Investigation of an Open-Ended Waveguide Array antenna Fed by a Stripline Transmission Line Network

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Abstract

A 2 x 2 open waveguide antenna array, fed by a stripline transmission line network is proposed. Printed half ring shaped transition elements are connected to the network and used to feed the antenna elements. It is shown that a bandwidth of about 50% has been achieved. Both simulation and measurement are in good agreement.

1 Introduction

Open-ended waveguide array antennas are known a lot of time [1]. These antennas are broadband and suitable for high power capability. More recent papers deal with blindness removal [2], modern analyzing techniques [3] and miniaturization, multi-functioning and multi-frequency possibilities [4]. In this work we investigate a compact and cheap stripline feeding network, including printed transition elements between the stripline transmission line network and the rectangular waveguides.

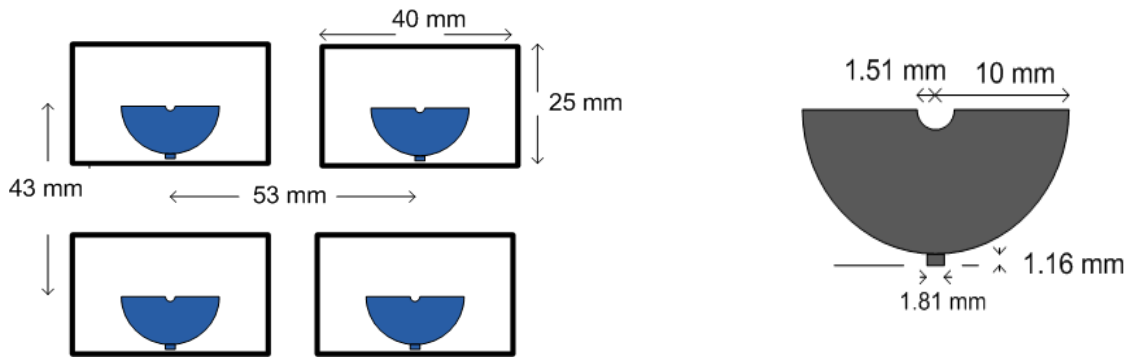
The structure of the paper is as follows: section 2 presents the geometry of the array, feeding network and the transition element. Section 3 is devoted to simulation results, and section 4 describes measurement results. Final conclusions are presented in section 5.

2 Geometry

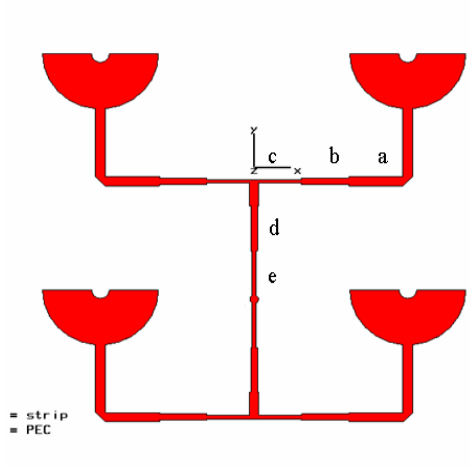
An upper view of a 2 x 2 waveguide antenna array is shown in fig. 1.a, the geometrical details of the transition element are presented in fig. 1.b, and the stripline transmission line feeding network is shown in fig. 1.c. The inner dimensions of the waveguides are: width a = 40 mm, height b = 25 mm. The distance between the centers of the waveguides are 53 mm on the horizontal axis and 43 mm on the vertical axis. A transition element is composed of a half a ring with outer radius r_{out} = 10 mm and inner radius r_{in} =1.51mm. The transition element is printed on one side of a Rogers 4003C dielectric substrate having relative dielectric constant 3.38 and thickness 1.524 mm, and covered by another similar substrate. The transition element has no ground planes. A short strip having width 1.81 mm and length 1.16 mm connects the transition element to the stripline transmission line network. The network is fed by a coaxial probe. The transition element is connected to a 50 Ω line (a) having width 1.81 mm. Sections b and c are quarter and 83.66 Ω and having widths 1.32 mm and 0.61 wavelength transformers having characteristic impedances 59.16 Ω mm respectively. Sections d and e are quarter wavelength transformers as well, having characteristic impedances 59.16 and 83.66 Ω and widths 1.32 mm and 0.61 mm respectively. The lengths of the transformers are 8.15 mm at 5 GHz. Ω

3 Simulation Results

The matching level of the transition element has been checked by feeding a single waveguide. As can be seen in fig. 2.a, a good matching level has been achieved, where the bandwidth is between 4.28 to 6 GHz for TE_{10} mode. The matching level of the array is slightly lower, but the bandwidth is the same as for the single waveguide antenna, from 4.2 GHz to 6 GHz for TE_{10} mode, and shown in fig. 2.b. A 3D pattern of the single waveguide antenna is shown in fig. 3.a. As expected the total efficiency is high and the gain is about 6.5 dBi. An E-plane radiation cut at 5 GHz is presented in fig. 3.b, showing a 99° beamwidth. The 3D radiation pattern of the 2 x 2 waveguide antenna array at 5 GHz is shown in fig. 4.a and a 2D radiation elevation cut for $\varphi = 0^o$ is shown in fig. 4.b. The directivity of the array is approximately 13.9 dB, however the total efficiency of the array is slightly lower than in the case of the single waveguide antenna due to lower matching level quality.



