12 GHz Planar Array Antenna for Satellite Communication

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Abstract— A novel microstrip array antenna of 32 elements is designed and built for broadcasting satellite orbital positions. It is working in the 12.43–12.53 GHz band (space-to-Earth). A corporate feeding network is used to give equal amplitude and phase to each element. The theoretical analysis is based on IE3D (Zeland) software and genetic algorithm to optimize the performance of the planar array. A dummy column of elements is assumed around the excited 32 elements. The effect of these dummy elements is tested using IE3D (Zeland) software on the return loss and voltage standing wave ratio (VSWR). The simulation shows the return loss and VSWR decrease as the number of columns of parasitic elements increases. On the other hand the center frequency increases as the number of parasitic elements increases. The return loss and VSWR are measured and compared with the simulated results. They are very close. Both the theoretical and experimental results are presented and discussed.

1. INTRODUCTION

During recent years, microstrip antenna array is widely used due to its several advantages, such as low profile, light weight, and low cost, etc. [1, 2]. In various communications and radar systems, a microstrip array is greatly desired. The designed antenna is suitable for the 12 GHz Broadcasting Satellite Service (BSS) frequency bands. It is working in the frequency band 12.43–12.53 GHz. A single-feed planar antenna can be easily integrated. The antenna consists of 32-elements with corporate feeding network. This feeding was designed to give equal amplitude and phase to each element. The dimension of each patch, spacing between patches, and the width of the feeding line are shown in Figure 1 [3]. The array was fabricated on a dielectric substrate called Teflon with $h = 0.7874$ mm, $\varepsilon_r = 2.2$, area of 91.5×53 mm. The dimension of the patch and the spacing between the elements in x and y directions are 9.5×7.6, 12.0482, and 12.0482 mm respectively. The feeding system includes three different microstrip transmission lines of different impedances and different widths. The impedances are 50 Ω, 71.7 Ω, and 100 Ω and the corresponding widths are 2.377 mm, 1.339 mm, and 0.655 mm respectively.

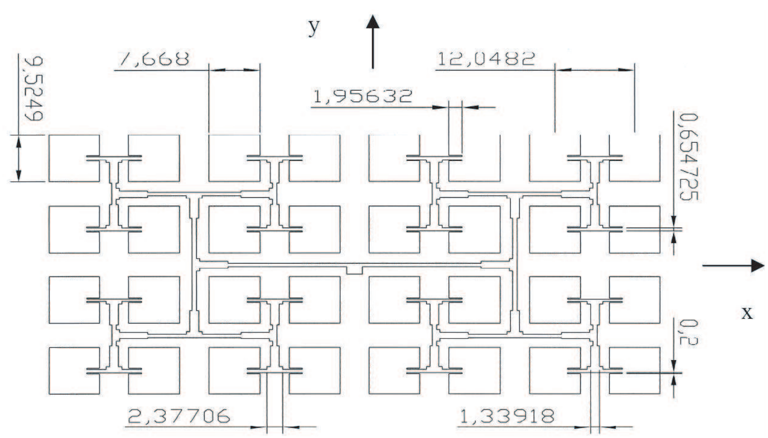


Figure 1: The dimension of the designed antenna and its feeding system.

2. ARRAY ANTENNA

The design of this array and its feeding is discussed in Section 2. The parameter of the antenna shown in Figure 2 is optimized using IE3D (Zeland) software. The simulated and measured return loss (S_{11}) and VSWR of 4×8 antenna array are shown in Figure 3. The simulated and measured results are very close. It can be seen from the figure that S_{11} and VSWR of the fabricated antenna

