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The Blade Edge-Shaped Microstrip Antenna for X Band Applications

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Abstract

In this paper, a simple design of a microstrip patch antenna with a blade edge shape is proposed. It is based on annular rings with blade-shaped edges. The antenna has a wide range of applications in the X band such as terrestrial, radar, satellite communication,wave-guide probing and etc. The model antenna has a compact structure with a size of 25 × 20 mm^2 and is etched over the FR-4 ($\in$ = 4.54). The design is simulated in Computer Simulation Technology, CST software-Microwave Studio. The proposed antenna offers a stable radiation pattern, a high gain factor, and a reduced lobe level. Sharp edges of antenna elements increase the antenna activity scale in the X band.

I. INTRODUCTION

Communication systems operating in the X-band are typically designed with separate antennas for each band. As the use of such systems in environments becomes more and more important, it is attractive to design a single antenna that operates at multiple frequencies for multitasking. Various types of multi-antenna or broadband antennas have been developed to meet the growing demand for modern portable wireless communication devices that can integrate multiple communication standards into one system. Of late, many authors[1-3] have conducted research to produce new designs, or variations of the original antenna, achieving some degree of wideband or multi-frequency operation in a single element. Many techniques have been implemented to attain single-frequency or multi-frequency operations.

In the last few years, to overcome the challenge of increasing X band applications, researchers and designers are being in constant effort to modify the overall performance of the microstrip antenna which is the most suitable candidate for modern wireless communication [4-5]. The wireless communication system has led to increasing constraints on antenna utilization in terms of cost, size, bandwidth, etc. Based on applications, modern antenna technology allows the use of different types of antennas [6-10]. Microstrip antenna provides a great revolution in the field of antenna design than conventional antennas [10-14]. Yet, the microstrip antennas have some drawbacks such as low gain, poor radiation efficiency, and low return loss, till now. Today, many types of antenna have been developed to meet the requirement of a compact, cheap and low-profile antenna [15-18]. Several methods such as stacked patches, material loading, and geometry optimization [19-20]have been considered to make a compact antenna but in this work, a simple antenna design by creating a sharp boundary of the patch element has been reported.

In this paper, a new design of an antenna that has improved radiation performance has been reported. In this study, a microstrip patch antenna that can be operated in the X band for performing various applications has been proposed. A simple adjustable geometry, moderate gain, and low return loss are some key features of the reported antenna. The proposed antenna has a boundary in from of the randomly distributed blade structures which reduces complexity and cost compared to the conventional antenna. The simulation has been carried out in the computer simulation software, CST.

This paper is divided into 3 sections. The details of the antenna geometry are shown in section 1. Section II shows the analysis of the simulated results while the conclusion is drawn in section III.

II. ANTENNA MODEL AND DESIGN CONSIDERATIONS

The built antenna has randomly cutting slots like the blade shape at its boundary. We want to emphasize that if multifrequency antennas can be constructed from a single antenna that would solve many complex problems. For a specific use like a waveguide probe antenna in the region between 8.6 and 12.4 GHz, a multifacet characteristics can be created to demonstrate that. The annular ring antenna is shown in Figure 1. The annular rings are modified by cutting the patches from their boundary and center keeping the same dimension as the ground plane.It shows good performance in X band applications in terms of radiation pattern and gains. The feed line (2.2 mm × 5 mm) of the proposed antenna is designed on FR4 ($\in r$ = 4.4) substrate with a 1.574 mm thickness. The dimension of the optimized antenna structure is 25 mm × 20 mm. The top view of an antenna is shown in Figure 1. The length of all blade sides is mentioned in Figure 1.

