IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 4, Issue 12, December 2015

Design and Analysis of Triple Band Inverted T-shaped Microstrip Patch Antenna

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Abstract: The aim of the paper is to design a triple band inverted T-shaped microstrip patch antenna. In this paper, method of moments based IE3D software is used to design a Triple Band inverted T shaped Microstrip Patch Antenna. The proposed antenna made from a two strip patch which made a shape of inverted T type so this antenna named as inverted T shaped MPA. This antenna operated at three frequency band with resonance frequencies 1.91 GHz (with a bandwidth of 19.63%), 2.256 GHz (with a bandwidth of 28.97%) and 5.676 GHz (with a bandwidth of 7.03%). So this antenna can be used for both mobile and satellite communication purpose. The simulated results for various parameters like radiation patterns, gain, reflection coefficient or return loss, VSWR and radiation efficiency of proposed antenna are also calculated with simulation software IE3D.

Keywords: Microstrip Patch Antenna, Inverted T-shape, Multiband, Return loss, Efficiency, Gain.

I. INTRODUCTION

Due to the rapid growth in wireless communication, the need of multiband frequency is raised. Thus, an antenna with multiband operations is required. Multiband antennas are developed for various wireless applications so that any equipment can employ several applications at a time. These applications can involve data transfer, video, audio, radio [1]. In multiband antenna, one part works for one band while another part works for different band. A Multiband antenna can have lower than average gains. These are manufactured to work at high frequencies from MHz to several GHz.

The antenna transforms electric current into EM by transmitting a signal into radio waves and transforms electromagnetic waves into electric current by receiving. One of major issue for antenna design is to make small size, multiband and wideband antenna. Microstrip antennas are best useful as they will make it good. Microstrip antenna consists of patch and ground separated by a dielectric called substrate. Although these antennas are having number of advantages but they suffer from a number of disadvantages, like these antenna may have large return loss, low gain, small bandwidth and lack of multibanding. Antenna in [2] has good characteristics but has bands above 6 GHz and also it has slight large size, so I shaped concept has been changed to inverted T-shape geometry by reducing size. Further parametric analysis can be applied to make antenna good for multiband and wideband applications.

A circularly polarized antenna allows stable data transmission and not depends on the orientation of transmitter and receiver. Hence, it is most suitable for portable and handheld mobile devices. Circular polarization (CP) in a conventional patch antenna can be achieved by simultaneous excitation of two orthogonally polarized modes with a 90 degree phase difference [3]. In literature, there exist a large number of techniques of achieving CP in a microstrip patch antenna using both single and dual-feed configurations [3]. However, the single-feed design is more popular as it avoids the use of an external power divider.

Khidre et al. [4] presented U slot microstrip antenna for higher mode applications. This antenna was having bandwidth of 600 MHz with a band from 5.17 GHz to 5.81 GHz. Gupta et al. [5] designed dual band microstrip patch antenna for C Band and X band applications. This antenna was having a patch with different slots so as to have good antenna characteristics. Janani. A et.al [6] designed E-shaped fractal patch antenna for multiband applications.

Fractal geometry had been used to obtain multiband characteristics. Waladi et al. [7] designed fractal microstrip patch antenna using star triangular shape. Fractal geometry had been applied on triangle to obtain star shape antenna. Ghorpade et al. [8] made a comparison between E-shape antenna and E-shaped fractal patch antenna. From this comparison it was found that fractal antenna gave multiband characteristics. Vinoy et.al [9] designed multiband ring fractal patch antenna using multiport network approach. Sun et al. [10] obtained large bandwidth on a thin substrate by making a rectangular slot. Chainool et al. [11] applied fractal geometry on loop antenna to make antenna useful for USB dongle application.

The Microstrip patch antennas are similar to parallel plate capacitors and microstrip antennas are attractive due to their light weight and low profile and low cost. The patch width, w is usually in the range $\lambda_o/3 < W < \lambda_o/2$, ratio of L/W>2 is not advised, L is the path length. Thickness of the dielectric constant substrate is less effective on the resonance frequency compared to dielectric constant, $0.003\lambda_o \leq h \leq 0.1\lambda_o$ is generally used.

