

Design and Analysis of Triangular Patch Antenna for X-Band Application

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Abstract:- This paper proposed a new design triangular patch antenna with coplanar wave guide fed to enhance the bandwidth for X-band applications. Antenna designed using FR-4 substrate with the value of 4.3, with substrate thickness of 1.6mm and loss tangent value of 0.0265. From the simulation result shown return loss value <-15dB with the VSWR <2dB. The results have simulated using HFSS software. This proposed antenna has been studied using Finite Element Method numerical techniques. The proposed structure is a high gain, low cost, low weight antenna. The characteristic analysis such as return loss, VSWR, radiation pattern of this antenna has been investigated numerically. Simulated results are carried out using HFSS software.

Keywords: X-Band applications, CPW, Triple square patch, antenna parameters.

1. Introduction

The introduction of microstrip patch antennas marked a turning point for wireless communication systems, and they still meet the evolving needs increased as a result of the widespread use of portable, affordable, multipurpose, and dependable wireless communication devices [1]. The majority of the time, distinct antennas are used in the construction of X-band communication systems. After the 2G boom, telecom companies advanced to the 3G technology, which enabled consumers to access anything using their devices, including calls, texts, and even web browsing [2] [3]. Each design configuration is supported with the integration of roaming facility and assignment, however the network based on cellular configuration couldn't translate signals across borders. Low capacity, unpredictable handoff, weak voice connectivity, and lack of security are all issues with 1G [4]. Microstrip antennas can be made in square, circular, rectangular, or elliptical designs, and any shape is feasible for a variety of purposes. Inset feed is the ideal feeding method because impedance matching may be easily accomplished by adjusting the inset gap and inset length. The microstrip patch antenna seen from above. The microstrip patch antenna seen from above. Low fabrication costs, the ability to create conformal structures, compact size, light weight, simplicity in MIC integration, dual and triple frequency operation, low profile, and increased gain are all benefits of microstrip patch antennas [5-8]. Although it has many benefits, it also has significant drawbacks, like limited bandwidth, poor efficiency, and inability to handle large amounts of electricity. Technology behemoths are aiming to release modems and other comparable communication devices on the market as 5G cellular systems enter their early phases of development. In the US and Europe, the test bands within the systems for generation of 5G networking models sampled at range of 27 GHz and 41 GHz. For many WLAN systems, including wireless fidelity (Wi-Fi) and international interoperability for microwave access (Wi-MAX), low profile antennas are particularly sought [9-11]. Since wireless communication technology has advanced to broadband, there is a greater need for portable mobile communication [12].

The utilisation of the electromagnetic spectrum in current communication systems is becoming more and more crowded. Therefore, a method of switchable EM spectrum utilisation is required to meet the demand for increased EM spectrum use [13]. Different types of original works have been researched and presented in recent years to address this problem. Mobile communication had significant development from the 0th Generation to the 4th Generation due to the mobile wireless technology period. There are several applications for recent advances in 4G technology, including data from video calls, remote host observation, and machine connection. Despite its various uses, it cannot address the issues of poor quality, interconnectivity, inadequate coverage, or poor

connections. Today's requirements state that multiband antennas are favoured over single band antennas in both commercial and military applications. Thus, by using Rectangular Grid type Patch antenna, a contribution has been made in that direction. Nevertheless, Teflon layer (Radom) and circular slotted polygon of the antenna's construction improve the antenna's performance. In [14], a rectangular microstrip antenna with probe feeding for X-band applications was proposed, although it had just one resonance frequency (9 GHz) [15]. Nevertheless, the insertion within the slit of L-shaped structured antenna developed can be later focused with the applications under the extension lead to the frequency resonated with the slot can be divided further with the utilisation of the markers made in the range of 56 GHz at the sample rate of 7.9 dB can be produced under the network built slot only expands the bandwidth up to 210 MHz at the reach in efficiency of the system crossing 92% in the miniaturized design for the suggested design network allocated to the multiple sorts can be configured [16-20]. The literature research mentioned above makes it clearly focused on the suggested design of antennas are expensive, non-compactness, non-miniaturized, complexity in developing the design architecture, and uncorrelated multiple sorts of bands.

This work presents the design of a triangular patch antenna with a dual band reduced size and an asymmetric CPW feed for X band use. We have contrasted the outcomes of simulations with those of a literature review.

