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# Feasibility of Perpendicular-Corporate Feed for a Multi-Layered Parallel-Plate Slot Array Antenna

Hisanori Irie, and Jiro Hirokawa
Department of Electrical and Electronic Engineering, Tokyo Institute of Technology
S3-20, 2-12-1 O-okayama, Meguro-ku, Tokyo, 152-8552, Japan
*E-mail: [irie.h, jiro]@antenna.ee.titech.ac.jp*

***Abstract*—This paper presents the feasibility of perpendicular-corporate feed for a multi-layered parallel-plate slot array antenna, where the coupling apertures are fed by a corporate feed circuit and each of the coupling apertures excites 2x2 radiating slots with additional one from the bottom to the top of the multi-layer parallel plates. Dielectric with proper permittivity is placed between the coupling aperture layer and the radiating slot layer to excite a standing wave to prevent leakage. A 2x2-element subarray fed by a waveguide provides 4.9 % bandwidth for VSWR ≤ 1.5 by the additional slot layer.**

***Index Terms*— parallel plates, slot array, perpendicular-corporate feed.**

## I. Introduction

This paper proposes a perpendicular-corporate feed for a multi-layered parallel-plate slot array antenna as shown in Fig.1. The coupling apertures on the bottom are fed by a corporate feed H-plane hollow waveguide and the spacing is longer than a free-space wavelength. Each of the coupling apertures excites 2x2 radiating slots with additional one from the bottom to the top of the multi-layer parallel plates perpendicularly. The structure is the replacement of the radiating part with multi-layered parallel plates in the plate-laminated waveguide corporate-feed slot array antenna [1]. Dielectric with proper permittivity is placed between the coupling aperture layer and the radiating slot layer to excite a standing wave to prevent leakage from the periphery [2]. An additional layer of slots is placed over the radiating slot layer to enhance the bandwidth.

## II. Analysis Model

Figure 1 shows the analysis model of a 16x16-element array. An 8x8-element subarray is used for the analysis of the 16x16-element array with uniform excitation because of its symmetry. The 8x8-element subarray consists of radiating slots, dielectric, additional slots, and coupling apertures. The polarization is along the *x*-axis. Each of the coupling apertures is fed by a waveguide as shown in Fig.2 (a) in the analysis. Around the periphery of the 8x8-element subarray, PEC (Perfect Electric Conductor) boundaries at both the edges parallel to the *yz*-plane and PMC (Perfect Magnetic Conductor) boundaries at both the edges parallel to the *xz*-plane are introduced by considering the *x*-polarization. For the external region, radiation boundaries are introduced for analyzing by Ansys HFSS.

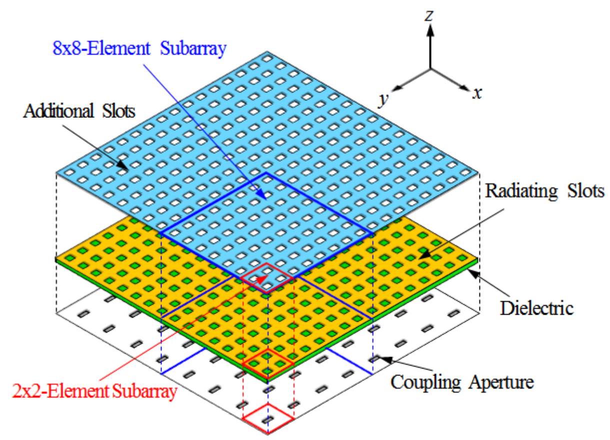


Fig. 1. Perpendicular-Corporate Feed for Multi-Layered Parallel-Plate Slot Array Antenna

## III. Effect of Dielectric

Figure 2 shows the structural difference between the proposed model and the conventional model of the 2x2-element subarray. The conventional model holds field in the cavity by the side walls of PEC. On the other hand, the proposed model introduces dielectric with proper permittivity between the coupling aperture layer and the radiating slot layer so that the effective electrical size increases from 1.72 free-space wavelength to two wavelengths to excite a standing wave to prevent from leakage.

† The distance between elements is constant: $0.86\lambda_0$

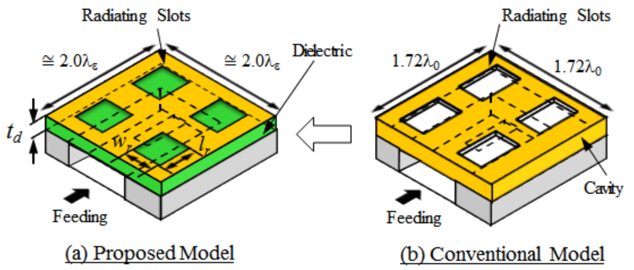


Fig. 2. Difference between the Proposed Model and the Conventional One

We analyze both the 2x2-element and the 8x8-element subarrays. Around the periphery of both the internal and the external regions for the 2x2-element subarray, PEC boundaries at both the edges parallel to the *yz*-plane and PMC boundaries at both the edges parallel to the *xz*-plane are introduced by considering the *x*-polarization to include the mutual coupling in its infinite array. The parameters for the parallel plates are the size $l_r$ and $w_r$ of the radiating slots, the thickness $t_d$ of the dielectric and its relative permittivity $\varepsilon_r$ as shown in Fig.2(a). These parameters are determined so that the desired operation is achieved where the frequency characteristic of the reflection of the 16 coupling apertures should be identical in the 8x8-element subarray and it should agree with that of the 2x2-element subarray. Furthermore, the other parameters relating to the coupling aperture are determined to minimize the reflection at the design frequency of 61.5 GHz. Once the desired operation is achieved, all the radiating slots are excited uniformly because of their periodic arrangement.