In this paper, a patch is made of inverted T-shaped and coaxial probe is used for feeding the proposed antenna to achieve triple-band operation.

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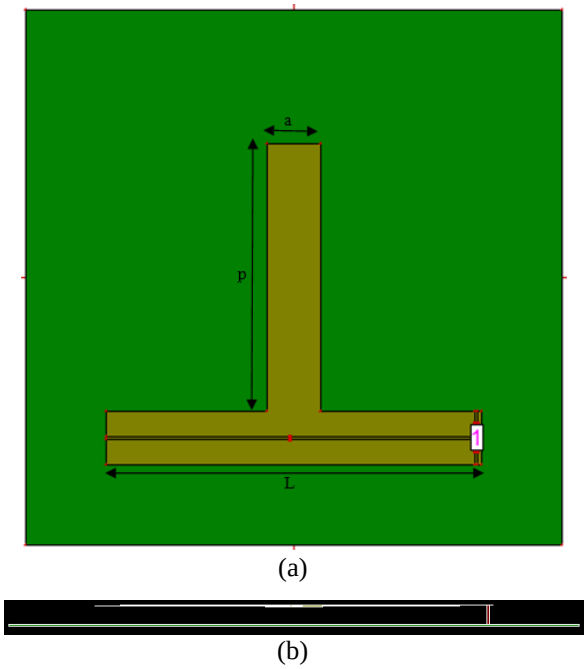
II. ANTENNA DESIGN METHODOLOGY

An inverted T-shaped patch antenna operating at around 3.2 GHz is chosen as the reference design. Low-cost FR4 epoxy substrate (ε_r= 4.4, tan δ = 0.02) with copper trace of 20µm is used for the antenna design. The length of square substrate or ground plane, L_S is 50 mm. The thickness of the dielectric substrate (h) is 1.6mm. The coaxial probe feed is used for excitation of this antenna. The location of probe feed in proposed patch antenna is (17,-15) mm from the centre of patch.

Table-1 Design specification of inverted T-shaped patch antenna

Parameter	Value (mm)
L	35
L_S	50
h	1.6
p	25
a	5
Feed location from center	(17,-15)

The two rectangular strips used to make an inverted T-shaped patch. These two strips having width, a, equals to 5mm and length p and L is 25 mm, 35 mm respectively. Antenna is feed at the point (17,-15) mm and simulated and result is obtained. Fig.1 shows the geometry of inverted T-shaped microstrip patch antenna. Detail specification of inverted T-shaped antenna is given in table 1.



(a)

(b)

Fig.1. (a)Top view,(b)side view of inverted T-shaped microstrip patch antenna

III. RESULT AND DISCUSSION

The proposed antenna has been designed using IE3D software. The IE3D is a full-wave, method of moment (MOM) simulator solving the current distribution on 3D and multi-layered structures of general shape. The performance of antenna has been analyzed in terms of resonant frequency, return loss(S_{11}), bandwidth, gain(dB), directivity (dBi), VSWR and antenna input impedance.

Fig. 2 shows the return loss plot of inverted T-shaped patch antenna. From the s parameter display the operating frequencies are centered at f_{c1}= 1.885 GHz, f_{c2} =2.467 GHz and f_{c3}= 5.656 GHz with maximum S(1,1) equals to -22.32 dB, -52.84 dB and -28.22 dB respectively.

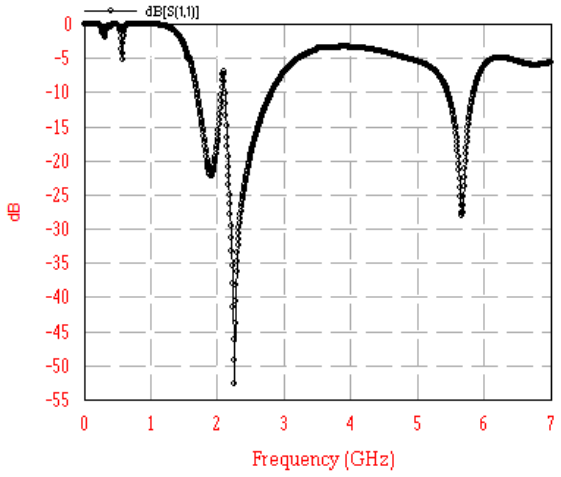


Fig.2. Return loss vs frequency curve for inverted T-shaped patch antenna

The resonance frequency of three frequency bands are 1.91GHz, 2.256 GHz and 5.676 GHz and the bandwidth percentages for respective band of this antenna are 19.63%, 28.97% and 7.03%.

