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The Ridged Cross-Junction Multiple-Way Power Divider for Small Blockage and Symmetrical Slot Arrangement in the Center Feed Single-Layer Slotted Waveguide Array

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1. Introduction

The alternating phase-fed single-layer waveguide slot array [1] is used in a variety of regions nowadays. One of the applications, 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 [2]. Compact and low-cost user terminals are realized by adopting alternating-phase fed single-layer waveguide slot arrays [3]. The unique structure of alternating phase fed arrays consists of two parts, a slot plate and a base plate with corrugations screwed to each other as shown in Fig.1 (a), which dispenses with electrical contact in the strict sense. Unfortunately, the waveguide slot array has a relatively narrow bandwidth. The feed waveguide is located at the center of the aperture to reduce long line effects of the slot array [4, 5]. This antenna has a boresight beam regardless frequency changes. One of the weaknesses is the blocking area at the center of the aperture. It causes high sidelobe level (almost -10dB) in H-plane.

To double the frequency efficiency, a dual polarization system is proposed using the high XPD of slotted waveguide arrays and high isolation (almost 80dB) [6] between Tx antenna and Rx antenna at the same frequency. The most important point is the arrangement of the slot array symmetry. To reduce blocking area, the structure of the ridge is adopted in the feed waveguide [7].

This paper demonstrates the characteristics of the divided amplitude and phase of two type ridged cross-junctions and cross-junction arrays. The reflection characteristic is less than –20dB for each cross-junction at the design frequency 25.3GHz. The phase difference from 180 degree in adjacent radiating waveguides using the two type arrays are 16.6 degrees and 3.4 degrees.

2. Structure

The ridged cross-junction is shown in Fig. 1 (b). This cross-junction is required to distribute the electric field of the Ez component with the same phase to each radiating waveguide. From this point of view, a ridged cross-junction is proposed. A unit cross-junction has a ridged structure to reduce the area of the broad wall on the antenna aperture. The structure of the notch in the ridge can produce a wave to suppress the reflection from the coupling windows. The two coupling windows control the division to the two radiating waveguides.

The divided power to radiating waveguide is controlled by Wl of the coupling window length. The reflection is controlled by Nl of the notch length, Nd of the notch depth, and its position Np from the center of the cross-junction. It is suppressed below -20dB at 25.3GHz in the design. The broad wall depth of the feed waveguide is set to 4.5 mm and the height of the ridged structure is

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set to 2.4 mm. This model can reduce the blocking area sufficiently. The symmetry of the slot array in the plane of the feed waveguide is obtained using this cross-junction. It reduces the blocking broad wall area from 9.0mm to 3.0mm compared with the conventional H-plane cross-junction.

The analysis of this model has many parameters. For understanding this structure, we should fix several parameters. In model A Nl is fixed at 1.0mm. In model B Nd is fixed at 1.0mm.

Next we discuss the power divider distribution characteristics and the multiple power divider analyses.

3. ANALYSIS

First, we designed model A and model B so that the total coupled power to the two radiating waveguides is 2/4=50%, which should be used just in front of the terminal dividers and is numbered 1^{st}. The amplitude of reflection and distribution in each model is shown in Fig.2. Reflection (|S11|), transmission (|S21|, |S31|, |S41|) characteristics are evaluated by the commercial Finite Element Method (FEM) software Ansoft HFSS^{TM} (High-Frequency Structure Simulator). The design frequency is 25.3GHz.

In the next, we designed model A and model B for the 2^{nd} power dividers to be used in front of the 1^{st} one so that the coupled power to each of the output port is 1/6=15%. The amplitude of reflection and distribution in each model are shown in Fig.3. The reflection and transmission characteristics can be designed at the design frequency. The model A's reflection is better than model B's one.

Finally, each model cross-junction is connected for multiple power dividers. The reflection and transmission characteristics can be designed at the design frequency. The designed phase difference at the adjacent two radiating waveguides is 180 degrees. The model A array phase error is 16.6 degrees difference. The ridge height or the brad wall height should be changed in the future study. On the other hand, the model B array phase error is only 3.4 degrees. It is good result.

4. CONCLUSION

We have analysed the ridged cross-junction for the feed waveguide in a center-feed single-layer waveguide. This feed waveguide is advantageous in terms of reducing the blocking area and slot array symmetry to obtain high isolation. The two models are analysed for example. The calculated reflection characteristics are less than -20dB and distributions to radiating waveeguides are almost same. The each model phase error of adjacent radiating waveguides is 16.6 degrees and 3.4 degrees. Our future study is to make the feed aperture of this ridged cross-junction array to use planar antenna.