Figure 3 shows the frequency characteristics of reflection of the 8x8-element subarray for $\varepsilon_r$ = 1.00 and $\varepsilon_r$ = 1.28. For $\varepsilon_r$ = 1.28 the above-mentioned desired operation is achieved while for $\varepsilon_r$ = 1.00 it is not. The effect of the dielectric is confirmed. However, the bandwidth for the reflection less than -14 dB is very narrow, which is about 0.5 %.

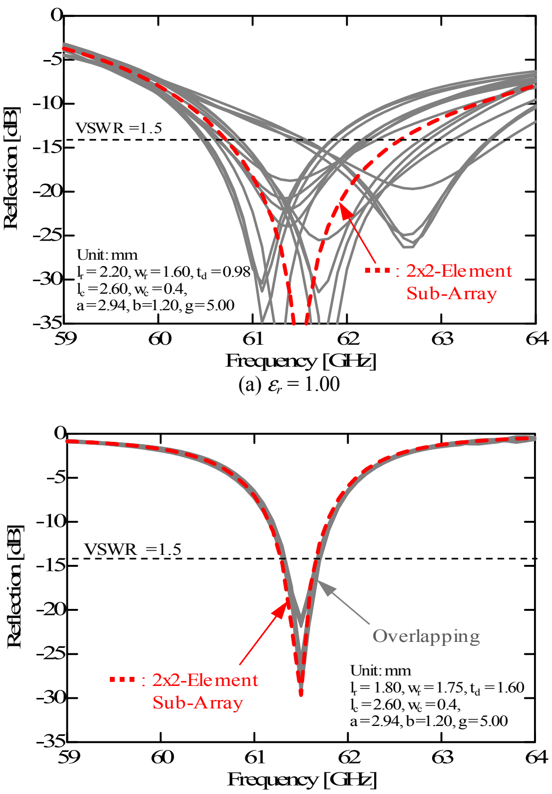


Fig. 3. Frequency Characteristic of Reflection

## IV. Additional Slots

To improve the bandwidth for $\varepsilon_r$ = 1.28, additional slots are placed on the radiating slots. A 2x2-element subarray with additional slots is shown in Fig. 4. The element spacing is constant: $0.86\lambda_0$ (4.20mm). The space between the radiating slots and the additional slots is hollow. The parameters are the size $l_a$, $w_a$ and $h_{ar}$ of the additional slots including $l_r$, $w_r$ and $t_d$. The design procedure is the same to that in the previous section. The frequency characteristic of the reflection is shown in Fig. 5. The reflection of the 2x2-element subarray is less than -14 dB over 4.9% bandwidth ranging from 60.0 GHz to 63.0 GHz. The bandwidth is improved from 0.5 % to 4.9 % by placing the additional slots on the radiating slots. The deviation of the frequency characteristics of the reflection among the 16 coupling apertures in the 8x8-element subarray cannot be suppressed completely; however, it is small.

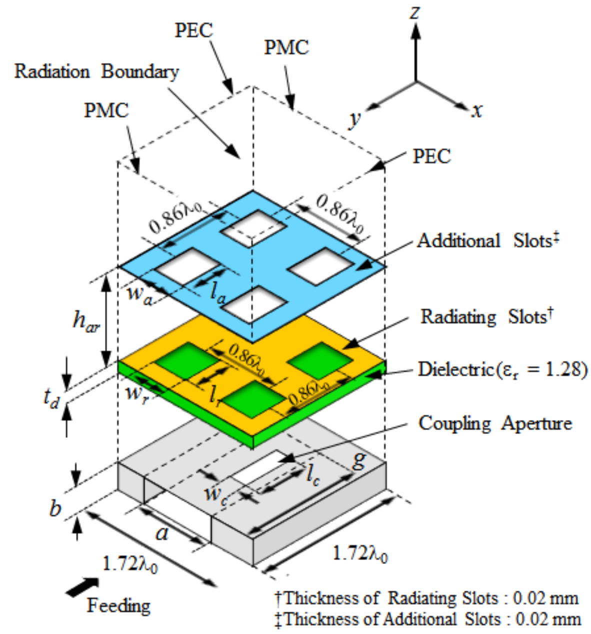


Fig. 4. 2x2-Element Subarray with Additional Slots

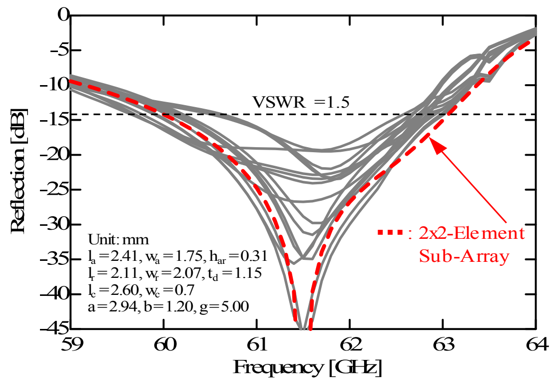


Fig. 5. Frequency Characteristic of Reflection

## V. Conclusion

In this paper, we presented the feasibility of a perpendicular-corporate feed for the multi-layered parallel-plate slot array antenna. The introduction of dielectric can excite each 2x2-element subarray uniformly by generating a standing wave. As a result, we realized 4.9% bandwidth for VSWR $\leq$ 1.5 by its multi-layered structure.

## Reference


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