2. Design for the Antenna Developed

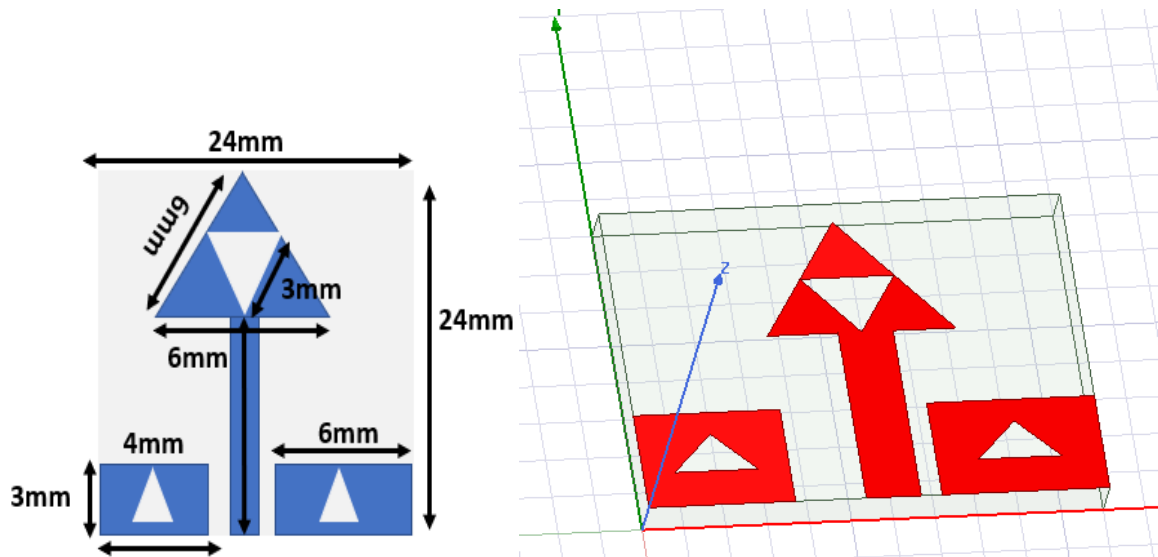


Fig.1. (a) Schematic view featuring antenna of Triangular patch with asymmetric CPW feed

Figure 1 depicts the proposed geometry of the antenna is small and straightforward. As illustrated in Figure 1, the proposed patch antenna triangular patch with asymmetric CPW feed. This antenna comprises an triple square patch with asymmetric CPW feed. The antenna designed in constructing the substrate for developing medium of FR-4. The dimensions are 24x24x1.6mm³. The proposed antenna dimensions are stated in the figure 1 and 2.

Equation (1) and (2) shows the fundamental mode resonant frequency of equilateral triangular patch antenna

$$f_r = \frac{2c}{3a_e \sqrt{\epsilon_r}} \quad (1)$$

$$a_e = a + \frac{h}{\sqrt{\epsilon_r}} \quad (2)$$

With:

c: Speed of light

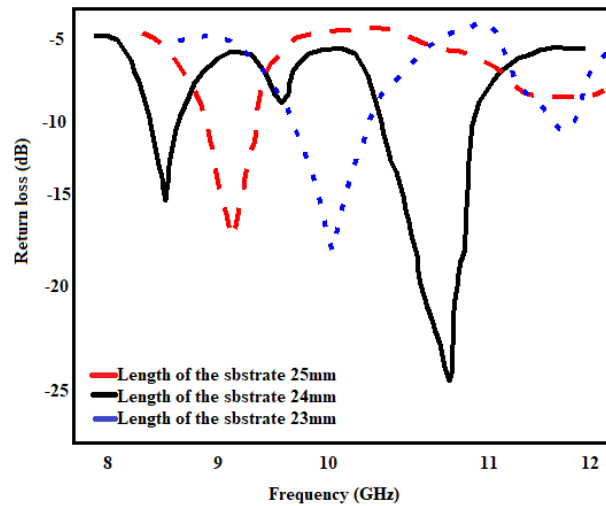
a: Patch side length (figure 1)

ae: the effective patch side length

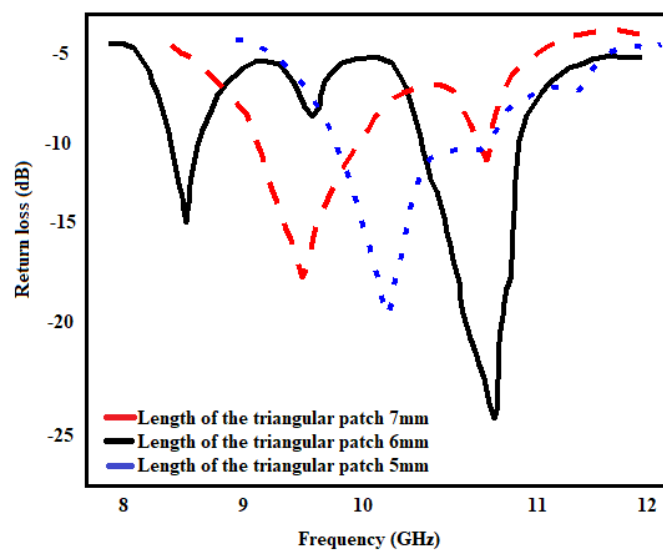
To design single patch microstrip antenna in this study conducted calculation channel feeder with impedance 50 Ohm. The function of the feeder line is intended to allow an impedance matching between the antenna and the transmission line. To determine the dimensions of channel feeder can use the equation (3) and (4) below.