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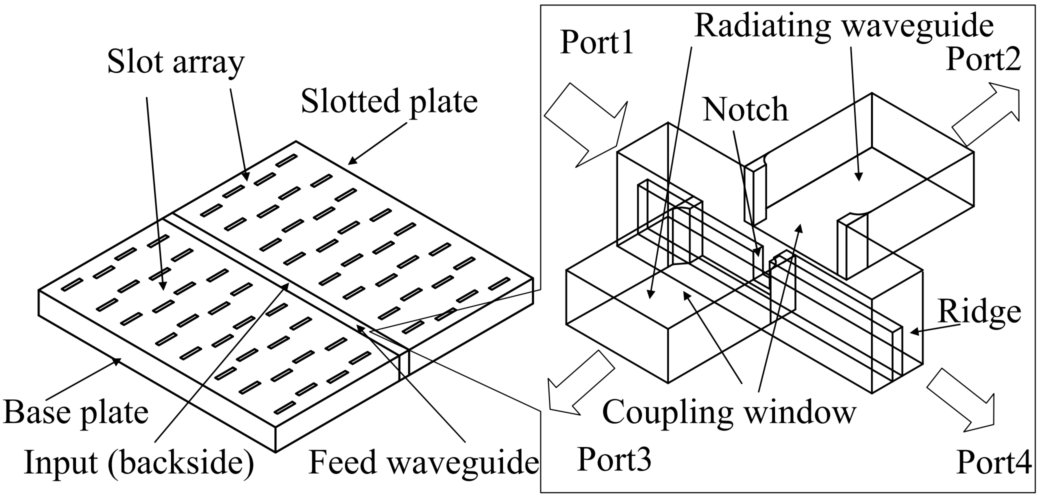
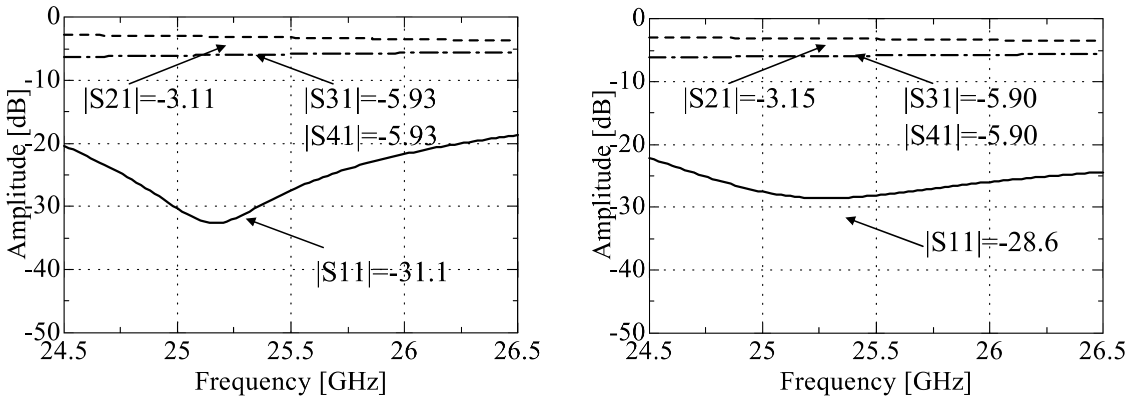


(a) Single-layer waveguide slot array antenna (b) The ridged cross-junction model

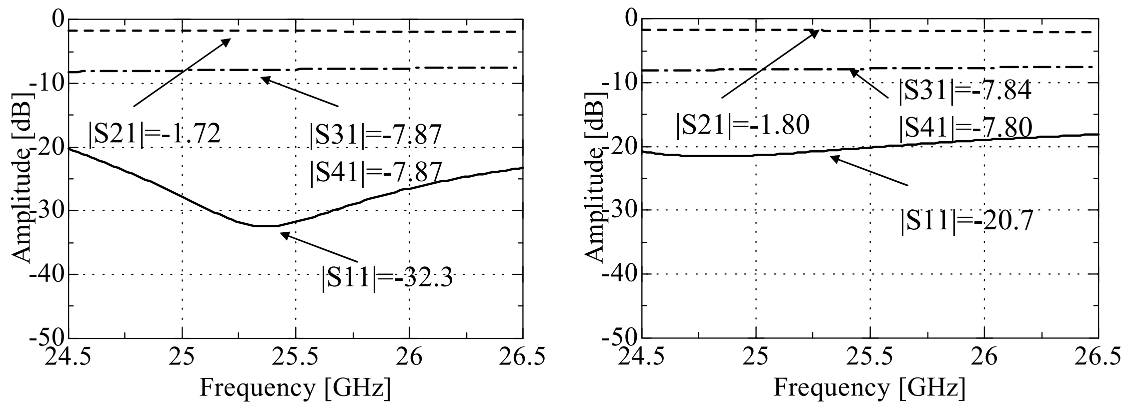
Figure 1: Structure of ridged cross-junction power divider



(a) The length of notch (Nl) is fixed at 1.0mm Wl = 5.6mm, Nd = 1.8mm, Nm = 0.7mm

