Analysis of Trapezium Shaped Microstrip Patch Antenna with A T-Slot for WLAN Application

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Abstract: ***This paper presents a Trapezium shaped microstrip patch antenna with T- slot. FR4 substrate are used to design Trapezium patch antenna. Substrate has relative permittivity4.4and loss tangent0.0013.The substrate is having thickness of 1.6mm on which a patch of Trapezium shape is designed with T- slot. The antenna is fed by 50 Ω coaxial probe feed. The selected design is simulated using IE3D software. By analyzing the design of proposed antenna a broad band width of 67.25% (2.38 GHz – 4.79 GHz), and operates at the resonant frequency of 4.45GHz.The proposed feed point on the patch gives a good match for impedance.Thus proposed antenna can be used for the wide band (2.38 GHz – 4.79 GHz).***

Keyword: T- slot, Wide band, Microstrip patch antenna, Co-axial probe feed.

1. Introduction

Due to day by day advancement in wireless communication there is always unprecedented demand to create compact or even electrically small antennas that are compatible with modern technology, which will operate on a small handheld ground plane, and satisfy the performance specifications, particularly with respect to bandwidth and efficiency[4].

Hence for the above purpose microstrip antennas are more attractive due to their light weight, conformability, low cost and ease of fabrication [1].These antennas can be integrated with printed strip-line feed networks and active devices. In its most fundamental form, a microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate and a ground plane on the other side. For a rectangular patch, the length of the patch is usually $0.3333\lambda_0 < L < 0.5\ \lambda_0$, where λ_0 is the free space wavelength. The patch is selected to be very thin such that $t << \lambda_0$ (where t is patch thickness).The height 'h' of the dielectric substrate is usually $0.003\lambda_0 \leq h \leq 0.05\lambda_0$ .The dielectric constant of the substrate (ε_r) is typically in the range $2.2 \leq \varepsilon_r \leq 12$ [9].

For good antenna performance, a thick dielectric substrate having a low dielectric constant is desirable since this provides better efficiency, larger bandwidth and better radiation [3-7].However such a configuration leads to a larger antenna size. To design a wideband microstrip patch antenna, substrate having higher dielectric constant is used, which is less efficient. This results narrow bandwidth. Hence a trade-off must be realized between the antenna dimensions and it's performance. However the major disadvantage of the microstrip patch antenna is its inherently narrow impedance bandwidth. Much intensive research has been done and going on to enhance thebandwidth and techniques. These techniques include the utilization of thick substrate with low dielectric constant and slotted patch also [1].

By the use of different feeding techniques one can get better performance results. In this paper we use 50 Ω co-axial probe feed.

2. Antenna Design

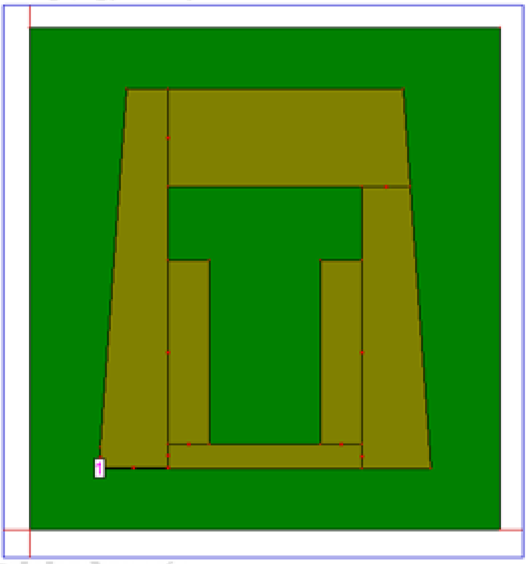

Figure 1: Proposed Antenna

The first step in the design is to choose a suitable dielectric substrate of appropriate thickness (t), dielectric constant and loss tangent. A thicker substrate, besides being mechanically strong it will increase the radiated power, reduce the conductor loss and improve impedance bandwidth [3].

