Design and Optimized Analysis of Defected U Shaped Microstrip Line Fed Patch Antenna with Trapezium Slot for Wideband Applications

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Abstract: ***This paper presents a simple design of microstrip patch antenna for wide band applications. The antenna is printed on a dielectric substrate FR4 (Glass Epoxy) and it utilized 50 Ω microstrip line feed for feeding. The proposed antenna is simulated by using IE3D (9.0.0) software package of Zeland, as per set size. The simulation results of proposed antenna meets the requirements of wideband antenna. By choosing the suitable feeding technique and dimension of slot, proposed antenna gained a wide impedance bandwidth (VSWR≤2) of about 76.32 % (1.289-2.88 GHz). The proposed antenna design shows a compact, low profile, wide bandwidth and minimum return loss.***

Keywords: U-shaped, slot, Micro strip line, Co-axial probe feed, Microstrip patch antenna, IE3D

1. Introduction

The continuous advancement in wireless communication systems has increased the demand of compact antennas with high gain and wideband operating frequency, to a great extant[1]. The concept of microstrip patch antenna has taken place to fulfil these requerements due to their advantages like low profile, ease of installation, light weight, ease of fabrication using printed circuit technology and low manufacturing cost etc[2]. A micrrostrip antenna is a simple antenna which uses conventional microstrip fabrication technology.

These antennas can be integrated with printed strip line feed network and active devices. Fundamentally, a microstrip patch antenna consists of a radiating patch on one side of dielectric substrate which has a ground plane on the other side. The resonant dimension depends on the shape of patch. However, microstrip patch antennas have some disadvantages also such as narrow bandwidth, low efficiency etc [3].

There are many well-known methods such as an increase of substrate thickness, the use of a low dielectric substrate, the use of various impedance matching and feeding techniques which results the improvement in antenna bandwidth [4]. In this paper, a wideband Microstrip antenna for improving the impedance bandwidth and minimizing the return loss with microstrip line feed is presented.

2. Antenna Design

In the antenna design, the first step is to choose a suitable dielectric substrate of suitable thickness (t), dielectric constant and loss tangent. The performance of micro strip antenna depends on the shape of patch, feeding technique, thickness and dielectric constant of the substrate. The dielectric constant is closely related to size and bandwidth of the microstrip antenna. The value of dielectric constant gains larger bandwidth while the high dielectric constant of substrate offers a compact size of antenna. So a trade-off relationship exists between antenna size and bandwidth [5]. The dielectric constant of substrate (ε_r) is typically in the range of $2.2<\varepsilon_r<12$.

A dielectric constant of **4.2**, loss tangent **$\tan\delta$=0.0013** and the height of dielectric constant **h=1.6 mm** are chosen for designing the proposed antenna. The operating frequency (f_o) is 2 GHz for this proposed antenna.

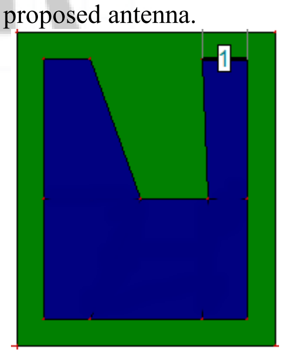


Figure 1: Proposed antenna

The mathematical expressions for calculating the dimensions of radiating patch of antenna with size of ground plane are given below (1-6)

The width of patch is taken from

$$\text{Width (W)} = \frac{C}{2f_r}\sqrt{\frac{2}{\epsilon_r+1}} \quad (1)$$

The effective dielectric constant is given by [7]

$$\epsilon_{reff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-\frac{1}{2}} \quad (2)$$

The length extension is given by [9, 10]

$$\Delta L = 0.412h\frac{[\epsilon_{reff}+0.3]\left[\frac{W}{h}+0.264\right]}{[\epsilon_{reff}-0.258]\left[\frac{W}{h}+0.8\right]} \quad (3)$$

The length of radiating patch is given by [6]

$$L = \frac{c}{2f_r\sqrt{\epsilon_{reff}}} - 2\Delta L \quad (4)$$

Length and width formula for ground plan is given by[8]

$$L_g = 6h+L \quad (5)$$

$$W_g = 6h+W \quad (6)$$

Where f_r is resonant frequency, c is the velocity of light in the free space, ε_r is the relative dielectric constant of the substrate and ΔL is length extension, W_g and L_g are the length and width of ground plane respectively.

