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DESIGN OF DUAL T SHAPED PIFA ANTENNA FOR MULTIBAND WIRELESS APPLICATIONS

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ABSTRACT

The development and simulation demonstrations of a Dual T shaped Planar Inverted F Antenna (PIFA) are presented in this paper. The design of single feed Dual T PIFA operating at 500 MHz to 3GHz is presented. CADFEKO version 5.5 is used in Dual T shaped PIFA antenna. A prototype of the antenna was constructed and the results exhibits a proper operation of the antenna in terms of return loss, bandwidth, efficiency, gain . The antennas feature remarkable properties while occupying a significantly small space, which makes them strong candidates for mobile applications and for the wireless communication applications too.

KEYWORDS Feed, Stub, PIFA, Return loss, Multiband, T-shape.

INTRODUCTION

Antennas enable wireless communications between two or more stations by directing signals toward the stations. An antenna is defined by Webster‘s Dictionary as a usually metallic device (as a rod or wire) for radiating or receiving radio waves‖. The IEEE Standard Definitions of Terms for Antennas (IEEE Std 145–1983) defines the antenna or aerial as a means for radiating or receiving radio waves.

For wireless communication system, antenna is one of the most critical components. A good design of the antenna can thus improve overall system performance. The Planar inverted-F antenna (PIFA) antennas are most desirable design in many applications due to their attractive features such as low profile, light weight, conformal shaping, low cost, high efficiency, simplicity of manufacture and easy integration to circuits. Achieving this is not an easy task considering that the new smart phones command more space for the electronics associated to multiple functionalities that these terminals order, leaving small room to accommodate the antenna system. The tremendous increase in wireless communication in the last few decades has led to the need of larger bandwidth and low profile antennas for both commercial and military applications. So we go for PIFA antenna.

The demands on wireless communication device performances have increased rapidly over the last few years. For high end products both economics and user expectations require them to cover as many bands as possible.

Currently at least five bands are assigned for world wide mobile services (850, 900, 1800, 1900 and 2100 MHz) so many antennas must cover 824–960 MHz and 1710–2170 MHz with high efficiency. Not only must the bandwidth of the antenna be very wide, but when transmitting data using high order modulation schemes, it is very important that antenna gain and efficiency are high as possible. Nowadays many devices (mobile phone) have the Bluetooth and Wireless LAN capability. By adding Bluetooth or WLAN at the mobile phone, data transfer can be easily made. For Bluetooth or WLAN Communication System uses frequency range from 2400–2450 MHz, hence the antenna designed must be able to operate in this frequency range. PIFA is currently being used as an embedded antenna in many wireless applications. It is one of the most promising antenna types because it is small and has a low profile, making it suitable for mounting on portable equipment. The antenna also has a high degree of sensitivity to both vertically and horizontally polarized radio waves, thus making the Planar Inverted-F Antenna ideally suited to wireless applications. In addition, PIFA has smaller backward radiation toward the user. This antenna also is reasonably efficient and free of excessive radiation illuminating the user (low SAR value) .

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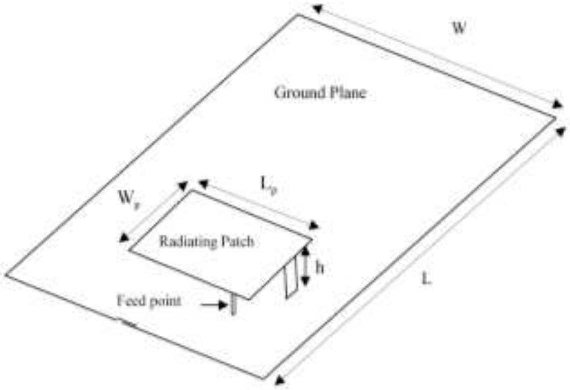
Other design methods have some drawbacks such as low efficiency, narrow bandwidth and not multiband. To enhance these drawbacks, especially narrow bandwidth, and to meet the requirements of mobile units, PIFA has been designed to achieve the multiband and wideband width. This method gives useful applications in wireless communications.

DESIGN OF PIFA

Figure 1:



Typical PIFA Structure

Typical PIFA Structure PIFA is also referred to as short-circuited micro strip antenna due to the fact that its structure resembles to short- circuit MSA. The shorting post near the feed point of PIFA structure is a good method for reducing the antenna size, but this result into the narrow impedance bandwidth which is one of the limitations. By varying the size of the ground plane, the bandwidth of a PIFA can be adjusted and optimized. The location and spacing between two shorting posts can be adjusted accordingly.

The Inverted F Antenna (IFA) typically consists of a rectangular planar element located above a ground plane, a short circuiting plate or pin, and a feeding mechanism for the planar element. The Inverted F antenna is a variant of the monopole where the top section has been folded down so as to be parallel with the ground plane. This is done to reduce the height of the antenna, while maintaining a resonant trace length. This parallel section introduces capacitance to the input impedance of the antenna, which is compensated by implementing a short-circuit stub. The stub's end is connected to the ground plane through a via. The ground plane of the antenna plays a significant role in its operation.

