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Design and Fabrication of a Dual-polarized Corporate-feed Waveguide 32x32-slot Array Antenna with an Orthomode Transducer for 40 GHz Band

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***Abstract* – A dual-polarized corporate-feed waveguide 32x32-slot array antenna with an orthomode transducer is designed for 40 GHz band (41~42 GHz) in order to integrate their two input ports. The simulation by HFSS gives the bandwidth for VSWR lower than 1.5 of 6.5 % (S_{11}) and 3.8 % (S_{22}), respectively, at the design frequency of 41.5 GHz. S_{12} is achieved less than –20 dB over the bandwidth. The simulated realized gain for both polarizations is 38.1 dBi at 41.5 GHz with the antenna efficiency of 78 %.**

***Index Terms* — millimeter wave, waveguide slot array, dual polarization, orthomode transducer, 40GHz**

1. Introduction

A dual-polarized corporate-feed waveguide slot array antenna was proposed and fabricated as a low-profile high-efficiency planar antenna for effective frequency reuse in the 60 GHz and 120 GHz bands [1] [2]. This paper presents a 32x32-slot array antenna in the 40 GHz band (41~42 GHz), where an orthomode transducer is introduced to integrate two input ports for the dual polarization.

2. Antenna Structure

This antenna radiates orthogonal linear polarizations. Figure 1 shows the structure of the antenna and Figure 2 shows the structure of the input section. y-directed (Mode 1) and x-directed (Mode 2) polarized waves are incident from the input port of a circular waveguide. Mode 1 propagates to the lower feeding waveguide and Mode 2 propagates to the upper feeding waveguide through the orthomode transducer. They propagate to a 2x2 radiating-slot sub-array at the ends of the feeding waveguides. The longitudinal coupling slot has an offset from the center of the lower feeding waveguide to excite the y-polarized wave. It has no offset with respect to the center of the upper feeding waveguide as well as the longitudinal slot of the cross coupling slot not to excite the upper feeding waveguide. Therefore we ensure high isolation between the upper and the lower feeding waveguides. The transverse slot of the cross coupling slot excites the x-polarized wave.

3. Measurement Results

The 32x32-slot array antenna is designed and fabricated. The antenna size is 187.2 mm x 187.2 mm. Figure 3 shows the photo of the fabricated antenna by diffusion bonding of 51 copper plates with 0.2 mm thickness.

The calculated and measured frequency characteristics of the reflection is shown in Figure 4. In the simulation, the bandwidth for VSWR less than 1.5 at the 41.5 GHz is 6.5 % (S_{11}: red dashed line) and 3.8 % (S_{22}: blue dashed line), respectively. S_{12} (green dashed line) is less than –20 dB over the above bandwidth. The solid lines show the measured results. The measured results are similar to calculated ones.

Figure 5 shows the frequency dependences of the realized gain and the directivity. At 41.5 GHz, realized gain of 38.1 dBi is obtained with 78 % antenna efficiency for both polarizations in the simulation. We used 5.8×10^7 S/m as the conductivity of copper. The measured realized gain is obtained by comparing with a standard gain horn in an anechoic chamber. It is 36.2 dBi (Mode 1) and 36.6 dBi (Mode 2), respectively. At 41.5 GHz, directivity of 38.7 dBi is obtained with 90 % aperture efficiency for both polarizations in the simulation. The measured directivity is obtained by a two-dimensional near-field distribution. It is 37.6 dBi (Mode 1) and 38.0 dBi (Mode 2), respectively.

The measured radiation patterns in the E-plane and H-plane for Mode 1 at 41.5 GHz are shown in Figures 6 and 7, respectively (the red line is for the measured result, the black dashed line is for the calculated one). We confirm the measured radiation patterns for Mode 2 are almost the same to those for Mode 1.

4. Conclusion

We have presented the measured results of the dual-polarized 32x32-element plate-laminated-waveguide slot array antenna with an orthomode transducer. The measured results of S parameters are similar to calculated ones. At the design frequency, the realized gain is 36.2 dBi (Mode 1) and 36.6 dBi (Mode 2), respectively, with high antenna efficiency.

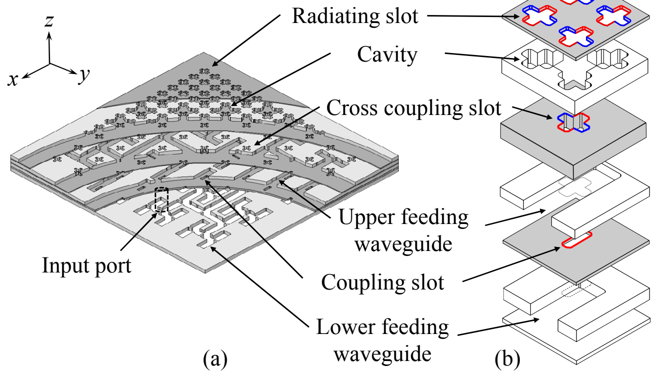

Figure 1
Dual-polarized corporate-feed waveguide slot array
(a) Overall structure (b) 2x2 radiating-slot sub-array