A larger patch width increases the radiated power, bandwidth and radiation efficiency and decreases resonant resistance. It has been suggested that the inequality 1< W/L< 2 must be satisfied for better performance. In case of microstrip antenna, it is proportional to its quality factor Q [9].

The dielectric material selected for this design is FR4 substrate, which has a dielectric constant $\boldsymbol{\varepsilon_r=4.4}$, loss tangent $\boldsymbol{\tan\delta=0.0013}$, the height of the dielectric substrate is $\boldsymbol{h}$ = **1.6** mm. The Wi-Fi applications use the frequency range from (**2.38-4.79**) **GHz**, ($\mathbf{f_o}$) selected for this design is **5GHz.**

The Design parameters of proposed MSA antenna is given in Table1.

Table 1: Antenna Design Parameters

Parameter	Value	Parameter	Value
H	1.6mm	Feed point 1	(5,5)mm
ε_r	4.4	Lg	34mm
f_o	5GHz	Wg	41mm
L_1	20 mm	L_5	3 mm
L_2	14 mm	W_1	15 mm
L_3	8 mm	W_2	6 mm
L_4	24 mm	W_3	2 mm

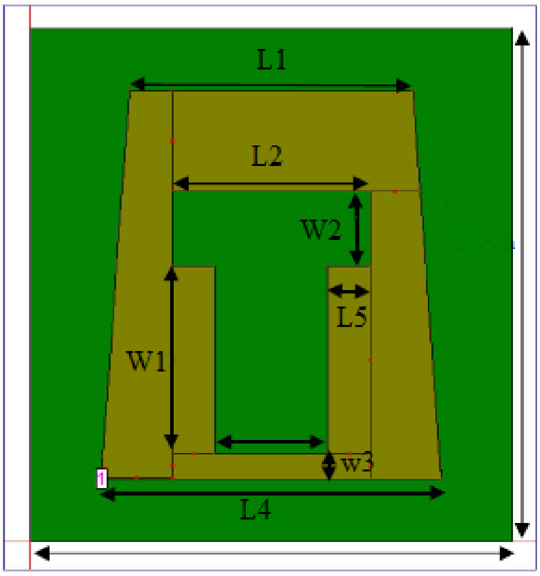

Figure 2: Proposed Antenna Geometry

Figure 1 shows the layout of a coaxial probe-fed trapezium patch antenna. First the ground plane of Length Lg and Width Wg is made and then a trapezium patch of given dimensions as mentioned in table 1, is printed above the ground plane to increase the bandwidth of microstrip antenna which is done at a height of **1.6mm**(in case of FR4 material) from the ground. Feed is provided by co-axial probe of 50 Ω at point (5, 5) and doing this the bandwidth has enhancedupto**67.25%** in frequency range (**2.38-4.79**) GHz.

For a rectangular patch, the length of the patch L is usually $0.3333\lambda o < L < 0.5\ \lambda_o$, where λ_o is the free-space wavelength. The patch is selected to be very thin such that $t \ll \lambda_o$ (where t is the patch thickness). The height h of the dielectric substrate is usually $0.003\ \lambda_o \leq h \leq 0.05\ \lambda_o$. The dielectric constant of the substrate (ε_r) is typically in the range $2.2 \leq \varepsilon_r \leq 12$ [9].

In the process of designingmicrostrippatch antenna, the size of the radiation patch and ground plane can be similar to the following formulas.

Width of radiating patch [12]:

$$W = \left(\frac{c}{2f_r}\right)\left(\frac{\varepsilon_r + 1}{2}\right)^{-0.5} \quad (1)$$

The effective dielectric constant [4]:

$$\varepsilon_{reff} = \left(\frac{\varepsilon_r + 1}{2}\right) + \left(\frac{\varepsilon_r - 1}{2}\right)\left(1 + \frac{12W}{H}\right)^{-0.5} \quad (2)$$

Length of radiating patch [12]:

$$L = \frac{c}{2f_r\sqrt{\varepsilon_{reff}}} - 2\Delta l \quad (3)$$

The length extension [9, 10]:

$$\Delta L = 0.412H\left(\frac{\varepsilon_{eff} + 0.3}{\varepsilon_{eff} - 0.258}\right)\left(\frac{\left(\frac{W}{H}\right) + 0.264}{\left(\frac{W}{H}\right) + 0.8}\right) \quad (4)$$

Length formula for ground plane [15]:
$W_g = 6H+W$.
Width formula for ground plane [15]:
$L_g = 6H+L$.

