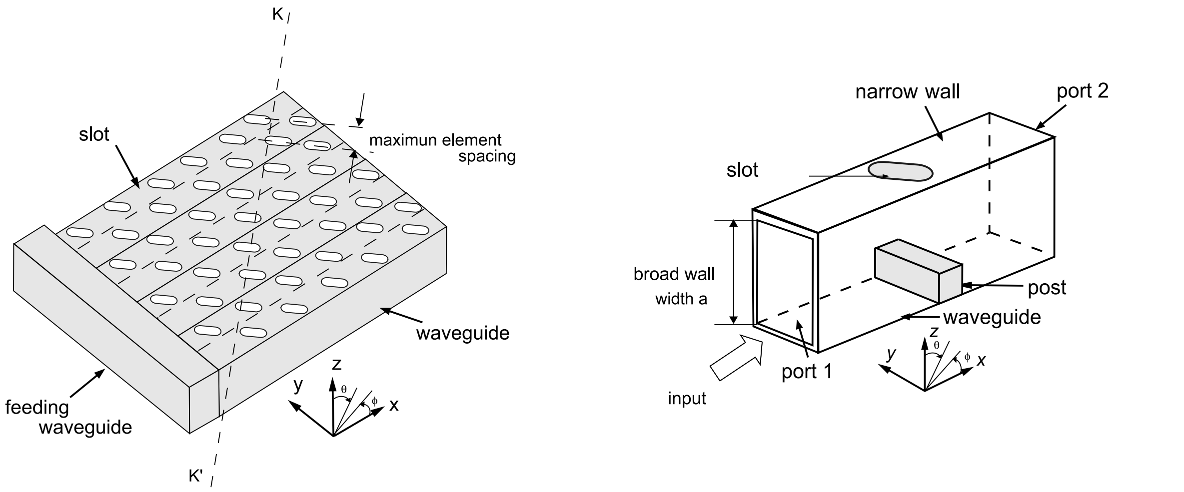
In order to clarify the effect of the proposed array element for grating lobe suppression, a slotted waveguide planar array antenna composed of 18-waveguide linear arrays are designed. Then, the array factor of the plane including K-K' line and perpendicular to the xy-plane is shown in Fig.4. Figure 4(a) shows array factor of the proposed slotted waveguide array antenna with post when a is 3.6mm (λ_g = 4.67mm). Figure 4(b) shows that of conventional slotted waveguide array antenna without post when a is 2.6mm (λ_g = 5.97mm). Radiation from the slot on the waveguide (a=3.6mm) is too small to design the array antenna without post. Narrower waveguide (a=2.6mm) is used to compare the performance with the proposed one. Beam tilting technique is indispensable for the antenna without post in order to improve the return loss characteristic. As a result of simulation, it is confirmed that peak of grating lobe appears in -60° direction and its lebel is -0 dB in the case without post as shown in Fig.4(b). On the other hand, grating lobes appear in ±90° directions and their lebels are -9 dB in the case with post as shown in Fig.4(a).

4 Conclusion

A narrow wall slotted waveguide array antenna with post is proposed to suppress grating lobes. It is confirmed by simulation that grating lobes appear in $\pm 90^\circ$ directions and lebels of them are -9 dB when the proposed element is used in the planar array. Furthermore, the installation of cavity to reduce the grating lobe level could be effectively combined with the proposed structure for future study.

References

[1] K.Sakakibara, et al.,"Millimeter-Wave Slotted Waveguide Array Antenna Manufactured by Metal Injection Molding for Automotive Radar Systems," IEICE Trans. Commun., Vol.E84-B,No.9,Sep.2001



(a) Slotted waveguide planar array antenna (b) Array element composed of a slot and a post