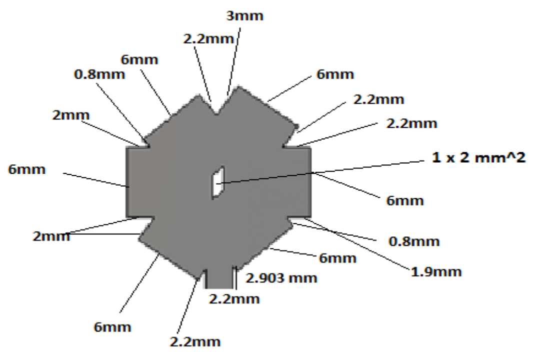


Figure 1. Proposed antenna geometry.

III. SIMULATED RESULTS AND DISCUSSION

The return loss, gain, power, radiation pattern, input impendence, etc of the built antenna have been obtained by microwave studio tool in CST software. The return loss (dB) vs frequency (GHz) curve is shown in Figure 2. The antenna shows the resonance at three different frequencies 8.6 GHz, 10.3 GHz, and 12.4 GHz frequencies with moderate values of the return loss -14 dB, 17.6 dB, and 13 dB, respectively. The values of gain at these frequencies are 1.95 dBi, 2.69 dBi, and 1.6 dBi, respectively (Figure 3). Maximum gain (4.4 dBi) appears at 11 GHz frequency in the operating frequency range (8- 13 GHz). Here we want to emphasize that our primary intention is not to compare with various parameters of other designs but to indicate that the parameters could be adjusted varying different edge dimensions. We believe the present manuscript carries interesting concepts and ideas that can inspire new research directions in the community.

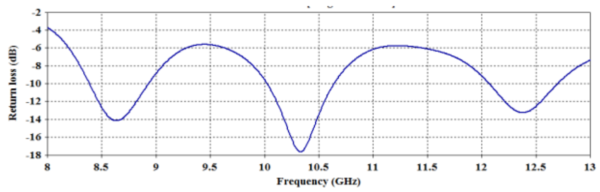
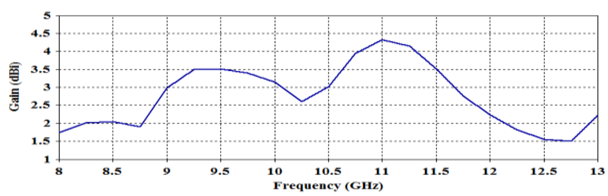
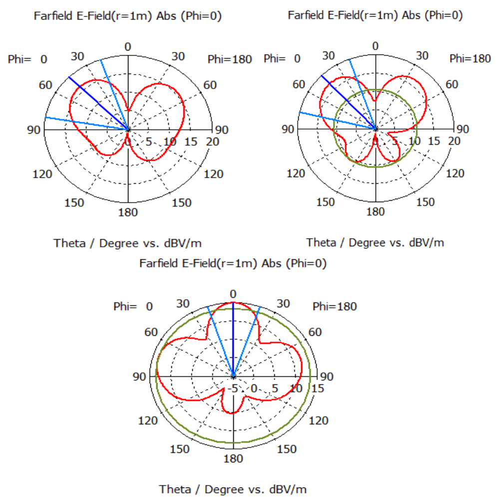


Figure 2. Variation of return loss (dB) Vs frequency (GHz)

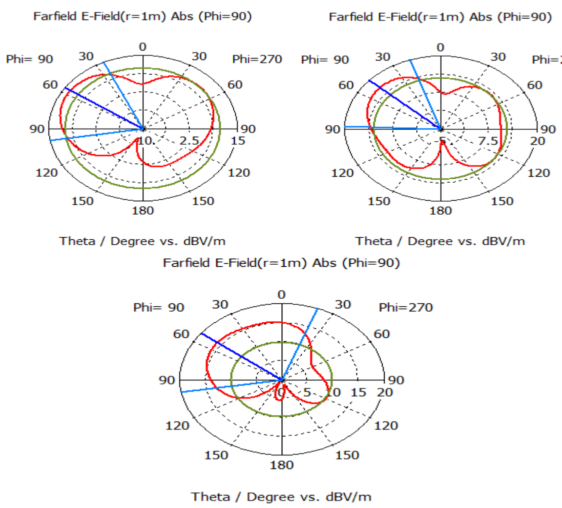


. Figure3.Variation of gain (dBi) Vs frequency (GHz)

