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Comparative Study of Rectangular and E-Shaped Microstrip Patch Antenna Array for X-Band Applications



Alok Kumar Rastogi, Gazala Pravin and Shanu Sharma

Abstract This paper deals with the characterization of microstrip patch antenna array. These antennas are designed for X-band frequency applications. In the design process, SONNET software is utilized and antenna parameters such as current density, return loss, radiation pattern and voltage standing wave ratio (VSWR) are plotted. The rectangular and E-shaped patch antenna array is realized on $2 \times 2 \text{ mm}^2$ Roger RT5880 sheet with thin layer of copper deposited over it, while the feed line is implemented using microstrip lines.

Keywords Microstrip patch antenna array · X-band frequency
Current density · Return loss · Voltage standing wave ratio

1 Introduction

In wireless communication technology, antenna is basically used to transmit and receive electromagnetic signals. By transmitting a signal into radio waves, the antenna transforms electric current into electromagnetic wave and vice versa by receiving [1].

Antenna plays an important role in today's telecommunication system. It is the heart of communication system as it is used to radiate as well as receive electromagnetic signals [2]. Today, main focus in communication is for circuits with reduced size, but improved performance is growing. So to reduce the size of circuit, antenna array is introduced and the basic and widely used patch antenna is microstrip. Microstrip patch antennas find its application in telemetry, radars, satellite, and GPS systems [3].

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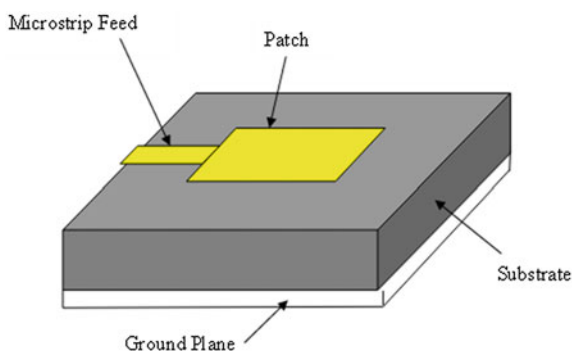
There are several feeding techniques such as coaxial probe, aperture coupling, proximity coupling, but here microstrip feeding is used. A sheet of dielectric substrate with very thin layer of copper layer deposited on both sides of the substrate is used for fabrication of microstrip patch antenna. One side acts as ground plane, whereas other metallization side can be of any shape such as rectangular, square, elliptical [4–6]. Demand for wideband, high-gain antenna is growing. So, single-element microstrip antennas are replaced by microstrip patch antenna arrays, which improve the performance over single-element microstrip antenna as well as E-shaped [7].

Rectangular as well as E-shaped microstrip patch antenna arrays were designed and simulated by using SONNET software. The proposed antenna arrays operate with center frequency approximately 10.9 GHz that supports at X-Band.

2 Geometry of Patch Antenna Array

The basic structure of rectangular patch antenna is shown in Fig. 1. In this method, RF power is fed directly to the radiating patch using microstrip line conducting element. This kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure. 2D structure of rectangular and E-shaped patch antenna arrays is simulated on Roger RT5880 substrate with dielectric constant of 2.2 and loss tangent, $\tan \delta = 0.0009$, which are shown in Fig. 2a, b, respectively. The thickness of the substrate is 0.8923 mm. The size of patch length (L) is 8.15 mm, patch width (W) is 11.85 mm, and feed lines of rectangular and E-shaped patch antenna array are 22.1 and 19.25 mm, respectively, which is suitable for most satellite and radar application.

