Indian Journal of Pure & Applied Physics
Vol.54, September 2016, pp. 562-564

Microstrip array antenna with wideband high gain

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Received 13 November 2013; revised 30 July 2015; accepted 5 August 2015

This paper presents theoretical and practical investigations on a planar array antenna with four circular radiating patches and square ground plane for high gain applications. The geometry of the antenna has been optimized to obtain peak gain of 11dBi and bandwidth better than 8 GHz. Good radiation characteristics have also been observed. Theoretical investigations have been done by Ansoft® Designer software. Measurements have been done using standard microwave test bench.

Keywords: Array antenna, Wideband, High gain, Radiation pattern, Return loss

1 Introduction

The features of the microstrip antennas are very attractive. They are such as low profile, light weight and easy fabrication. But the disadvantages of the microstrip antenna are narrow bandwidth, low efficiency and low gain which limit their applications. There are some techniques to enhance the bandwidth of the microstrip antenna, reported in earlier studies[1-2]. The gain enhancement methods have been proposed using multiple superstrates in various studies[3-4]. Actually there are some problems for using the superstrates above an antenna which may affect the antenna's basic performance characteristics, i.e., gain, radiation resistance and efficiency. There are some ways to obtain high gain and broad band antenna such as loading some slots/slits on the patch or ground plane[5], appropriate choice of the thickness of the substrate[6], partial ground planes[7,8]. Improvement of the gain as well as the bandwidth of the antenna also depend on the shape and size of the patch and ground plane. Selecting an appropriate size of ground plane will provide better bandwidth as well as increase of the antenna gain.

In this paper a simple array antenna with four circular patches on a square ground plane has been presented. These four radiating patches are fed by four coaxial probes. This array antenna can radiate practically at the resonant frequency of 14 GHz, the minimum return loss at resonant frequency is -13.54 dB. The practical bandwidth at -10 dB is 8.15 GHz. The novelty of the work is that a high gain of 11 dBi is achieved by this array antenna.

2 Antenna Design

Figure 1 shows the designed array structure. The proposed antenna consists of four circular shaped radiating patches on a square shaped ground plane. The radius of each circular patch is 5 mm. The dimension of the square ground plane is 50 mm×50 mm. The array antenna is printed on an FR4_epoxy substrate with a relative permittivity of 4.4 and thickness of 1.6 mm and is fed by coaxial probe feed method. The feeding point is so positioned to obtain better impedance matching.

For best matching of input impedance, the four radiating patches are placed in that position with respect to ground plane of the antenna which is shown in the figure. The element spacing of this array antenna was 1.16 λ0 at 14 GHz to minimize coupling. The design of the antenna has been drawn in Ansoft® designer software. The image of the fabricated array antenna is shown in Fig. 2.

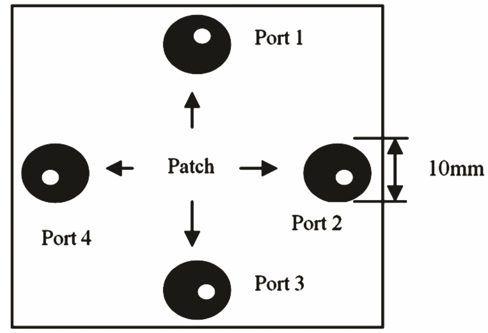

Fig. 1 – Design of the array antenna

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3 Measurements

The proposed array antenna on an FR-4 substrate has been fabricated for practical investigation. The arrangement of gain and radiation pattern measurement of the fabricated array antenna is performed using a standard microwave test bench. Reflection coefficient is measured using Agilent made Network analyzer. The measured results have been plotted in Fig. 3.

4 Results and Discussion

Figure 3 shows the theoretical and practical values of reflection coefficient vs frequency plot for the designed array antenna, respectively. The practical bandwidth at -10 dB is 8.15 GHz. The gain of this antenna is very high which is around 11 dBi at 13.8 GHz frequency. The achievement of this simple antenna is no doubt a novel one. The theoretical and practical Gain vs frequency plot is shown in Fig. 4. From this figure it is shown that practical gain is lower than theoretical gain at any frequency. The theoretical and practical radiation patterns are shown in Figs 5-8 with normalized values.