Excitation of currents in the printed IFA causes excitation of currents in the ground plane. The resulting electromagnetic field is formed by the interaction of the IFA and an image of itself below the ground plane. Its behavior as a perfect energy reflector is consistent only when the ground plane is infinite or very much larger in its dimensions than the monopole itself. In practice the metallic layers are of comparable dimensions to the monopole and act as the other part of the dipole. In general, the required PCB ground plane length is roughly one quarter ($\lambda/4$) of the operating wavelength.

Table 1. Parameter Characteristics

Parameters	Effects
Length	Determines resonance frequency
Width	Control impedance matching
Height	Control Bandwidth
Width of shorting plate	Effect on the anti-resonance and increase bandwidth
Feed position from shorting plate	Effect on resonance frequency and bandwidth

$L_p + W_p = \lambda/4$ (1)

Where Lp is Top patch length

Wp is Top patch Width

λ is wavelength corresponding to resonant frequency

When W/Lp=1 then

$L_p + h = \lambda/4$ (2)

When W=0 then

$L_p + W_p + h = \lambda/$

DESIGN AND PROCEDURE

The geometry of the proposed multi band dual T shaped PIFA antenna is shown in Figure 2.

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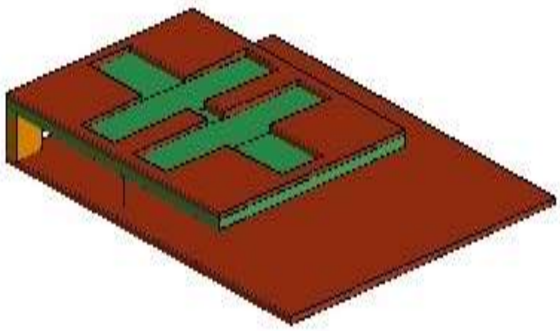
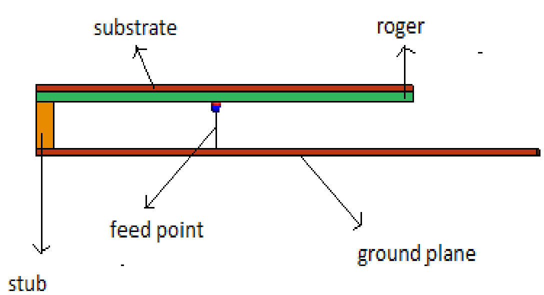
Figure 2:



Dual T shape PIFA antenna

The Dual T PIFA with the total antenna size is 60x50 mm , height 5.813 mm. The radiating square patch is set to be the dimension of 45x35 mm. Here we are using CADFEKO version 5.5 before designing an antenna the unit module set to mm then choose rectangular icon with the measure of 60x50(width x depth)mm thickness 0.5 mm which is ground plane probably it is copper. Place the stub on the ground plane 2x5 mm, height 4 mm which is dielectric material

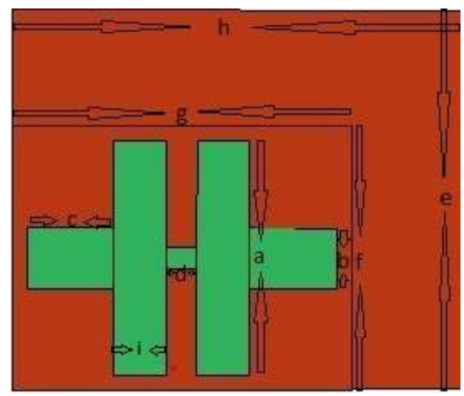
Figure 3:



Dual T shape PIFA antenna-side view

Above the stub roger is placed; the size of the roger is 45x35mm thickness 0.813mm. substrate is placed on the roger , the measure of the substrate is 45 x35mm thickness 0.5mm. From the substrate desired dual T shaped slot is made(measures are given below). Feed is given to power the antenna. Union and Mesh are the two important design consideration while designing an antenna. Finally run the design and the return loss is obtained.

Figure 4:

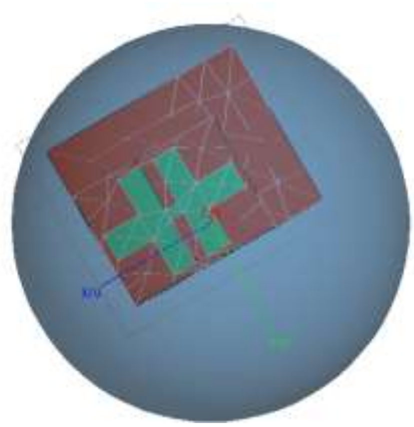


Dual T shape pifa antenna-top view

Table 2. Geometric parameters

Parameter indication	*Size (mm)*
a	31
b	8
c	11.5
d	4
e	50
F	35
G	45
H	60
I	7

Figure 5:



Dual T shape pifa antenna-3D plane

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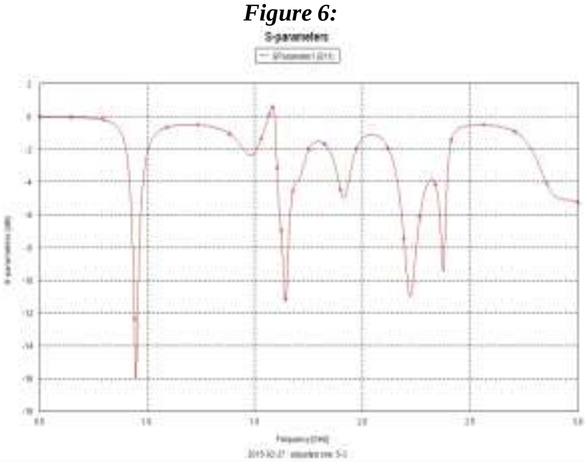
RESULTS AND DISCUSSION

The return loss is the most important parameter which has to be taken into account. Simulation results are shown below for the frequency 0.5 to 3 GHz for the designed antenna.