Where f is the resonant frequency, c is the free space velocity of the light, L is the actual length of the current, ε_r is the effective dielectric constant of the substrate and Δl is the length of equivalent radiation gap.

The far electric fields of the trapezium patch are as follows:

$$E_\theta = \frac{Ke^{-jor}}{r}\cos\left(k_0 h\sqrt{\varepsilon_r}\cos\theta\right)\frac{\sin\left(\frac{\pi W}{\lambda_0}Sin\theta Sin\varphi\right)Cos\left(\frac{\pi L}{\lambda_0}Sin\theta\cos\varphi\right)\cos\varphi}{Sin\theta Sin\varphi} \quad \textbf{(5)}$$

$$E_\varphi = \frac{-Ke^{-jkr_0}}{r}Cos\left(k_0 h\sqrt{\varepsilon_r}Cos\theta\right)\frac{Sin\left(\frac{\pi W}{\lambda_0}Sin\theta Sin\varphi\right)Cos\left(\frac{\pi L}{\lambda_0}Sin\theta Cos\varphi\right)\cos}{Sin\theta Sin\varphi} \quad \textbf{.... (6)}$$

Equations 5 & 6 enables one to plot the radiation pattern for every mode of the trapezium micro strip patch antenna.

3. Result and Discussion

Figure 3 shows the return loss of a coaxial probe-fed trapezium patch with T slotmicrostrip antenna which resonates atfrequency **4.449GHz,** andobtaineda wide impedance bandwidth of **67.25%.**Hence it is more suitable to use prosed antenna for wide band applications. Figure 4 shows the smith chart. Figure 5 shows the VSWR (VSWR<2) curve which is of wide band microstrip antenna obtained from IE3D.The proposed microstrip antenna have better antenna efficiency and good radiation efficiency of about %. Figure 9 & figure 6 shows 3D radiation pattern & elevation pattern at **3GHz.**