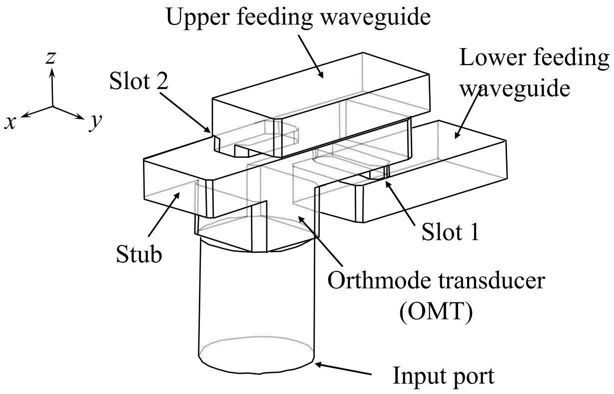

Figure 2 Structure of the input section

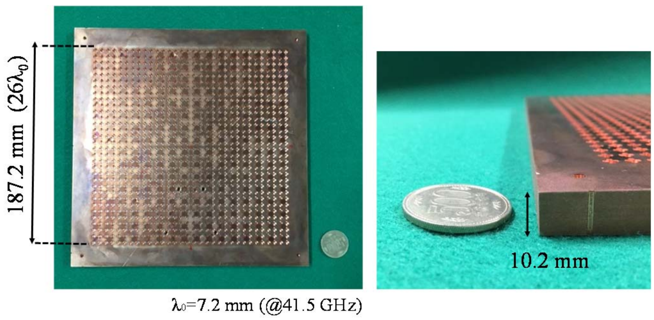

Figure 3 Fabricated antenna

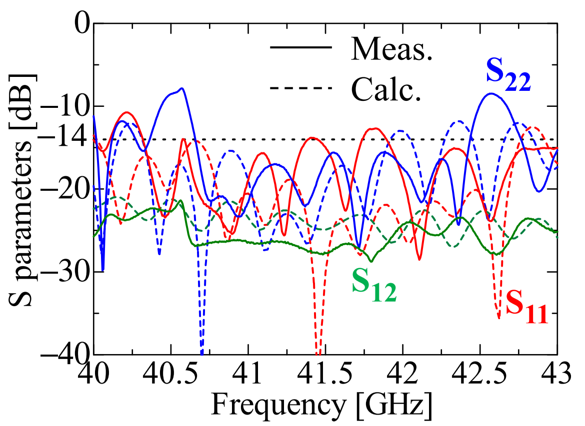

Figure 4 Frequency characteristics of the S parameters

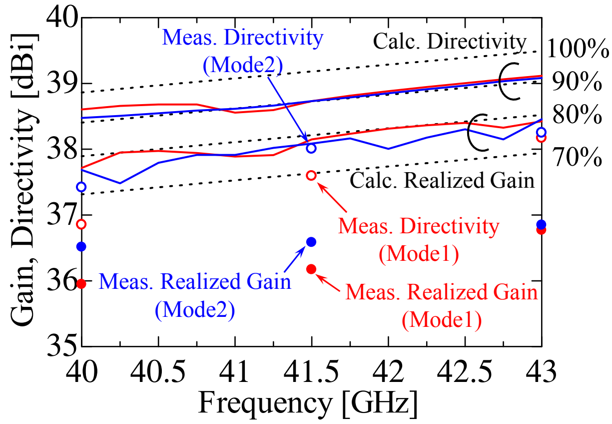

Figure 5 Frequency characteristics of the realized gain and the directivity

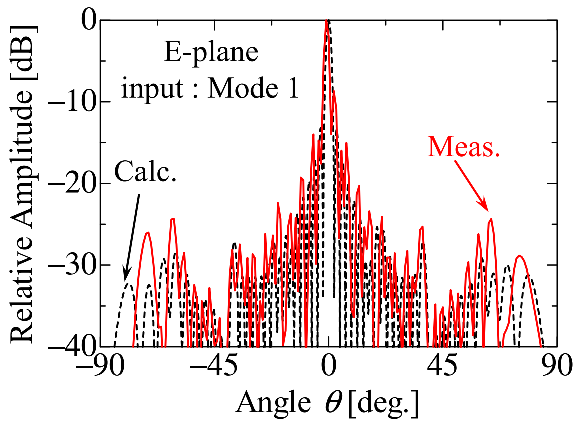

Figure 6 E-plane patterns at 41.5GHz

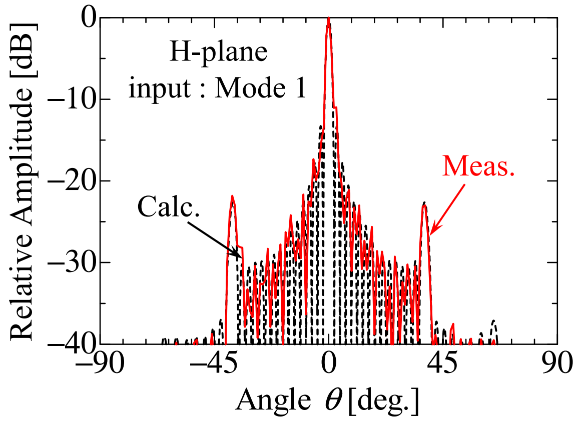

Figure 7 H-plane patterns at 41.5GHz

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