Fig. 1 Basic configuration of microstrip patch antenna



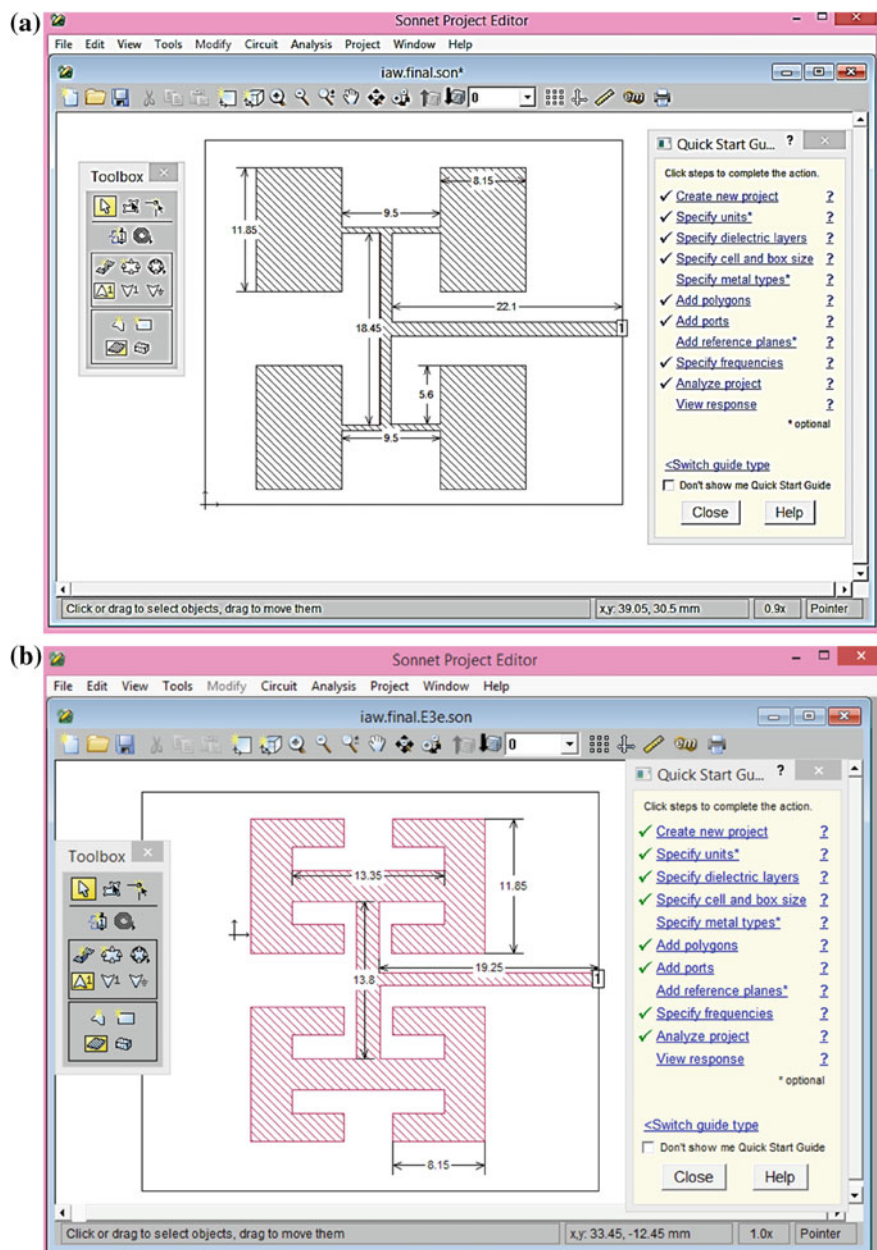


Fig. 2 2D Structure of **a** Rectangular patch antenna array, **b** E-shaped patch antenna array

3 Result and Discussion

In this study, wideband rectangular and E-shaped patch antenna arrays are studied. The methodology which is used for the research paper is based on full-wave analysis which is used to analyze the scattering matrix of both patch antenna arrays. The SONNET software is used for simulation of both patch antenna arrays. Simulation results of both antenna arrays are presented, compared, and discussed.

Figure 3a, b shows the current density of rectangular and E-shaped patch antenna array, where current density reflects how an antenna produces beams. Figure 4a, b shows the 3D view of rectangular and E-shaped array designed on SONNET software with single-band operation for X-Band applications.

Figure 5 shows Smith chart of VSWR of the rectangular microstrip antenna array that radiates normal to its patch surface, and the elevation pattern for $\varphi = 0^\circ$ and $\varphi = 90^\circ$ is plotted. Figure 5 shows that the VSWR of rectangular patch antenna array is 1.621608 at 10.86 GHz, and Fig. 6 shows radiation pattern of antenna for $\varphi = 0^\circ$ and $\varphi = 90^\circ$ in SONNET for E-field.

Figure 7 shows Smith chart of VSWR of E-shaped microstrip patch antenna array. It is clear from the figure that the VSWR is 1.023614 at 10.92 GHz. Figure 8 shows radiation pattern at $\varphi = 0^\circ$ and $\varphi = 90^\circ$ in E-field of the E-shaped microstrip patch antenna array.