$$WZ = \frac{2h}{\pi} \left\{ B - 1 - \ln(2B - 1) + \frac{\epsilon_r - 1}{2\epsilon_r} [\ln(B - 1) + 0.39 - \frac{0.61}{\epsilon_r}] \right\} \quad (3)$$

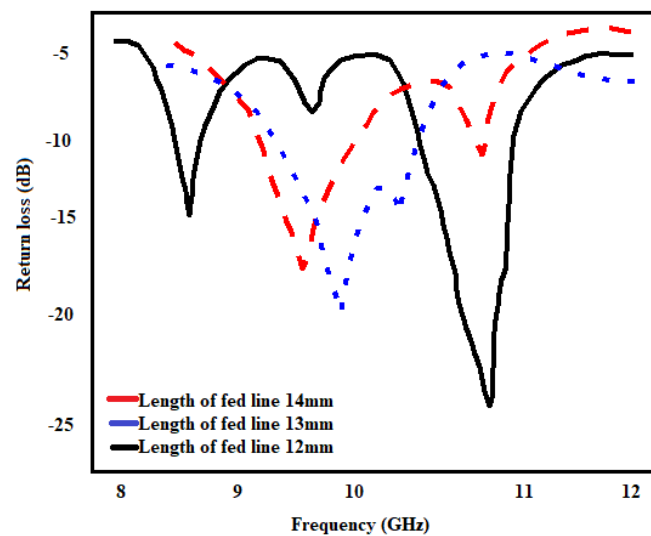
$$B = \frac{60\pi^2}{Z_0\sqrt{\epsilon_{eff}}} \quad (4)$$



(a)



(b)



(c)

Fig.1.b Parametric analysis of the proposed antenna

The above figure 1.b states the parametric analysis of the proposed antenna to get the optimized dimensions. By trial-and-error method in HFSS simulator the parametric analysis is performed. The length of the substrate, length of the patch and length of fed was optimized which was stated in the below figure across the optimized dimension the proposed antenna stating dual frequency.

3. Results and Discussions

For wireless applications, various types of printed monopole antennas are investigated, including circular, square, elliptical, hexagonal, pentagonal, octagonal, and so on. Such shapes have been associated with asymmetric CPW feed with triangular patch for the consideration of analysis within the design developed.

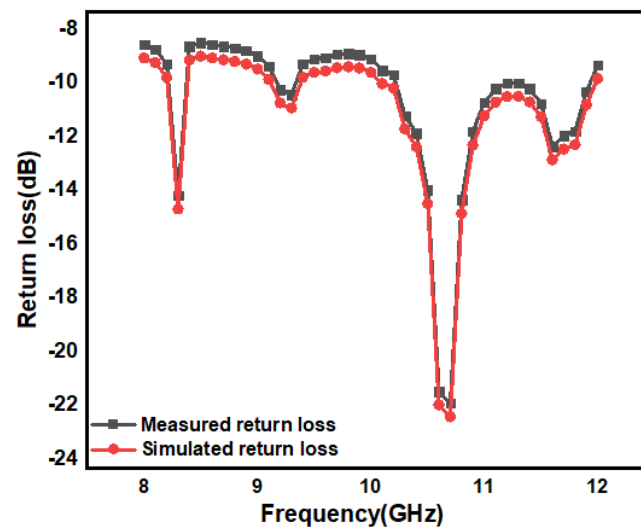
**Fig.2 Return loss value**

Figure 2 stating antenna designed with returned loss across operating frequency configured through having return loss value of -15dB across the operating frequency of 8.3 GHz, similarly 10.9 GHz under every frequency functioned with the antenna stating value of -23 dB loss returned. By the implementation of the triangular patch with asymmetric CPW feed of the proposed antenna showing high performance values in terms of the antenna parameter.