3. Antenna Geometry

The top view and geometry of proposed antenna of the proposed antenna is presented in figure 1 and figure 2. The proposed antenna design comprises a ground plane of 46x56 mm and patch of 36.4 x 46.4 mm. A slot of trapezium shape is etched on rectangular patch as shown in figure 2. The substrate used here is FR4 (Glass Epoxy) with substrate thickness of patch h = 1.6 mm and has relative dielectric constant $\varepsilon_r = 4.2$. Micro strip line of 50Ω is used for feeding the patch.

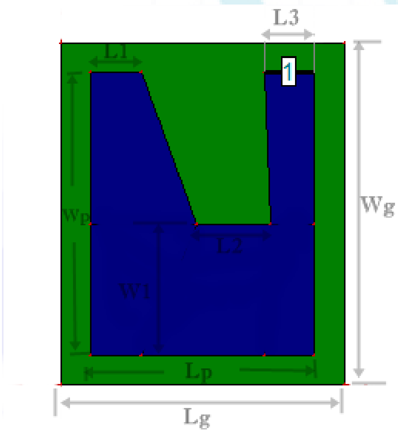


Figure 2: Geometry of proposed antenna

Table 1 shows the optimized design parameters for the proposed antenna.

Table 1: The antenna design parameters

Parameter	*Value(mm)*	*Parameter*	*Value*
W_g	56 mm	ε_r	4.2
Lg	46 mm	W_1	21.4 mm
Wp	46.4 mm	L_1	8.2 mm
Lp	36.4 mm	L_2	12 mm
H	1.6 mm	L_3	8.2 mm

The antenna size reduction is one of the important consideration in the wireless communication devices. However, the antenna size reduction reduces the impedance bandwidth of antenna as well. Therefore, the enhancement in bandwidth is obtained by choosing the suitable slot shape, proper feeding technique and suitable dielectric constant.

4. Results and Discussions

The proposed antenna is successfully simulated on IE3D (9.0.0) software package of Zeland. The simulated impedance bandwidth is **76.32%** is at **-10dB** return loss. The simulated -10 dB return loss is shown in figure 3. The VSWR is shown in figure 4. The simulated 3D radiation pattern of the proposed antenna is shown in figure 5. The simulated smith chart and 2D pattern of proposed antenna are shown in figure 6 and 7. The simulated Gain, Directivity, and Efficiency of proposed antenna are shown in figure 8, 9 and 10 respectively.

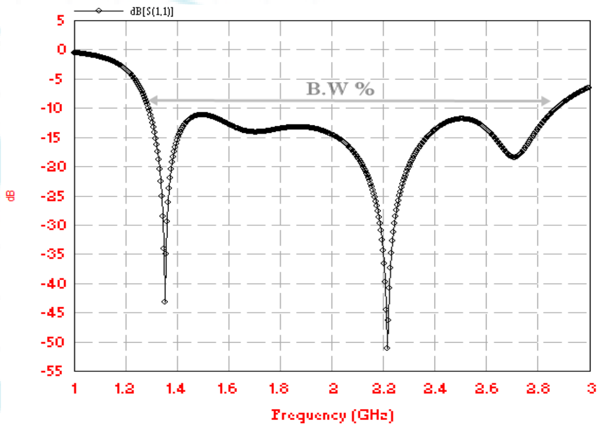


Figure 3: Simulated return loss of the proposed antenna.

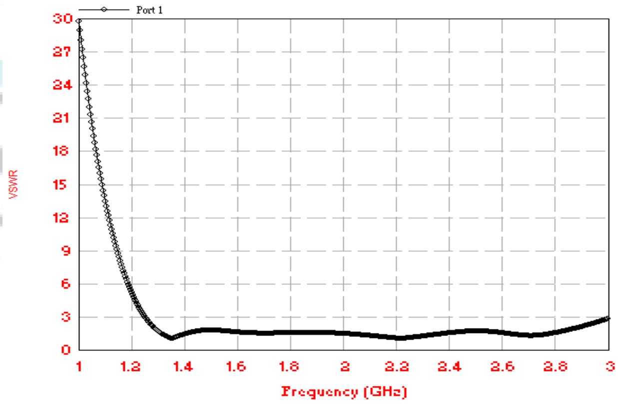


Figure 4: simulated VSWR of the proposed antenna.