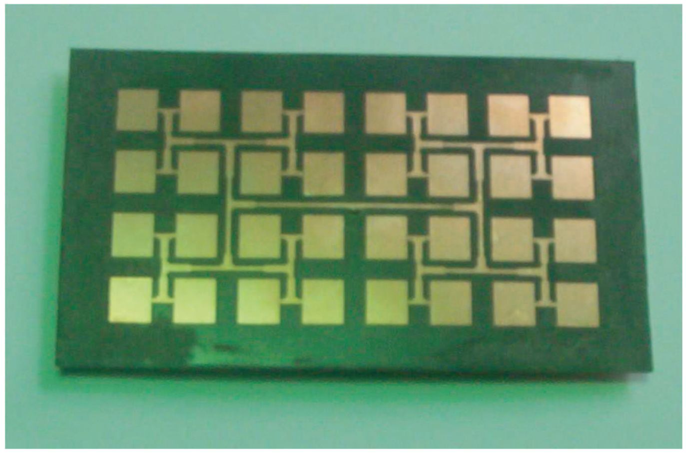
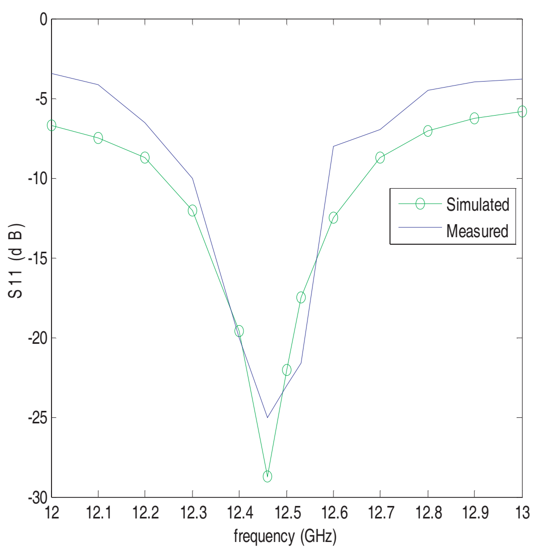
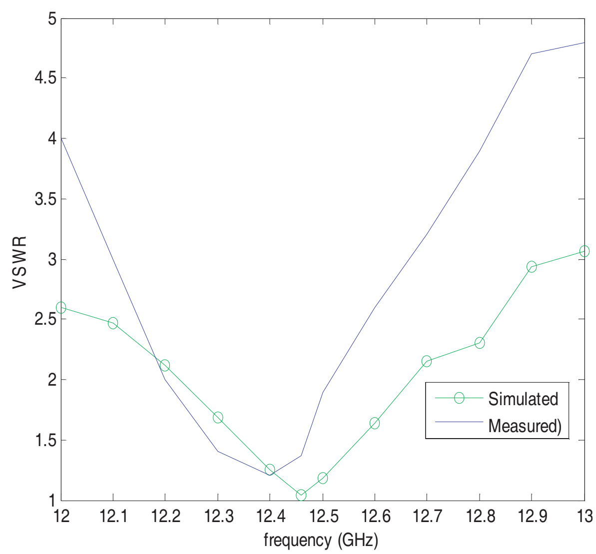


Figure 2: The fabricated array antenna.



(a)



(b)

Figure 3: (a) Simulated and measured return loss. (b) Simulated and measured VSWR.

are −25 dB and 1.2 respectively. On the other hand, the simulated results show that S_{11} and VSWR of the designed antenna are −28.7 dB and 1.0357 respectively.

The impedance smith chart obtained for the designed array is shown in Figure 4. For the plot, it shows that the points are located at the middle of the circle as the frequency becomes nearer to the center frequency. Hence, this indicates that the matching of this antenna is quite good, as the desired location of the points should be in the middle of the circle (50 Ω).

3. THE EFFECT OF PARASITIC ELEMENTS

A study is done on 4×8 array to investigate the effect of parasitic elements using IE3D (Zeland) software [4]. Figure 5 shows one row and two rows of passive elements on each side of the array antenna.

The simulation results of both S_{11} and VSWR for different cases are shown in Figure 6. The different values of return loss and VSWR and the corresponding frequency for 4×8 array antenna with and without parasitic elements are listed in Table 1. The resonant frequency increases as the number of rows of parasitic elements increases.

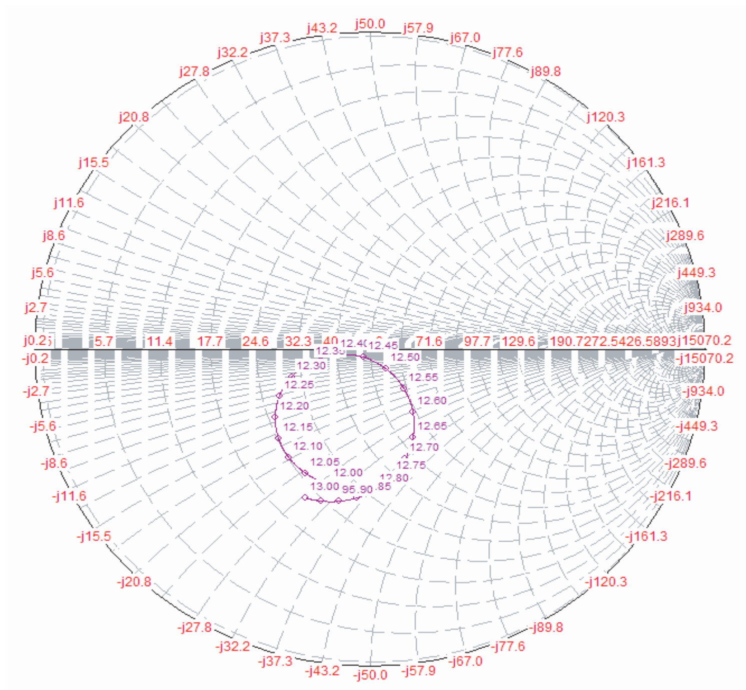
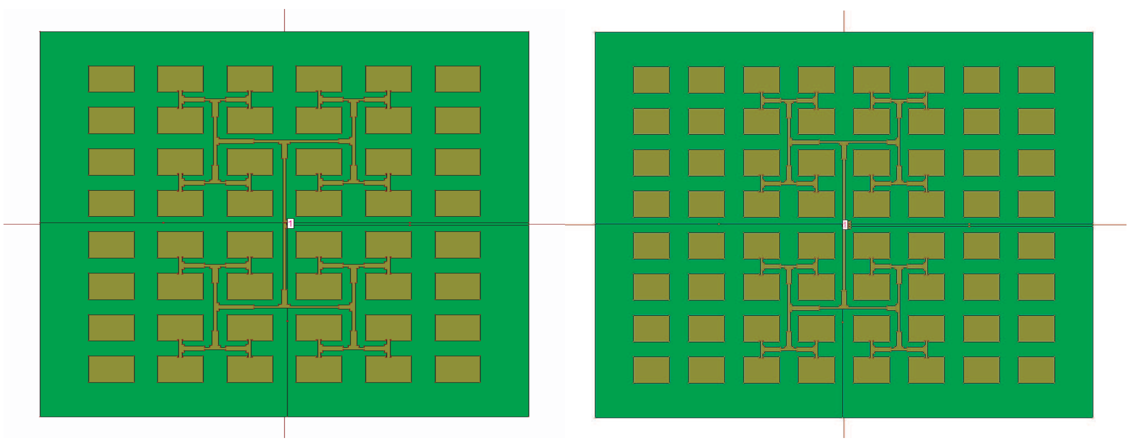