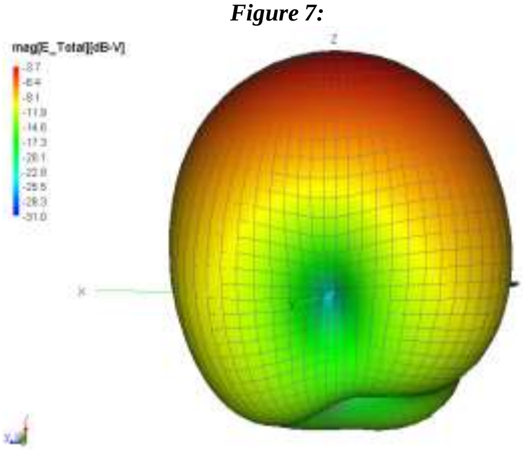
Application for the frequency 2.22GHz WIMAX, 2.37-2.42GHz for WLAN, 0.94GHz for GSM 900and 1.91GHz for RFID and UMTS.

Figure 6:



Return loss

Figure 7:

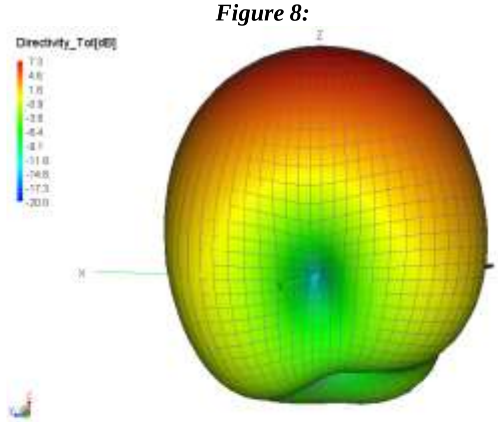


E field

Gain:

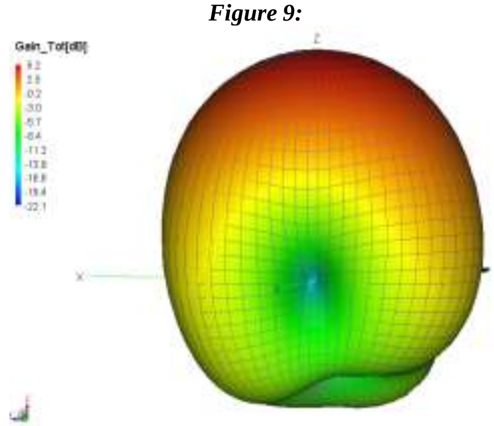
The gain of an antenna will be affected by the area of the ground-plane. The ground-plane of a PIFA is electrically one half of the dipole (known as the image antenna) and thus a larger ground-plane will yield an improved gain.

Figure 8:



Dirctivity

Figure 9:



Gain

Bandwidth:

A reduction of the ground plane area can effectively broaden the bandwidth of the antenna system. An increase in the bandwidth of the PIFA (and thus a reduced quality or Q-factor), can be achieved by inserting several slits at the ground plane edge, however this is not always practical in real life systems.

$$\text{Patch width: } W = \frac{1}{2f(\sqrt{\varepsilon_0\mu_0})}\sqrt{\frac{2}{\varepsilon+1}}$$

(3)

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$$\text{Patch length: } L = \left(\frac{1}{2f(\sqrt{\varepsilon_{eff}}\sqrt{\varepsilon_0 \mu_0})} \right) - 2\Delta L$$

(4)

$$\text{Effective patch length: } Le = L + 2\Delta L$$

(5)

CONCLUSION

A Dual T shaped PIFA antenna has been designed and simulated by FEKO v 5.5 . The designed multi-band antenna, built on PIFA structure, is very sensitive to any changes to the dimensions of the structure including the ground plane. Ground plane of the antenna is used as a radiator resulting in overall size reduction and improvement in the operating bandwidth. Also there is significant improvement in gain and radiation efficiencies at obtained resonant frequencies. The development of wireless technologies and mobile communications has included considerable research on the production of small, easily adaptable, low cost antennas. One such device, the PIFA (Planar Inverted F Antenna), is widely used in mobile, automotive and wireless communications. The advantage of using this type of antenna in wireless communications is its small size, low profile, and avoidance of additional matching networks. Simulation results show that multi band characteristics.The radiation pattern shows an omnidirectional pattern with broadsight direction for all frequencies at 0.5 GHz and 3 GHz.

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