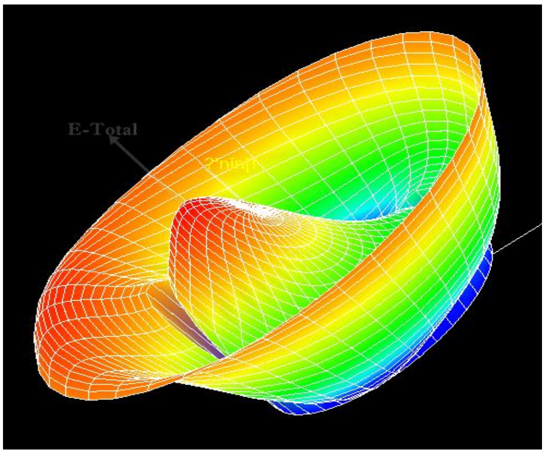


Figure 5: Simulated 3D radiation pattern of proposed antenna.

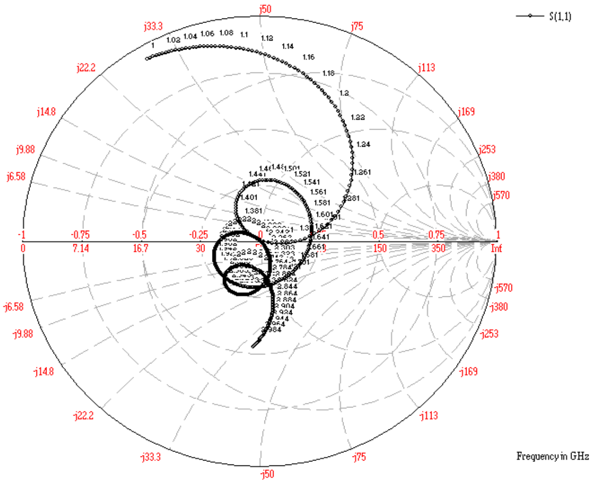
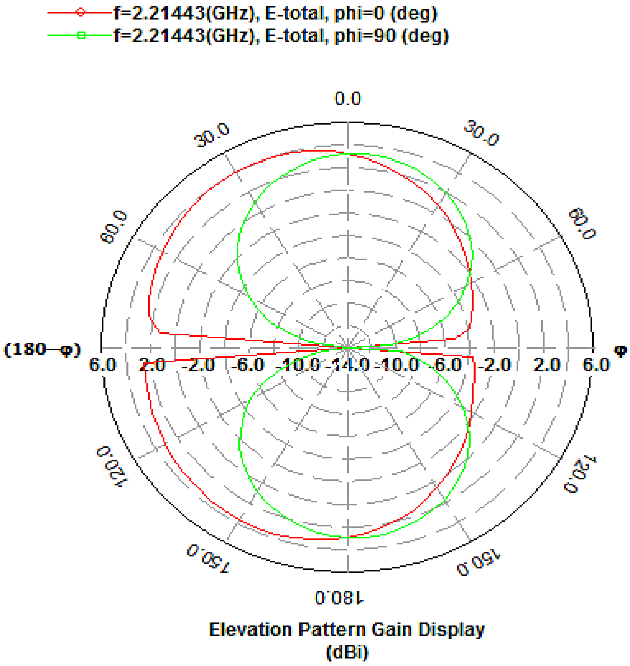


Figure 6: Smith chart plan of proposed antenna



(a)

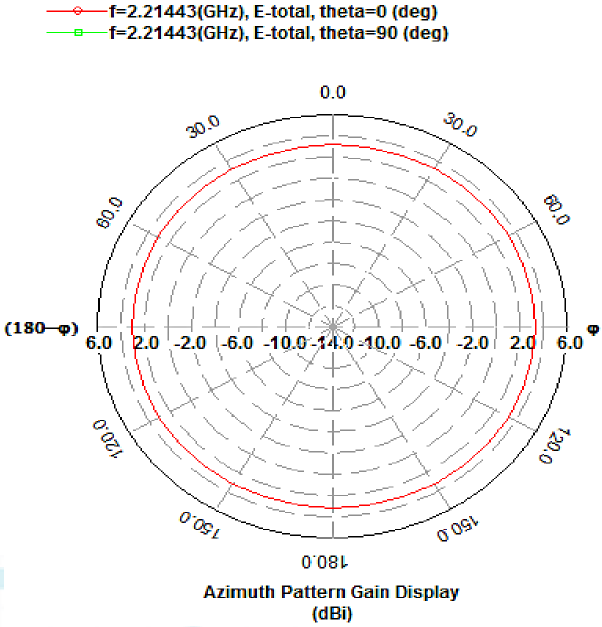


Figure 7: Simulated radiation pattern of the proposed antenna (a) Elevation pattern (b) Azimuth pattern.