Figure 4: The impedance smith chart obtained for the designed array.



(a) (b)

Figure 5: Passive elements on each side of the array antenna (a) one row (b) two rows.

Table 1: The minimum values of return loss and VSWR and the corresponding frequency for 4 × 8 array antenna with and without parasitic elements.

parameter / Case	F (GHz)	S_{11} (dB)	VSWR
array antenna without parasitic elements	12.46	-28.7	1.0357
array antenna with One row of parasitic elements	12.52	-21.144	1.1785
array antenna with two rows of parasitic elements	12.6	-21.2	1.161

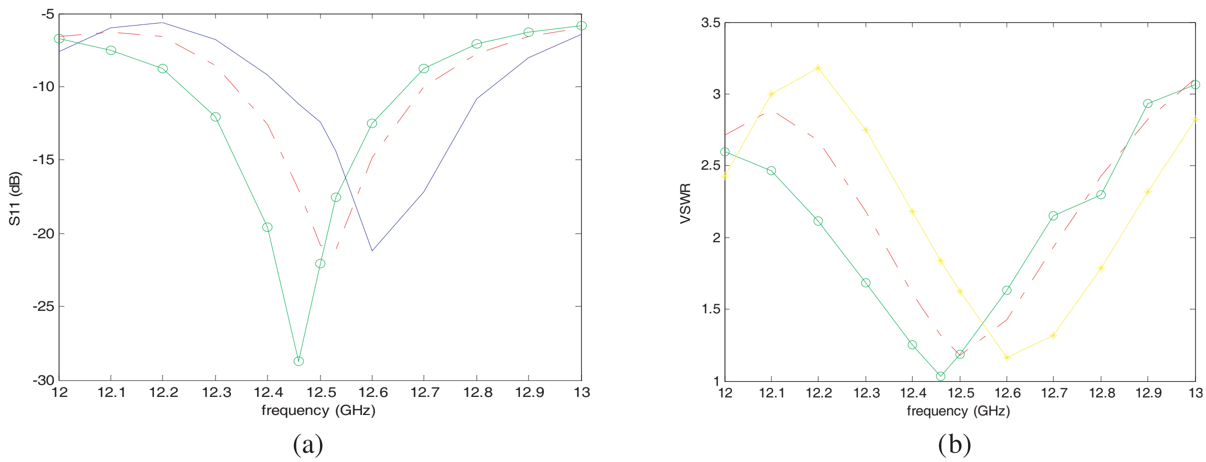


Figure 6: (a) S_{11} for the array antenna with and without parasitic elements: – o without parasitic elements, –. with one row, and — with two rows. (b) VSWR for the array antenna with and without parasitic elements: – o without parasitic elements, –. with one row, and – * with two rows.

4. CONCLUSIONS

A novel 4×8 microstrip array antenna was developed at 12.46 GHz and presented numerically and experimentally. The parameters of the array such as S_{11}, VSWR, and input impedance are optimized using Zeland software. The measured return loss and VSWR of the designed antenna are is -25 dB and 1.2 respectively, while the simulated values are -28.7 dB and 1.0357 respectively. The simulated and measured results show a reasonably good agreement. The small deviation between them is due to fabrication inaccuracy. The center frequency of the array can be controlled by the number of parasitic elements around it.

REFERENCES

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2. James, J. R. and P. S. Hall, *Handbook of Microstrip Antennas*, Peter Peregronic Ltd., London, 1989.
3. Bhartia, P., et al., *Millimeter-wave Microstrip and Printed Circuit Antennas*, Artech House, Norwood, Mass., 1991.
4. IE3D Software Release 11.5 developed by Zeland Software, Inc.