

Characteristics of E- to H-Plane Multiple Way Power Divider for the center feed in alternating phase fed Single-Layer Slotted Waveguide Array

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1. Introduction

Fixed Wireless Access (FWA) systems in the 26 GHz band have been commercialized in Japan for high-speed Internet connections between subscribers and base stations [1]. Compact and low-cost user terminals are realized by adopting alternating-phase fed single-layer waveguide slot arrays [2]. To double the frequency efficiency, we proposed a dual polarization system that utilizes high XPD of slotted waveguide arrays [3]. A single layer slotted waveguide array has been one of the key components in this system, since it has high efficiency and a mass producible structure. This array, in its original form, has the cascaded feed at one end of the aperture with traveling wave operation. It suffers the frequency dependent beam shift as is usual the case with the traveling wave arrays and brings about the fatal difficulty in dual-polarization FWA systems where a terminal consists of two linearly-polarized arrays arranged orthogonally. To solve this problem, authors have developed H-plane cross-junction multiple way power divider for feeding the array from the center of the aperture, which still lies in the same layer as the radiating waveguides [4][5][6]. Recently, the blocking due to the feeding waveguide located in the center of the aperture is remedied by E- to H-plane multiple way power divider [7] with its narrow wall parallel to the aperture. If the blocking of this feed waveguide, still in single layer, can be made small enough, it can run freely in the aperture without causing blockage. Figure 1(a) shows the conceptual model of partially corporate feed array which drastically widens the bandwidth of alternating phase fed single-layer waveguide slot arrays. As the unique structure of alternating phase fed arrays, it consists of two parts, a slot plate and a base plate with corrugations screwed to each other, which dispenses with electrical contact in the strict sense.

This paper demonstrates the predicted and measured characteristics of an E- to H-plane cross-junction as well as the multiple way power divider consisting of its cascade for the use in the alternating-phase fed single-layer waveguide array. The low reflection over a wideband is confirmed as the unique advantage of the feed with E- to H-plane cross-junctions.

2. Structure of the feed waveguide

A multiple way power divider with suppressed aperture blockage is proposed in Fig.1 and Fig.2 (a). It consists of a novel unit structure of the E- to H-plane cross-junction presented in Fig.2 (b) [7], where the narrow wall of the feed waveguide is embedded on the top instead of the broad wall in the conventional H-plane cross-junction, in order to reduce the blocking area of the slot array in Fig.1. A unit cross-junction has a wall at the bottom of the feed waveguide to suppress the reflection and two windows to control division to two radiating waveguides. The division is controlled by the width L_w of the coupling windows. The reflection is controlled by the height W_h of the wall and its position W_p from the center of the cross-junction. It is suppressed below -30dB at 25.3GHz in the design. The broad wall of the feed waveguide is set 7.2mm so that the spacing of the radiating waveguide is an half of the guided wavelength of the feed waveguide. The narrow-wall width of the feed waveguide is chosen 3.6mm, which is an half of the broad-wall width.

A cascade of seven E- to H-plane cross-junction multiple way power divider has reflection below -20dB in a bandwidth wider than an array of conventional H-plane cross-junction multiple way power divider [4] as shown in Fig.3. The reason is that the reflections from the two coupling windows in opposite broad walls of a junction cancel each other in principle.

3. Experimental Results

Fig.4 shows the photo of a model antenna. Seven cross-junctions multiple way power divider and a t-junction for the termination are cascaded to form the feed waveguide. The input port is located on the left in the figure. The junctions are designed to be divided with equal amplitude and alternating phase between adjacent radiating waveguides. This model has 10 slots with uniform excitation on the both sides of each junction. This fabrication is to show that the side-lobe level in H-plane does not increase due to the blocking by the feed waveguide. The walls and the windows can be fabricated in the grooved feed waveguide simultaneously. This structure still has an advantage that it can be dug only from the side of the slotted aperture in the manufacture. Fig. 5 shows the results of predicted and measured overall reflection of the cascaded cross-junctions multiple way power divider, the t-junction and the slot array. Also Fig. 5 shows the results of predicted overall reflection in the case of the H-plane cross-junction multiple way power divider and one linear slot array. In this time, the predicted reflection characteristic of a linear slot array has reflection below -15dB in a bandwidth almost 1GHz. The antenna which is adopted the E- to H-plane cross-junction has good reflection characteristics below -15dB in a bandwidth wider than the antenna which is using conventional H-plane cross-junctions. The FEM analysis is conducted using HFSS for each component and the full model. The predicted and measured reflection characteristics of the full model is less than -20dB at the design frequency 25.3GHz as shown in Fig. 5. Fig.6 shows the results of predicted and measured radiation pattern of the H-plane which has blocking area in the center. The predicted and measured radiation pattern, this antenna uses E- to H-plane cross-junction multiple way power divider, has the first side-lobe level is -13.7 dB. This was improved at a point of the first side-lobe level in comparison with the antenna which uses H-plane cross-junction multiple way power divider. The beam width in H-plane is 3.2 degree. Fig.7 shows the measured results of amplitude and phase distribution for the frequency change of plus or minus 500MHz from the design frequency. The design frequency is 25.3GHz. To compare with the design frequency (25.3GHz), the frequency change gives the phase taper, which results in the beam shift. Fig.8 shows the E-plane radiation pattern. The main beam is tilted for frequency change. The antenna directivity gain calculated by the aperture field distribution is 30 dB in 25.3GHz. The aperture efficiency is about 65%.