The polar presentation of the E and H radiation pattern at their resonance frequencies is shown in Figure 4. E radiation pattern is depicted in Figure 4(a). At first and second resonance frequencies, the maximum E radiation pattern is tilted nearly a 45-degree angle with an angular width of 16.2 db V/ m while at the 12.4 GHz, the major lobe direction is normal to the patch geometry. The minor lobes appear at a 90-degree degree angle opposite to this major lobe. The H radiation pattern is depicted in Figure 4(b) and appears bidirectional in nature. For all resonance frequencies, the major lobe is oriented at a 52-degree angle. The minor lobe's direction is just opposite it.



(a)



(b)

Figure 4. Variation of (a) E and (H) plane radiation patterns at their resonance frequencies.

The smith chart is shown in Figure 5. The detected value of the input impedance is 60.05 ohm which is near 50 ohms. VSWR lies in the range 1<VSWR ≤3 with an average value of 1.5.VSWR is close to +1. at all resonance frequencies (Figure 6).

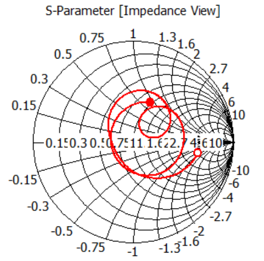


Figure5. Impendence view chart

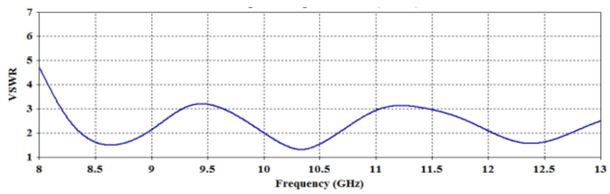


Figure6. Variation in VSWR Vs frequency (GHz)

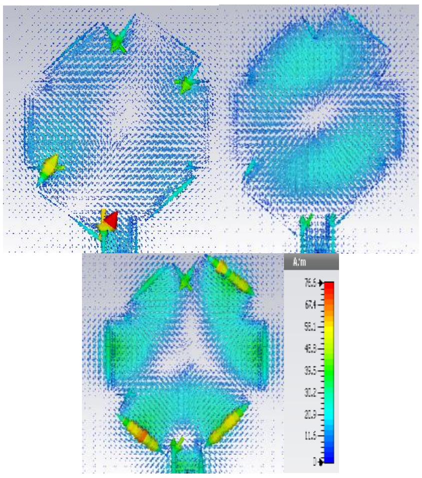


Figure 7. Surface current density at the patch on the proposed antenna geometry at the resonance frequencies respectively.

The surface current distribution on the antenna is shown in Figure 7. A high magnitude of the current appears at the notch area on the boundary of the patch. At 8.64 GHz frequency, the current appears at the feed and patch junction while a high magnitude current flows along the patch and feed line boundary. Moderate current appears across the rectangular slot notched from the center of the patch. Such surface current distribution is adjustable with the current conducting elements in the X band. There are scopes of using unique, symmetrical, fractal structures for particular applications or in general for improvement of the existing standard structures or also of borrowing structures found in nature. Some of these works [21-25] may bring a new way to affect the designing of microstrip antennas for X band applications.

IV. CONCLUSION

A simple antenna has been proposed in this paper. The proposed antenna offers a moderate value of the return loss -14dB, 17.6dB, and 13dB at the 8.6GHz, 10.3GHz, and 12.4GHz frequencies, respectively.The average value of the gain is 4.3dBi at 11GHz frequency. Analysis of E and H radiation patterns is also provided in this work. The sharp edge of the patch boundary of the proposed antenna makes it a suitable candidate for X band applications. We would like to emphasize here that the main intention of this research is not to compare designs and optimized results as such, but to point out that parameters can be adjusted by varying various edge dimensions. It may usher in a new channel of the research field.

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