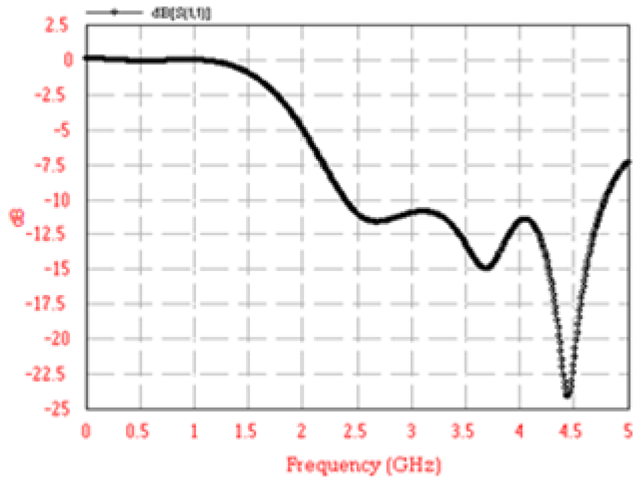

Figure 3: Simulated Return loss of proposed MSA

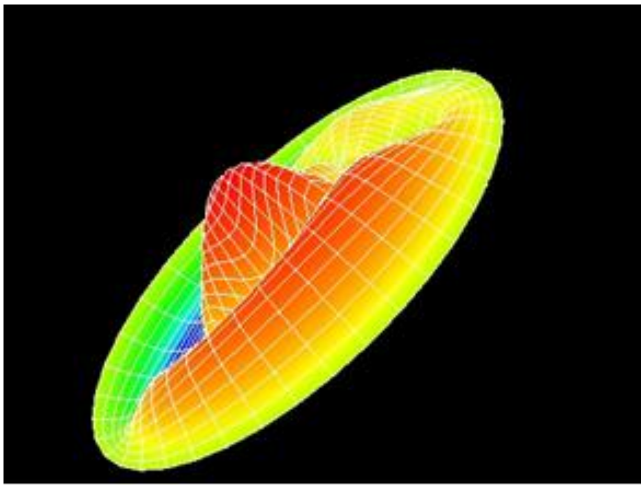

Figure 6: Radiation pattern of proposed microstrip antenna

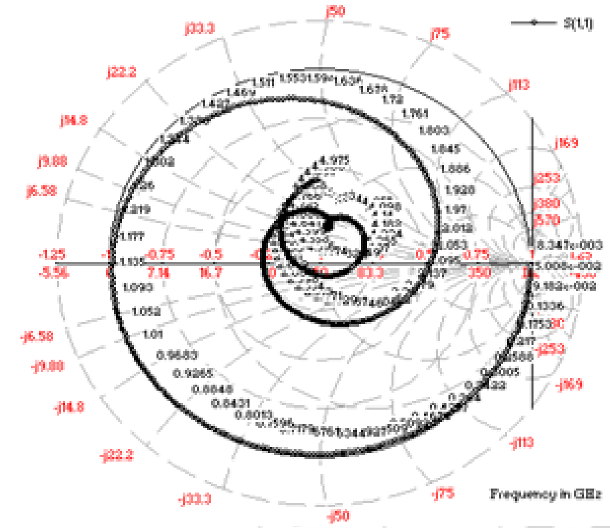

Figure 4: Smith chart plot of proposed microstrip antenna

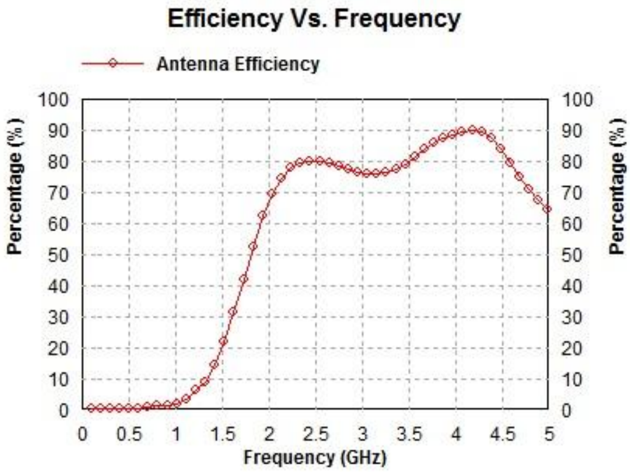

Figure 7: Gain of proposed microstrip antenna

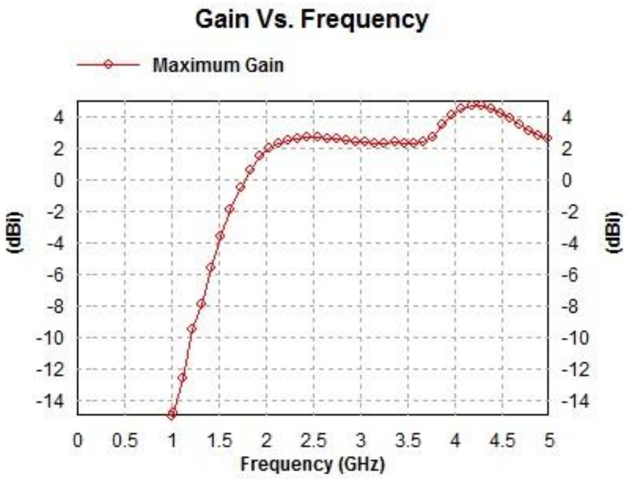

Figure 8: Directivity of proposed microstrip antenna

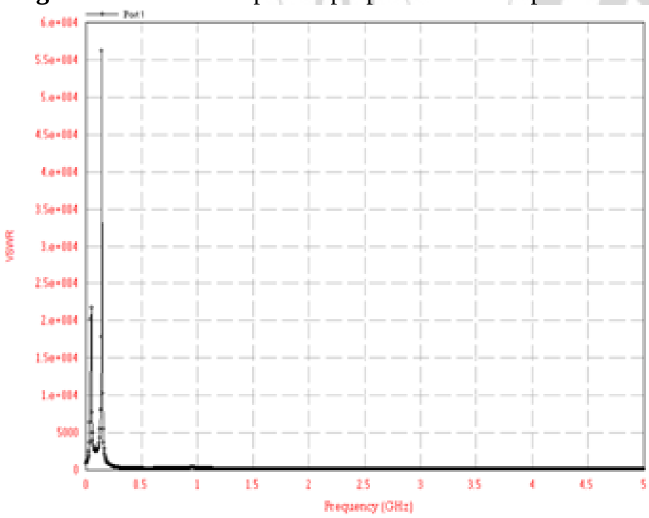

Figure 5: VSWR Vs frequency of proposed micro strip antenna

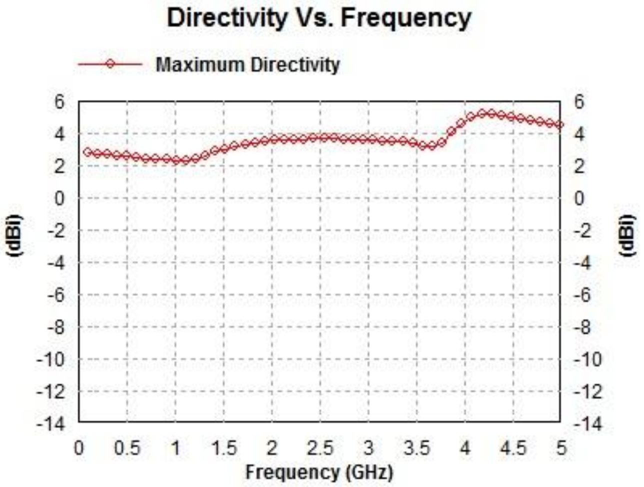

Figure 9: Efficiency Vs frequency of proposed microstrip antenna

Table 2: Simulated Data

Resonance Frequency	4.449 GHz
Gain	4.19692dB
Directivity	4.4919dB
Bandwidth	67.25%
Frequency Range	2.38 GHz - 4.79 GH$_Z$
Return Loss	-24.19dB
VSWR	1.132
Radiation efficiency	84.1316%
Antenna efficiency	83.657%

4. Conclusion

In this analysis, a new design of linearly polarized trapezium shapedmicrostrip patch antenna with T- slotis designedfor wireless application and result shows the achievement of a wide impedance bandwidth of **67.25%** at **-10 dB** return loss,in the frequency range **2.38GHz –4.79GHz**. In my design,the antenna is fed by co-axial probe feed of 50 Ω at point (5, 5).So I have achieved enhanced bandwidth of **67.25%**, efficiency of %, gain of dBi, directivity of dBias shown in figure 3,7,8 and 9 respectively.

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Author Profile

Mr. Kaushal Prasad is a M. Tech. student in Bundelkhand Institute of Engineering and Technology Jhansi, India in Electronics and Communication Engineering. He has specialization in communication field. He has 2 years industrial and 1 year teaching experience. He has published one paper in IEEE 2nd international journal conference on Communication and Signal Processing (ICCSP-2013), 2 papers in international conference on Advanced Information Communication Technology in Engineering (ICAICTE-2K13), 1 paper in international conference on Recent Trends in Engineering Sciences, 1 paper in international scientific journal on science engineering and technology (ISJSET) and also published one paper in national conference on challenges of efficient energy technology for clear energy.Thus he has published 5 international 1 national research paper.His current area of research includes MSA for wide band and ultra-wide band applications.

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