(b) The depth of notch (Nd) is fixed at 1.0mm. Wl = 5.3mm, Nl = 2.2mm, Nm = 0.9mm

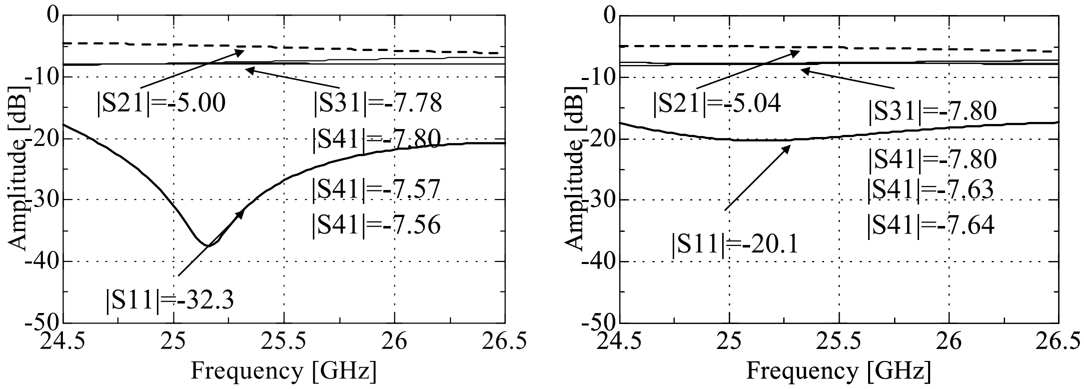
Figure 2: Amplitude characteristics of the 1st (just before the terminal one) cross-junction power divider. Target: |S11| = less than -20dB, |S21| = -3.01 dB, |S31| = |S41| = -6.02 dB



(a) The length of notch (Nl) is fixed at 1.0mm Wl = 5.0mm, Nd = 1.35mm, Nm = 0.6mm

(b) The depth of notch (Nd) is fixed at 1.0mm. Wl = 4.8mm, Nl = 1.6mm, Nm = 0.9mm

Figure 3: Amplitude characteristics of the 2nd (from the end) cross-junction power divider. Target: |S11| = less than -20 dB, |S21| = -1.76 dB, |S31| = |S41| = -7.78 dB



(a) The length of notch (Nl) is fixed at 1.0mm (b) The depth of notch (Nd) is fixed at 1.0mm.

Figure 4: Amplitude characteristics of series of cross junction (the 1st and the 2nd).
Target: |S11| = less than -20 dB, |S21| =1/3=-4.77 dB, |S31| = |S41| = |S51|= |S61=1/6= -7.78 dB

References

[1]Naohisa Goto, “A waveguide-fed printed antenna,” IEICE Technical Report, AP89-3, Apr. 1989.

[2]Yuichi Kimura, Yohei Miura, Jiro Hirokawa, and Makoto Ando, "A LOW-COST AND COMPACT WIRELESS TERMINAL WITH AN ALTERNATING PHASE FED SINGLE-LAYER WAVEGUIDE ARRAY FOR 26GHz FIXED WIRELESS ACCESS SYSTEMS," JINA, Nov. 2002.

[3]26GHz FWA http://www.jrc.co.jp/eng/product/26g_fwa/index.html

[4]Sehyun Park, Yasuhiro Tsunemitsu, Jiro Hirokawa, Makoto Ando, ”Center Feed Single Layer Slotted Waveguide Array,” IEEE Trans. Antennas Propag., vol. 54, no5, pp. 1474-1480, May 2006.

[5]Yasuhiro Tsunemitsu, SeHyun Park, Jiro Hirokawa, Makoto Ando, Yohei Miura, Yasuhiro Kazama, and Naohisa Goto, "Reflection Characteristics of Center-Feed Single-Layer Waveguide Arrays," IEICE Transactions on Communications, Vol.E88-B, No.6, pp.2313-2319, June 2005.

[6]Yasuhiro Tsunemitsu, Jiro Hirokawa, Makoto Ando, Yohei Miura, Yasuhiro Kazama, and Naohisa Goto, “Polarization Isolation characteristics between two Center-Feed Single-Layer Waveguide Arrays Arranged Side-by-Side”, Applied Computational Electromagnetics Society Journal, Special Issue on Phased and Adaptive Array Antennas, Vol.21 No.3 p.240-p.247, November 2006

[7] Yasuhiro Tsunemitsu, Jiro Hirokawa, Makoto Ando, and Naohisa Goto, "Ridged Cross-Junction Power Divider for the Center Feed in a Single-Layer Slotted Waveguide Array," 2006 INTERNATIONAL SYMPOSIUM ON ANTENNAS AND PROPAGATION (ISAP2006), Session: SB2, Singapore, Nov. 1-4, 2006.