(a) (b)



(c)

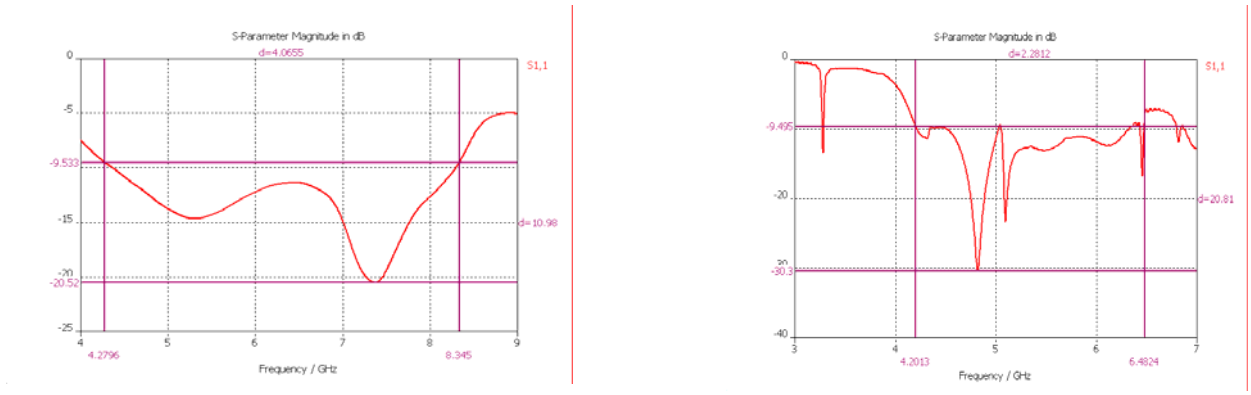
Fig.1.(a) Upper view of a 2 x 2 rectangular waveguide antenna array. The inner dimensions of a single waveguide are a = 40 mm and b = 25 mm. The distances between the centers of the waveguides are 53 mm on the horizontal axis and 43 mm on the vertical axis. (b) Detailed geometry of the transition element. (c) The feeding network.

4 Measurement Results

A picture of the 2 x 2 waveguide array antenna is shown in fig. 5. The return loss of the antenna is shown in fig. 6. The measured return loss shows slightly greater bandwidth than the simulated bandwidth, from 3.6 GHz to 6 GHz, and with a better matching quality. Fig. 7 shows elevation radiation cuts for $\varphi = 0^o$ at frequencies 4.7, 5, 5.2, 5.6, 5.8 and 6.1 GHz. The average beamwidth is 25°.

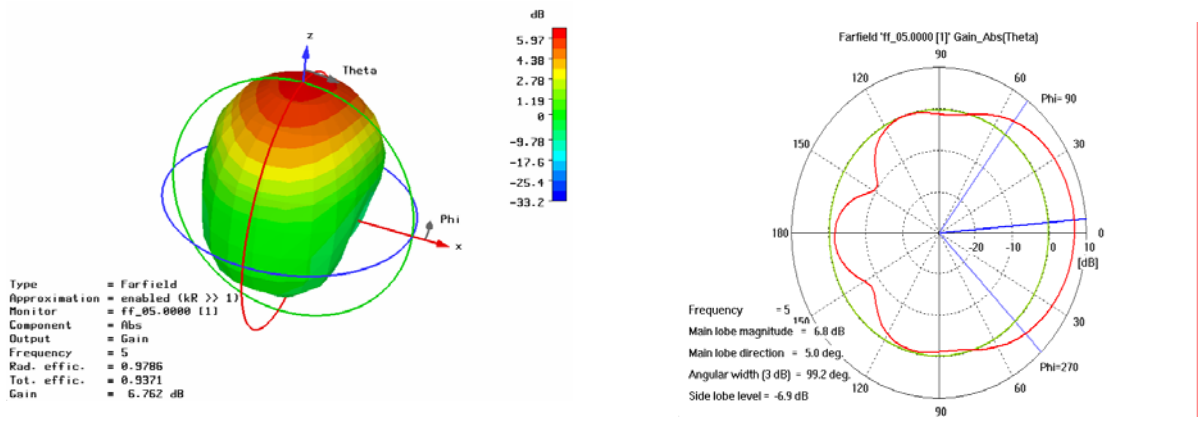
5 Conclusions

An open-ended 2 x 2 waveguide array antenna fed by a stripline transmission line network was investigated. Each waveguide contains a printed transition element, and full TE_{10} mode bandwidth has been achieved. The feeding network is compact and cheap. This type of antenna array can be designed to include more elements and to have a lower sidelobe level by a proper power division between the antenna elements.