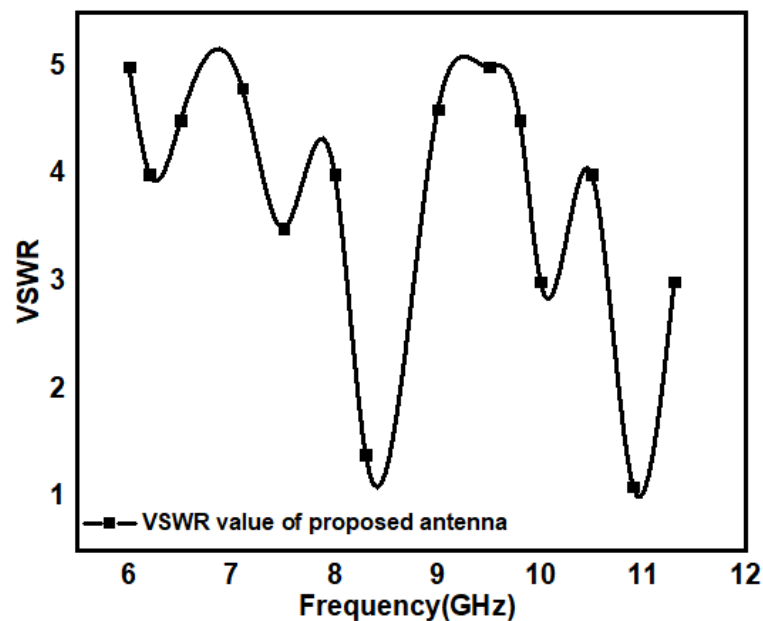


Fig.3 VSWR value of proposed antenna

Figure 3 depicts the measuring quantity of VSWR that correlated to the associated line in connection to the described signal sampled for the frequency operated in means to the required samples, further made to proposed antenna configuration having value of VSWR at 1.3 across the operating frequency of 9GHz, similarly 10.9 GHz sampling rate to bandwidth stating VSWR quantity at 1.2 which are in acceptable range. By the implementation of the triangular patch with asymmetric CPW feed of the proposed antenna showing high performance values in terms of the antenna parameters.

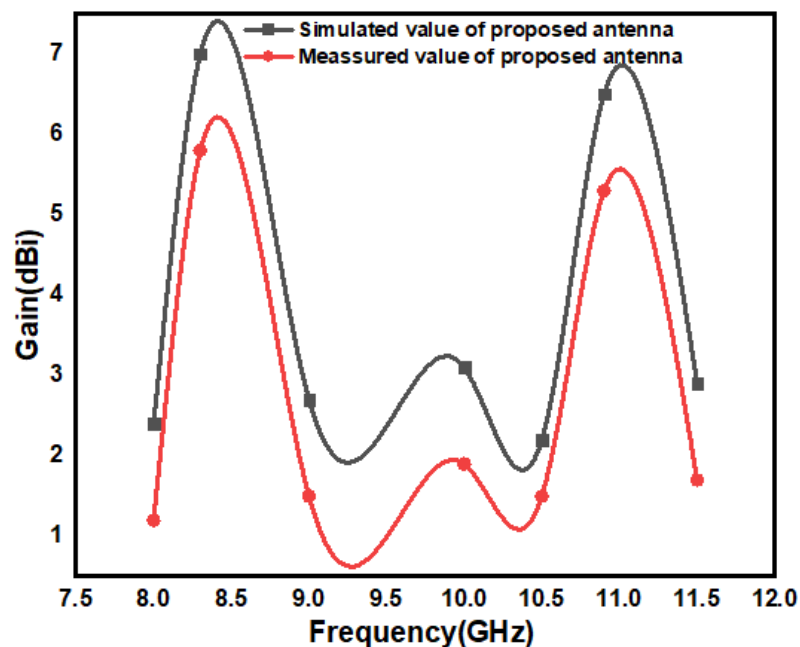


Fig.4 Gain value

Figure 4 depicts the proposed antenna stating the gain value of >2.5dBi across the operating frequency of 8.3, 10.9 GHz which are used in X-band applications.