Bandwidth Calculation

For 1st band

f_{L1} =1.7GHz, f_{H1} = 2.07GHz, f_{c1}= 1.885GHz

Bandwidth = $\frac{2.07-1.7}{1.885} \times 100$ = **19.63%**

For 2nd band

f_{L2} =2.11GHz, f_{H2} = 2.825GHz, f_{c2}= 2.467GHz

Bandwidth = $\frac{2.825-2.11}{2.467} \times 100$ = **28.97%**

For 3rd band

f_{L3} =5.457GHz, f_{H3} = 5.855GHz, f_{c3}= 5.656GHz

Bandwidth = $\frac{5.855-5.457}{5.656} \times 100$ = **7.03%.**

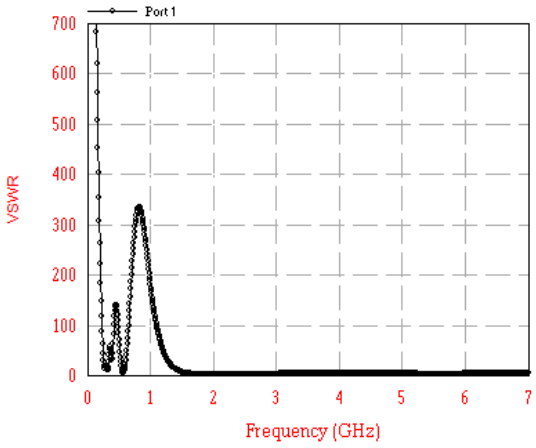


Fig 3.VSWR vs frequency graph of inverted T-shaped patch antenna

DOI 10.17148/IJARCCE.2015.41225

IJARCCE

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Table 2 shows the all results at three bands of inverted T-shaped patch antenna. Fig. 3 shows the VSWR plot of inverted T-shaped patch antenna. This graph shows that the value of VSWR can be seen to be within 1 to 2 in the operating range. Fig.4 shows the gain vs frequency graph of inverted T-shaped patch antenna. The maximum gain of this proposed antenna is 5.5dBi at the frequency 5.676 GHz.

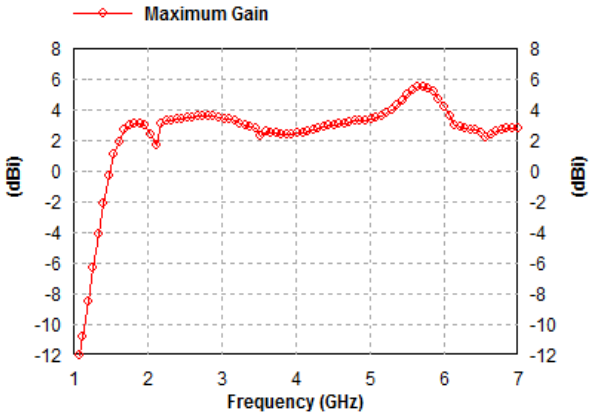


Fig.4. Gain vs frequency graph of inverted T-shaped patch antenna

Table-2 Results at three bands of inverted T-shaped patch antenna

Parameter / Band	Lower cutoff frequency f_L (GHz)	Higher cutoff frequency f_H (GHz)	Center frequency f_c (GHz)	Bandwidth (%)	Return loss (dB)	Gain (dBi)
1st band	1.7	2.07	1.885	19.63	-22.32	3.04
2nd band	2.11	2.825	2.467	28.97	-52.84	3.22
3rd band	5.457	5.855	5.656	7.03	-28.22	5.5