4. Conclusion

A multiple way power divider using seven cascaded E- to H-plane cross-junctions are fabricated for the blocking free center feed of the alternating-phase fed single layer slotted waveguide array. The characteristics are confirmed by in experiment and simulation. The wide band characteristics of suppressed reflection is confirmed. The side lobe level in the H-plane does not increase by the blocking area in the aperture center.

Acknowledgment

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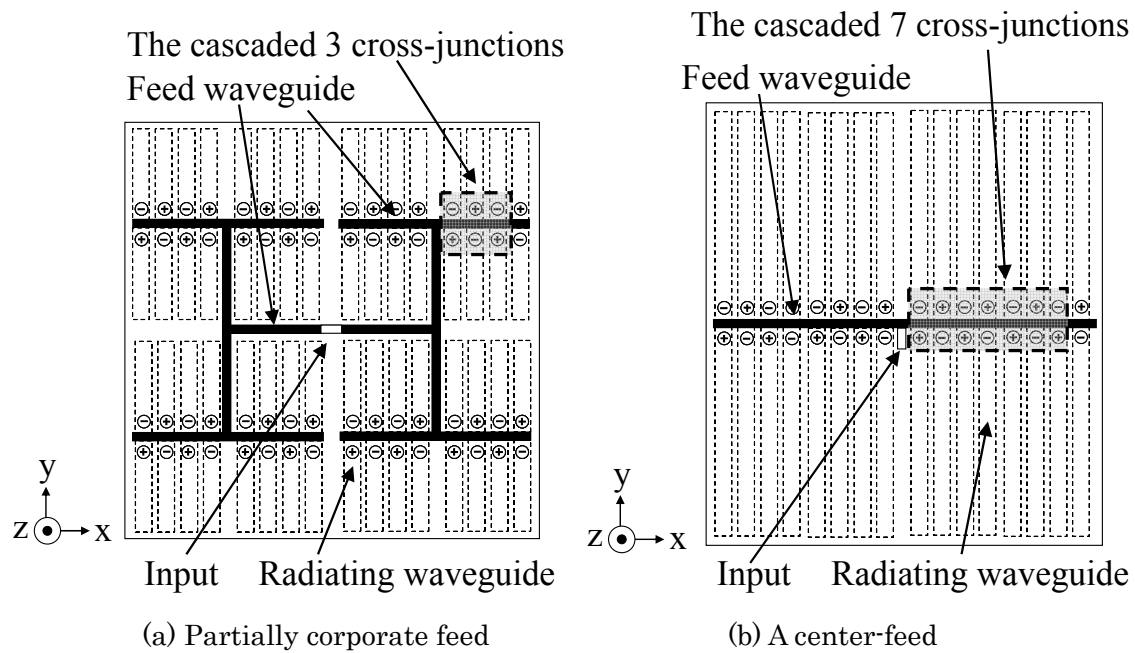


Fig.1 The center-feed alternating phase fed single-layer waveguide.

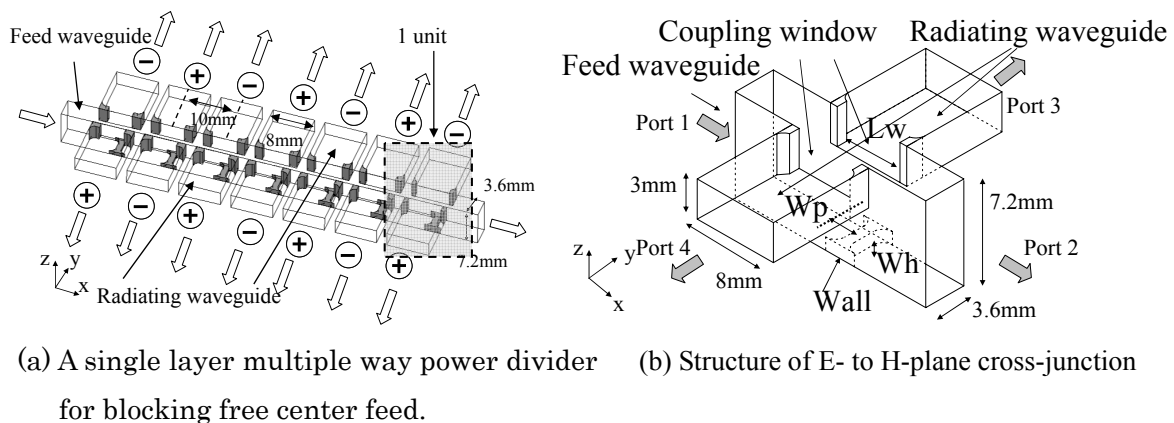


Fig.2 Structure of E- to H-plane cross-junction

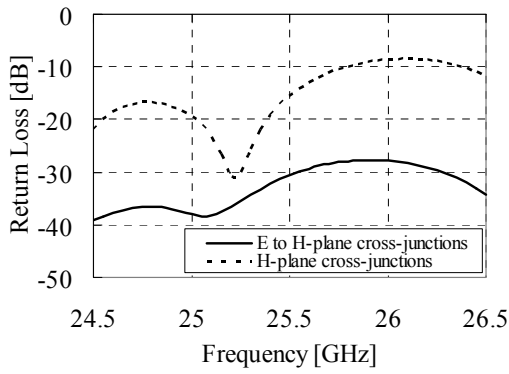


Fig.3 The predicted reflection characteristics of a cascade of 7 cross-junctions. (Cal.).