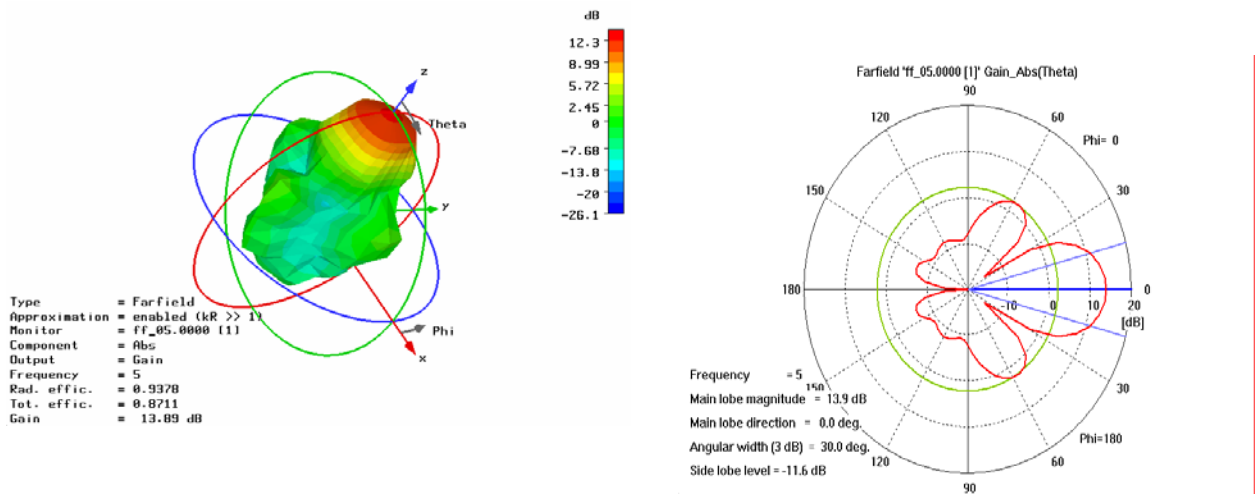
(a) (b)

Fig. 2 (a) Return loss of a single waveguide antenna element fed by the proposed arc shaped transition element. (b) Return loss of the 2 x 2 waveguide antenna array.



(a) (b)

Fig. 3 (a) 3D radiation pattern of a single open rectangular waveguide antenna element. (b) 2D radiation elevation cut for $\varphi = 90^{o}$.



(a) (b)

Fig.4. (a) A 3D radiation pattern of the 2 x 2 waveguide antenna array. (b) A 2D radiation H-plane cut.

Fig. 5 A picture of the 2 x 2 waveguide array antenna.

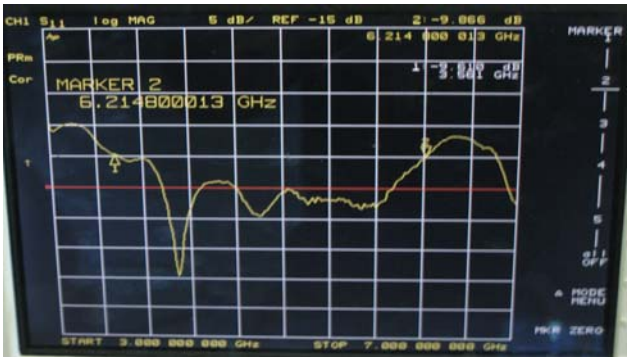


Fig. 6 Measured return loss of the array.

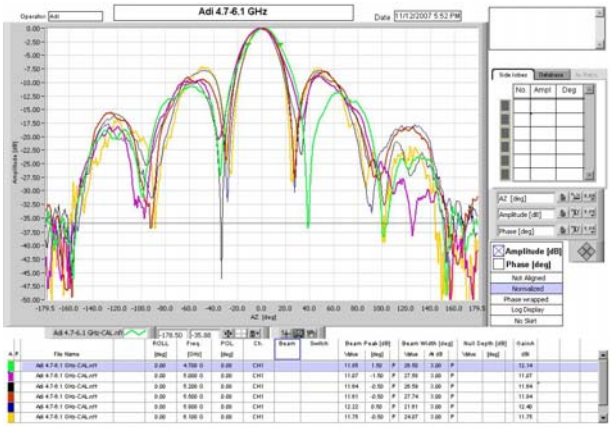


Fig. 7 Measured elevation radiation cuts for $\varphi = 0^{o}$ at frequencies 4.7, 5, 5.2, 5.6, 5.8 and 6.1 GHz

6 References

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