Comparison is done for both the antenna arrays on the basis of VSWR and return loss. Figure 9 shows comparison of return loss of both antenna arrays. Return loss for E-shaped array is far better and improved than rectangular-shaped array. Figure 10 shows the comparison of VSWR for both antenna arrays. It is clear from Figs. 9 and 10 that at the resonant frequency, the return loss of rectangular patch antenna and E-shaped patch antenna array is -12.5 and -38.66 dB, respectively.

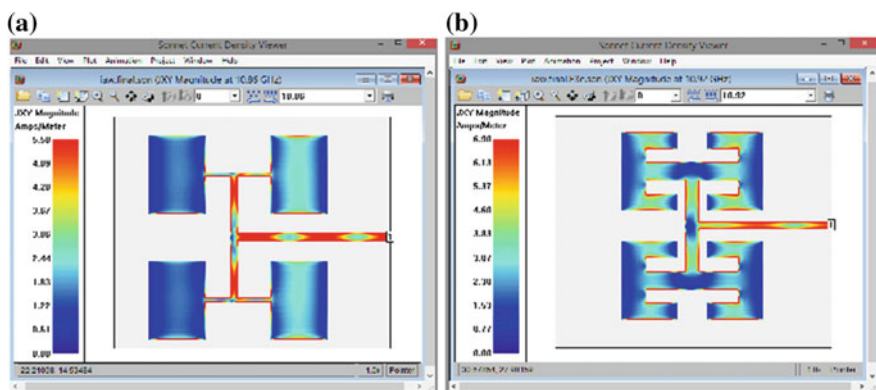


Fig. 3 Current density of **a** rectangular and **b** E-shaped patch antenna array

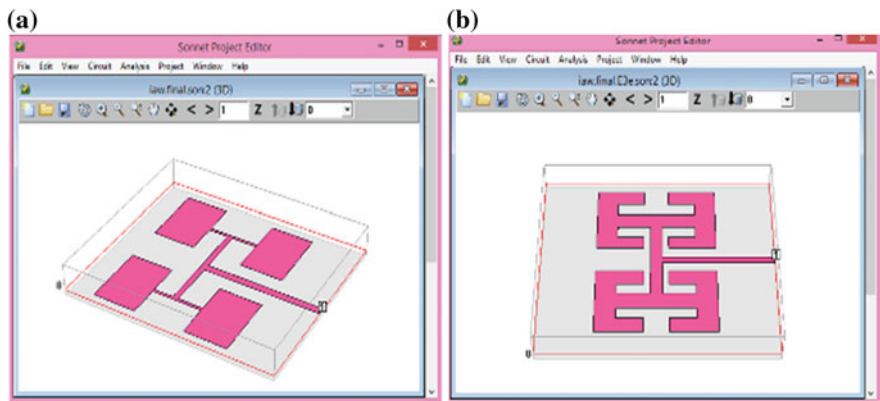


Fig. 4 3D view of **a** rectangular and **b** E-shaped patch antenna array

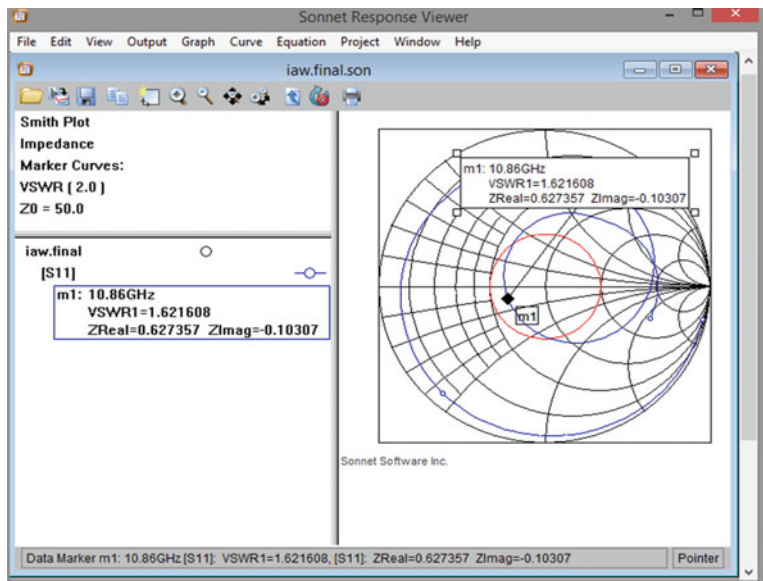


Fig. 5 Smith chart of VSWR of rectangular patch antenna array

Return loss of E-shaped antenna array is nearly 3 times that of rectangular patch antenna array; i.e., maximum power is reflected from E-shaped array. Also, VSWR is 1.66 and 1.024, respectively. VSWR is mismatch between antenna and feed line, which should be as small as possible. At resonant frequency, VSWR for E-shaped patch antenna array is closer to 1.