Figure 1: Proposed slotted waveguide array antenna

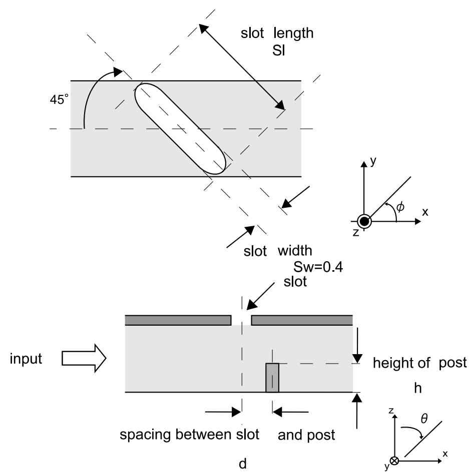


Figure 2: Top view and cross section of proposed slot element

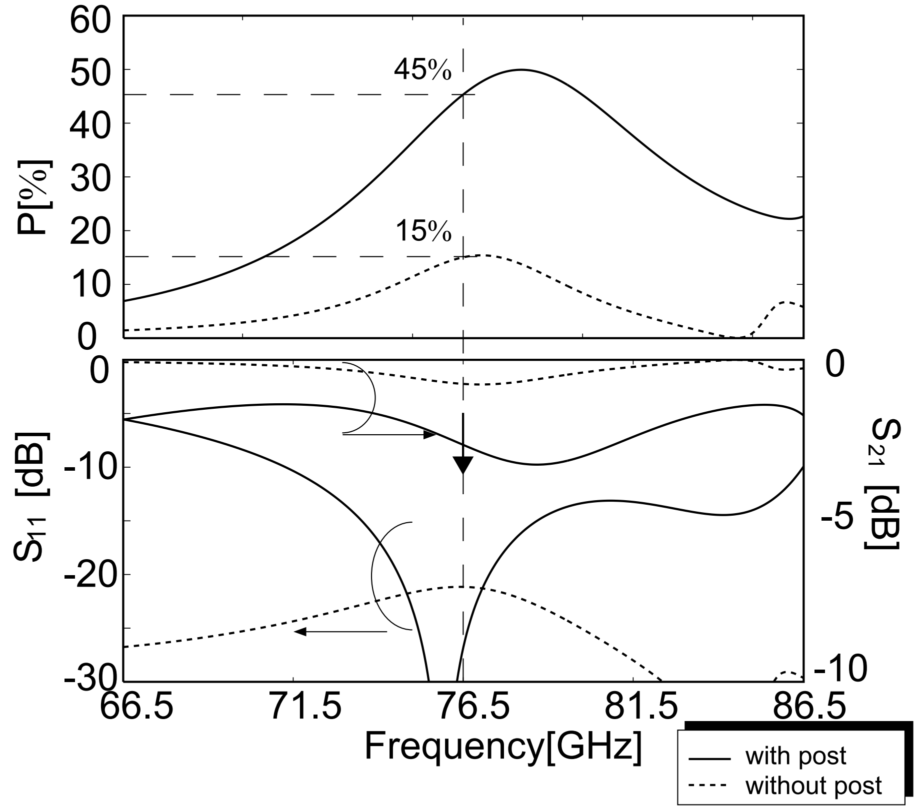


Figure 3: Frequency dependency of radiated power and scattering coefficints S_{11} and S_{21}

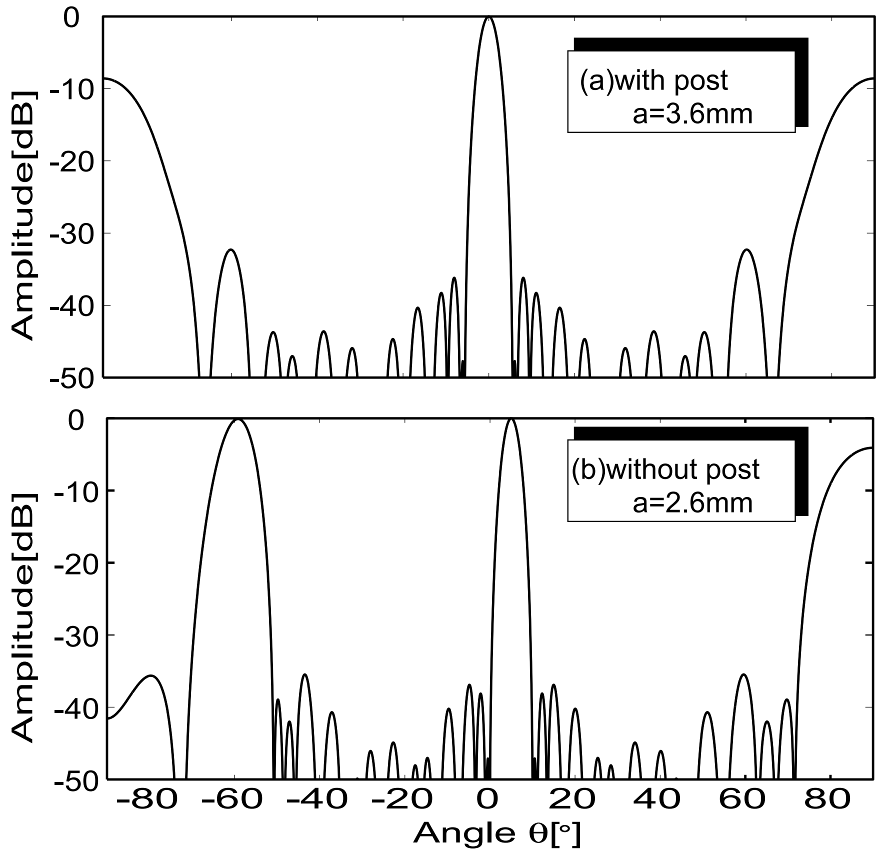


Figure 4: Array factor in plane plane including K-K' line and perpendicular to the xy-plane