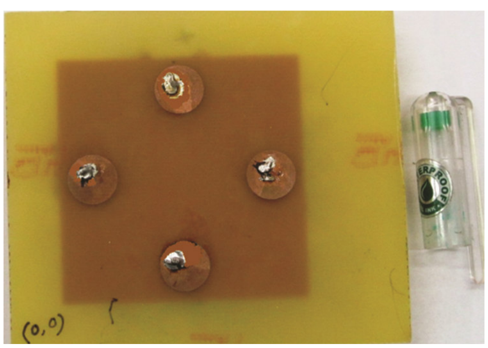

Fig. 2 – Fabricated array antenna

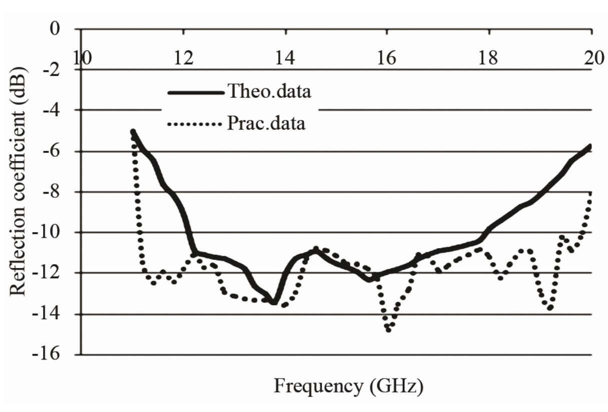

Fig. 3 – Theoretical and practical reflection coefficient vs frequency plot of the array antenna

From these figures it is found that the radiation pattern of the array antenna is good. The 3D view of the radiation pattern of the antenna is shown in Fig. 9, which is also very good.

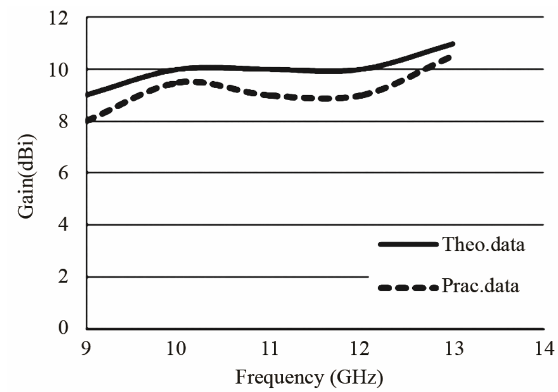

Fig. 4 – Theoretical and practical gain vs frequency plot of the array antenna

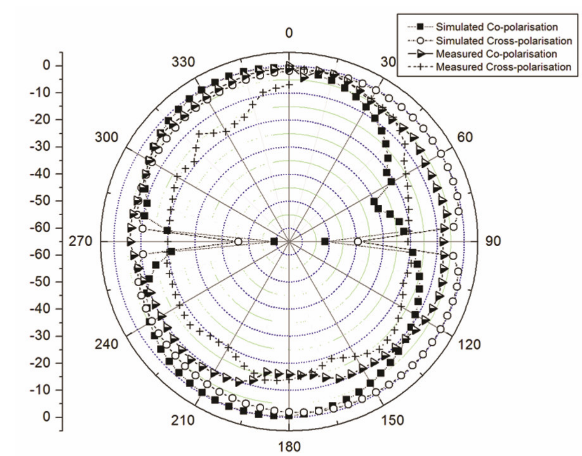

Fig. 5 – Theoretical and practical E plane cross radiation pattern plot at 9 GHz frequency

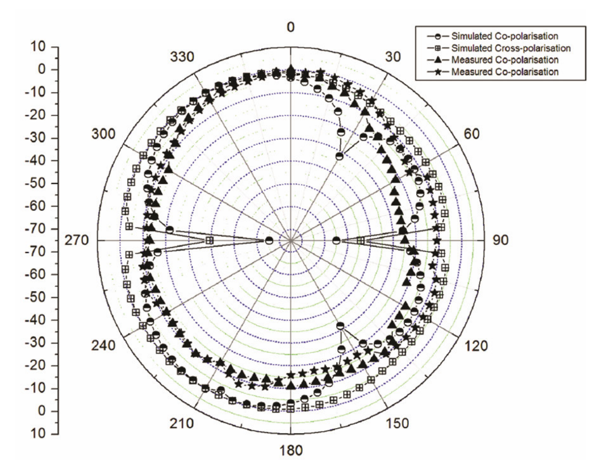

Fig. 6 – Theoretical and practical H plane cross radiation pattern plot at 9 GHz frequency