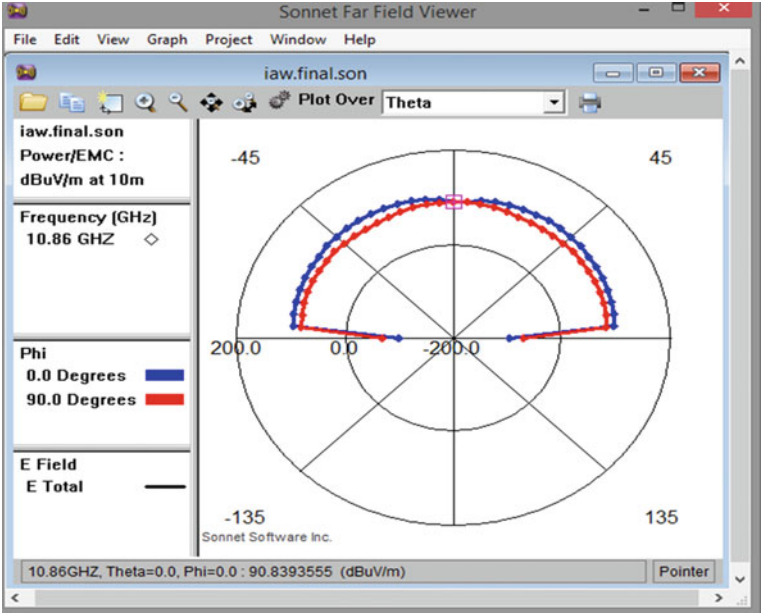


Fig. 6 Radiation pattern of rectangular patch antenna array

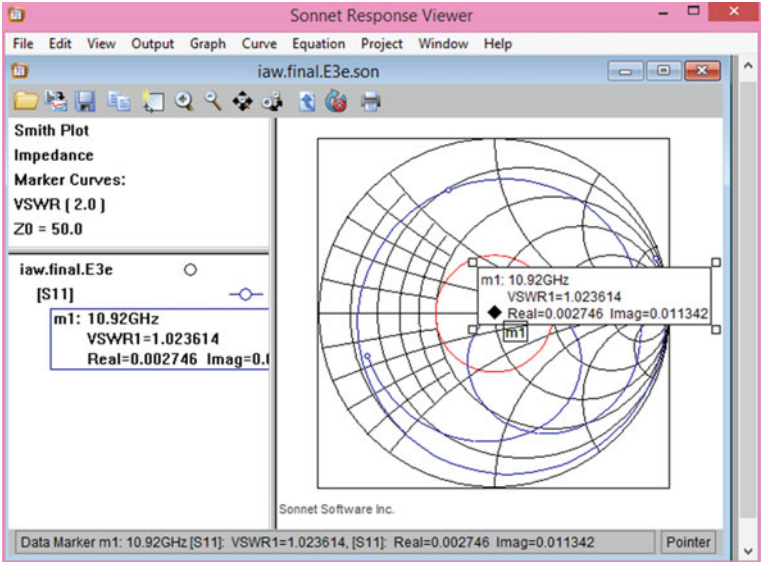


Fig. 7 VSWR of E-shaped patch antenna array

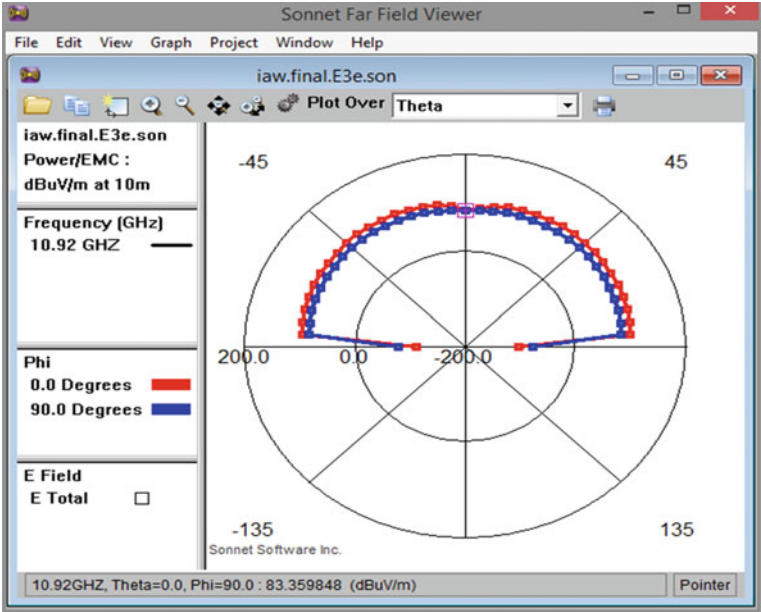


Fig. 8 Radiation patten of E-shaped patch antenna array

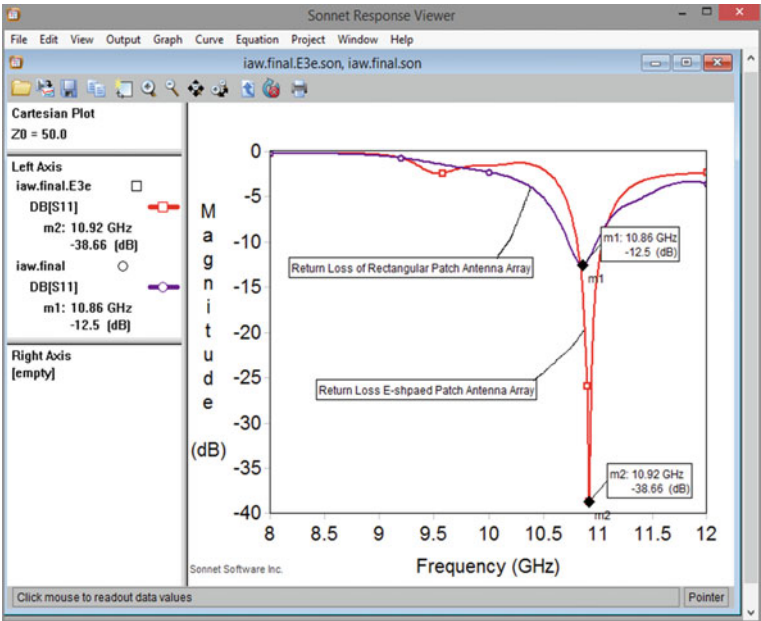


Fig. 9 Comparison of return loss of rectangular and E-shaped patch antenna array

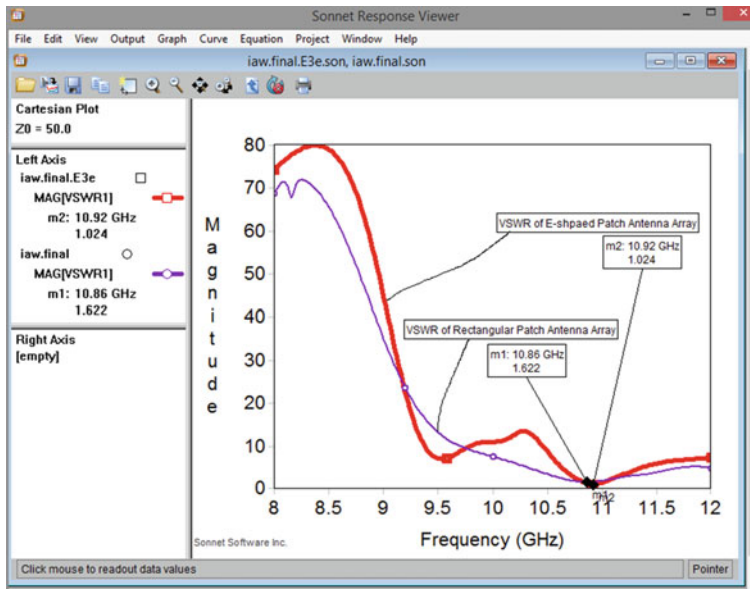


Fig. 10 Comparison of VSWR of rectangular and E-shaped patch antenna array

4 Conclusion

In this paper, rectangular and E-shaped patch antenna arrays are discussed for X-band applications. The resonant frequency was taken 10.9 GHz [approx.] for both antenna design, and parameters such as S-parameter, current density, radiation pattern, and VSWR for both arrays were plotted. The return loss of E-shaped patch antenna array is better than any existing rectangular patch antenna array at same resonant frequency. The VSWR at resonant frequency for E-shaped antenna array is also far better than rectangular patch antenna array.

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