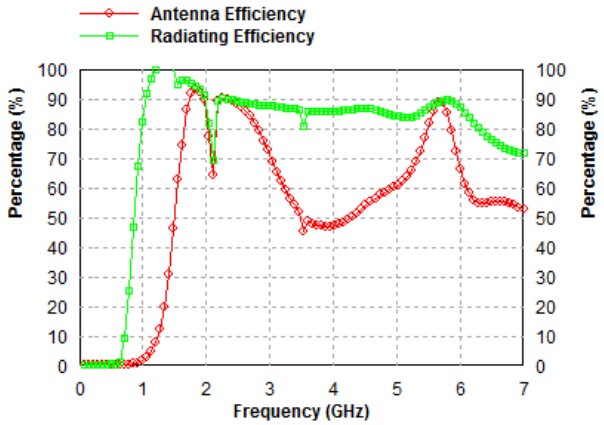
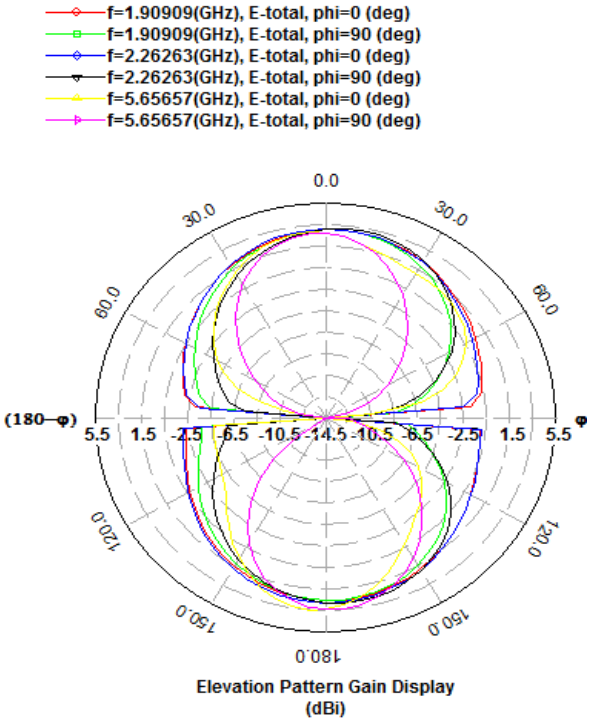
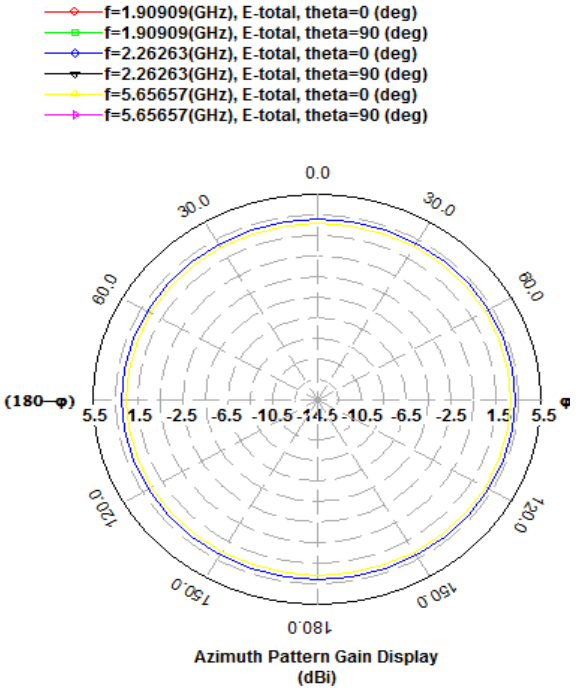


Fig.5. Efficiency vs frequency graph of inverted T-shaped patch antenna

Above figure shows the antenna efficiency and radiating efficiency with frequency graph of inverted T-shaped patch antenna. Fig.6 shows the 2-D elevation and azimuth radiation pattern of inverted T-shaped patch antenna.



(a)



(b)

Fig.6. 2-D (a) Elevation (b) Azimuth radiation pattern of inverted T-shaped patch antenna

IV. CONCLUSION

A triple band Microstrip Patch Antenna has been successfully designed. It can be concluded from the above results that the inverted T-shaped microstrip patch antenna has studied under great details with the help of experimental results. The proposed patch field desirable results throughout the operating frequency range.

DOI 10.17148/IJARCCE.2015.41225

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