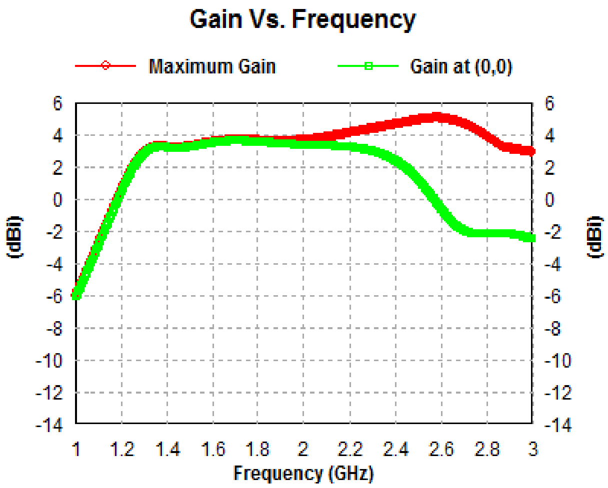


Figure 8: Simulated gain of proposed antenna.

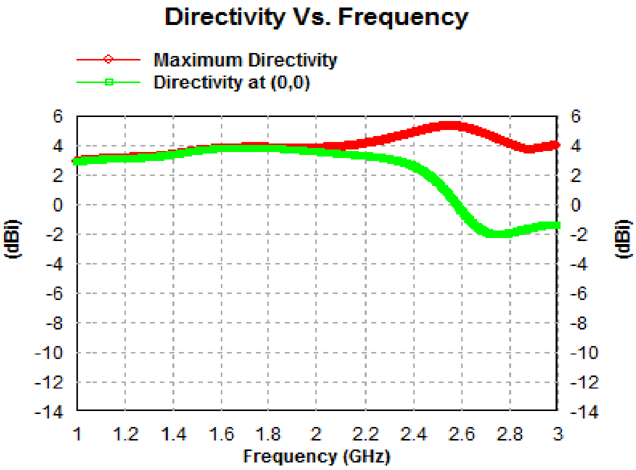


Figure 9: Simulated directivity of proposed antenna

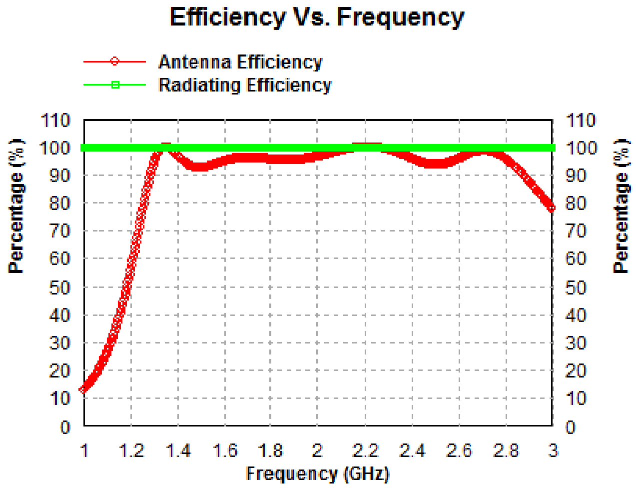


Figure 10: Efficiency vs. frequency of proposed antenna

Table 2: Simulated Results

Resonance frequency	2.214 GHz
Gain	4.11207 dB
Bandwidth	76.32 %
Frequency Range	(1.289-2.88) GHz
Return loss	-51.24 dB
VSWR	1.005
Antenna efficiency	99.999 %
Radiation efficiency	100

5. Conclusion

The proposed antenna is designed to enhance the impedance bandwidth and minimize the return loss of antenna. The proposed antenna design has been properly simulated on IE3D. In the simulation of proposed antenna, the proposed wideband microstrip antenna occupies **1.289-2.88 GHz** frequency band. As the result of proper designing and successful simulation of the proposed antenna, the enhanced bandwidth of **76.32 %** at **-10 dB** with gain of **4.11207 dB** is obtained.

Return loss of antenna is also minimized to the **-51.24 dB**. The proposed microstrip antenna posses the wide band characteristics.

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