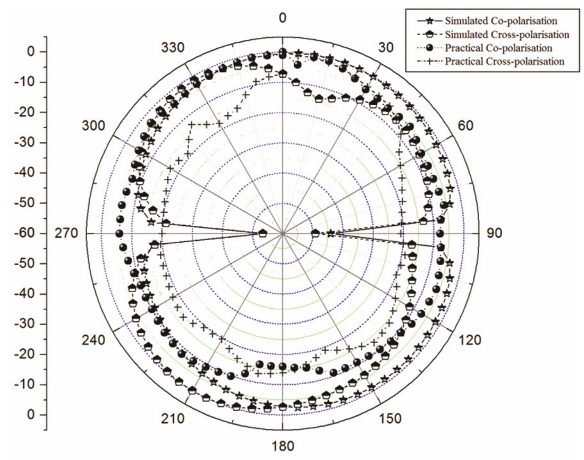

Fig. 7 – Theoretical and practical E plane cross radiation pattern plot at 13 GHz frequency

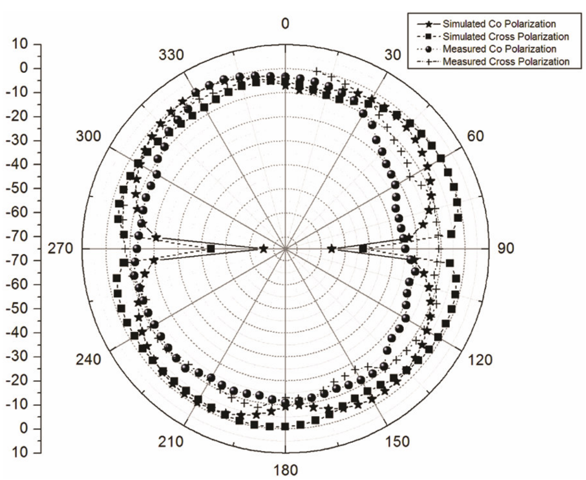

Fig. 8 – Theoretical and practical E plane cross radiation pattern plot at 13G Hz frequency

5 Conclusions

The bandwidth of the antenna at -10 dB is 8.15 GHz. It is very important to mention here that the peak gain of the very simple antenna is 11dBi. Both theoretical and practical gain of the antenna is always better than 6 dBi throughout the frequency region 9 GHz to 14 GHz. Practical gain is always around 1 dBi less than theoretical gain. This may be due to connector or cable loss. Generally microstrip antenna suffers from two disadvantages. They have narrow bandwidth and low gain. A good number of research works has been reported for broad banding or achieving high gain by different methods. Here both broad banding and high gain have been achieved simultaneously. Moreover radiation patterns are good in both theoretical and practical cases. This type of antenna may be extensively used in the field of mobile or satellite communication.

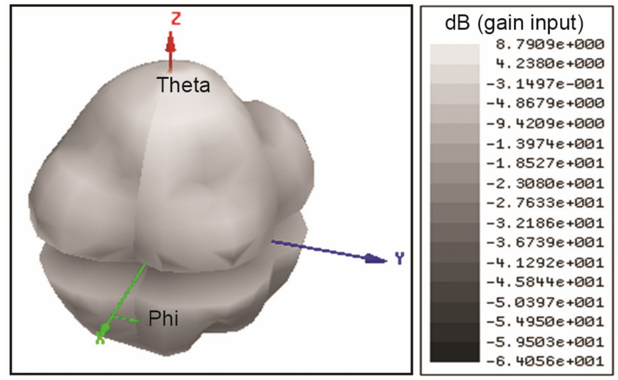

Fig. 9 – Theoretical result of 3D radiation pattern of the array antenna

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