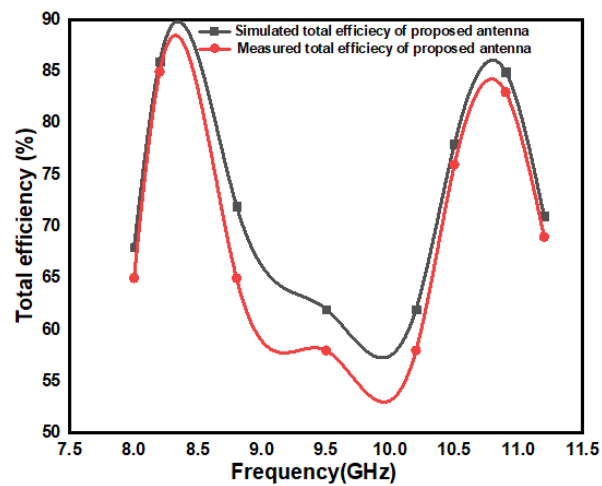


Fig.5 Efficiency value of proposed antenna

Figure 5 depicts the proposed antenna stating efficiency value of $>87\%$ across the operating frequency of 8.3GHz, next across the operating frequency of 10.9GHz the proposed antenna showing the efficiency value of $>89\%$.

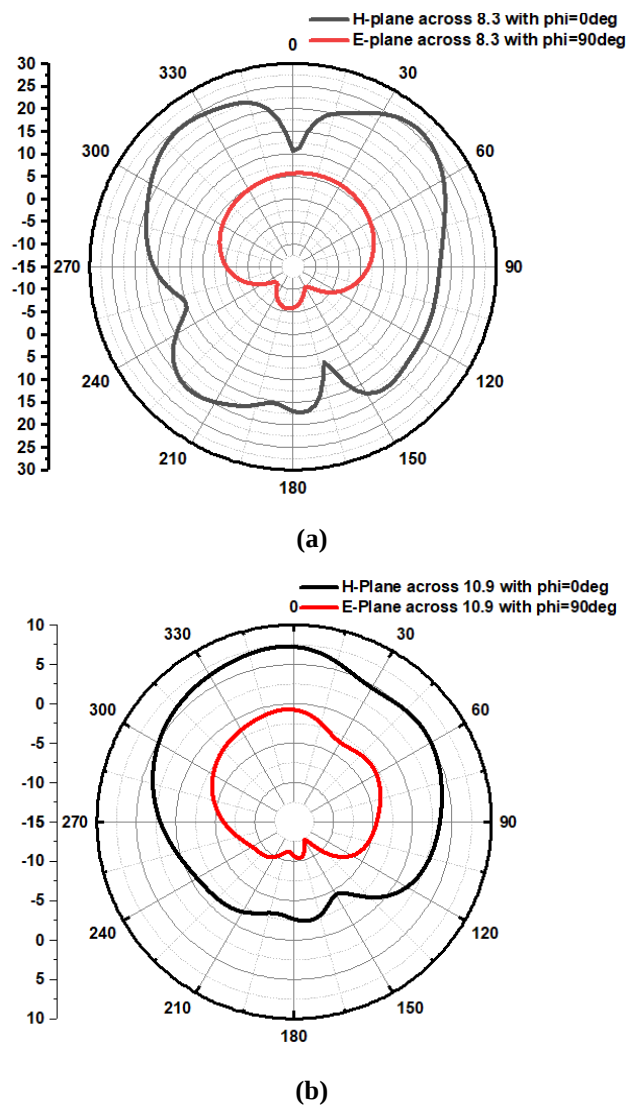


Fig.6. Radiation patterns across the operating frequency

Figure 6 demonstrates stating pattern incorporated the radiation count under every individual frequency ranged for the samples of 8.3GHz, 10.9 GHz. The antenna showing the omni direction in h-plane and single and butterfly shape in E-plane in figure 6.

Table.1 Comparison work of proposed antenna with literature survey

Ref	Dimensions(mm)	Operating frequency (GHz)	Bandwidth (B.W)- (MHz)	Peak Gain(dBi)
[9]	43.25x30x1.6	10.16	3700	N/A
[7]	30.08x45.9x1.6	10	1100	6
[21]	25.4x25.4x1.6	9.76	N/A	N/A
[22]	17.56x18.04x1.6	9.75	1801	3.56
Proposed Work	24x24x1.6	8.3 and 10.9	800,600	7,6.8

Table 1 illustrates the tabular column with dimension, operating frequency of antenna, bandwidth rate, peak gain rate within the proposed antenna under comparison of existing approach.

4. Conclusion

The study analyzed the performance of dual-band triangular patch networked antenna integrated to asymmetric CPW feed covering X- Band applications across 8.3, and 10.9 GHz band sampled with the estimation of stability under the feedback of the system gained in the factoring of prediction. Moreover, the created design enables the promising feature such as simple, compactness, and economical which claims as easily fabrication with using available FR-4 material. The triangular patch antenna with asymmetric CPW feed improves the performance of the proposed antenna acting throughout the design structure with radiators leading with the element fed to the system. Thus, it can find the application to be operating under every circumstance of porting with multiple bands with wireless procedure.

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