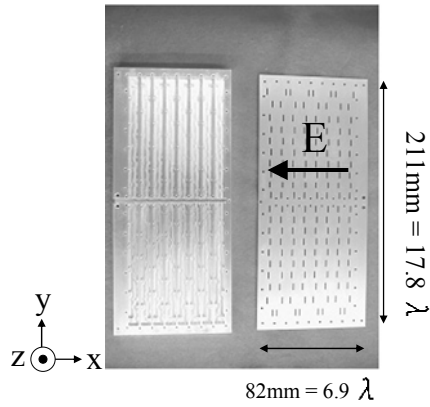


Fig.4 Prototype antenna which is adopted E- to H-plane cross-junction.

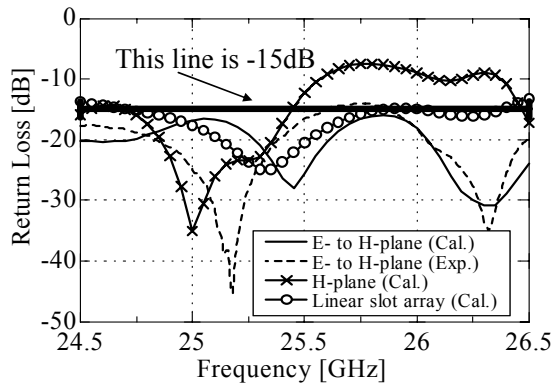


Fig.5 The predicted and measured reflection characteristics each model and one linear slot array.

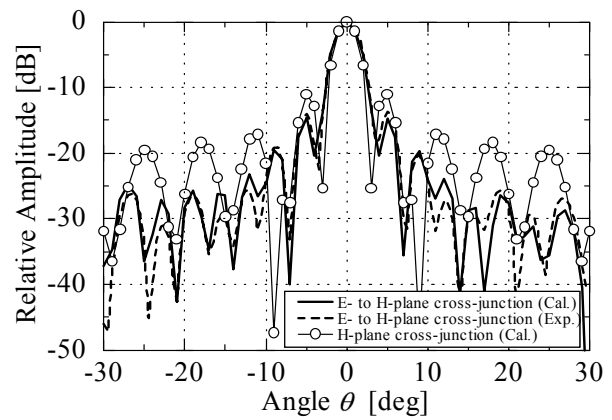


Fig. 6 Radiation pattern is improved by using E- to H-plane cross-junction (H-plane).

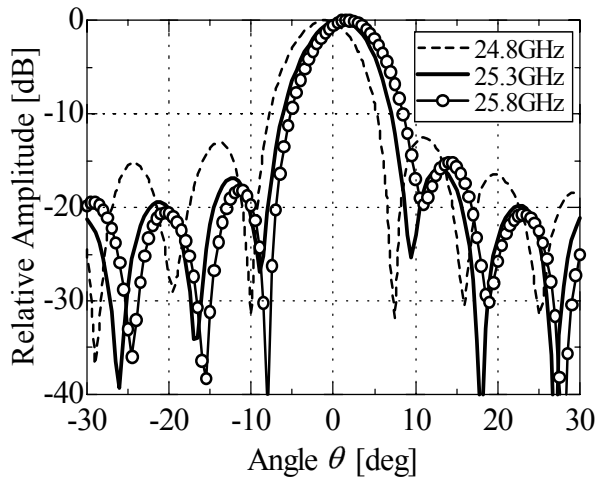
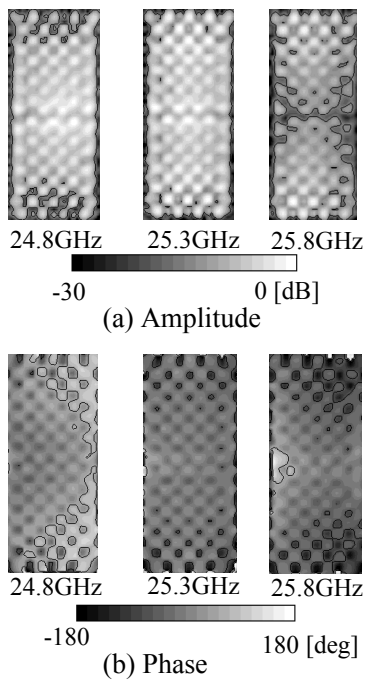


Fig.7 Field distribution (Exp.). Fig.8 Depends on frequency change in E-plane (Exp.).