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***Research paper***

# Compact SIW Based Planar Inverted F Antenna

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**Abstract**
This article describes the single band Planar Inverted F Antenna (PIFA) for movable application. This structure of the antenna comprises of a rectangular patch located on top of the Flame Retardant 4 (FR4) dielectric substrate using Substrate Integrated Waveguide (SIW).The bottom side of the substrate is completely covered by a full ground made up of copper material. The complete measurement of PIFA is 21.72 mm x 18.5 mm x 4mm.This antenna has low profile, small size, and good gain hence it is more suitable for mounting on the cellular phone. The performance of PIFA antenna is represented in terms of return loss, VSWR and gain by using the simulation tool Ansys HFSS.

***Keywords***: *PIFA, FR4 Substrate, LTE, patch element, Return loss, VSWR, SIW.*

## 1. Introduction

The planar inverted-F antenna (PIFA) is well-liked because of its compressed size and low profile makes more suitable for moveable wireless equipment [1]. The PIFA is planned to work with a complete ground plane and the main part of antenna assembly is ground which controls the bandwidth of the antenna. In many applications the dimension of the ground is a restrictive factor for the PIFA [2]. A few papers have provided about the working of PIFAs placed on the conducting box of standard size. PIFA mostly used in mobile radio and wireless communications. The PIFA is simple, small in size and provides Omni-directional radiation with good efficiency [3]. Reviews from the previous works established that PIFA has a superior Omni-directional pattern and good impedance matching for several applications [6]. In recent years microwave and millimeter-wave technology become growing and very capable technology for circuits and components using Substrate-integrated waveguide (SIW) [7]. SIW structures are commonly made-up by means of two rows of conducting slots entrenched in a dielectric substrate that connects two parallel metal plates, and allow the realization of conventional waveguide.

The coaxial probe feed system provides 50 Ω connected with SMA connector and suitable for PIFA and insert on to the top radiating patch. To reduce the height of the antenna a tiny circuiting plate used in the PIFA design [4]. The top radiating patch is connected with ground through via.The fabrication of PIFA antenna is simple because it consists of single dielectric substrate, copper layer for ground and patch with via holes, which is a good benefit for crowd fabrication [14].

## 2. Antenna Design

Fig.1 shows the statistical structure of traditional PIFA. The dimension of suggested PIFA structure is shown in Fig.2 with the measurement of ground plane length, Lg = 70 mm. The top view and side view of the suggested PIFA is shown in Fig. 3 (a) and (b). On the top of the substrate rectangular patch is located with height, H. The radiating patch is made of Copper plate with thickness, 0.035mm. FR4 is used as a substrate material with Ɛr=4, height, hs =1.6 mm and dielectric loss tangent, δ = 0.02. The size of the ground plane is Lg x Wg and size of the patch is L1 x L2.

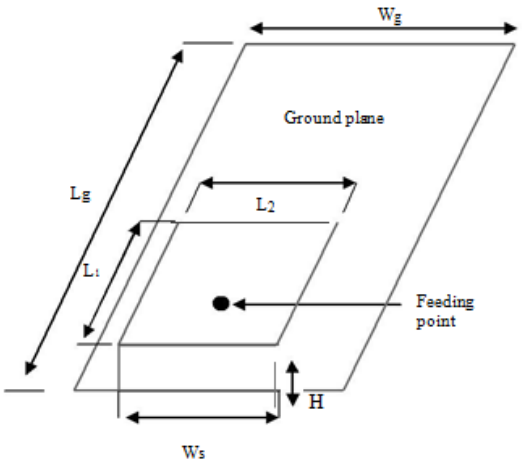



**Fig. 1:** Construction of traditional PIFA

The antenna height is crammed with an air substrate (εr = 1.0). The radiating patch and the ground plane are connected by a vertical conducting strip made from PEC. Here the dimension of ground plane is minimized around 42% compare to the traditional PIFA and it is shown in Fig.2. Generally, the length of a traditional PIFA is about 100 mm to 120 mm and it seems to be a large ground. Because of the larger ground plane it is not convenient to use in the mobile device. Hence, the size of the suggested PIFA antenna is minimized to 70mm to construct as a compressed structure.
To minimize the dimension of the antenna a bending plate is used between the top and bottom plate and it hold the complete antenna. The type of feed is coaxial feed which is matched to 50Ω impedance and connected to the top of radiating patch. The location

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of feed spot and shorting plates is varied to get the most favorable results.

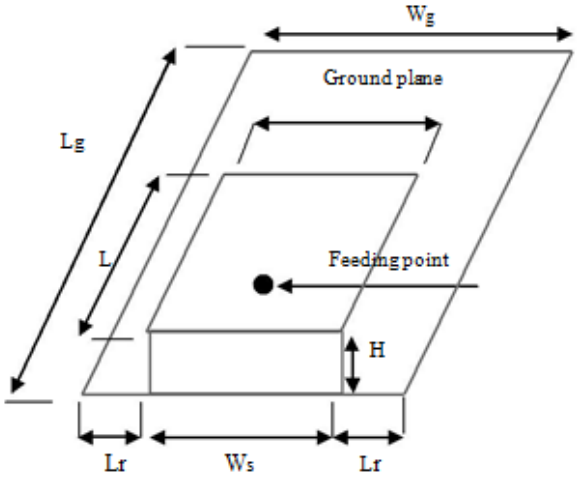



**Fig. 2:** Construction of single band PIFA

**Table 1:** Dimension of PIFA

| Parameters | Values (mm) |
|---|---|
| L1 | 21.72 |
| L2 | 18.5 |
| $L_g$ | 70 |
| $W_g$ | 30 |
| W | 18.5 |
| H | 4 |
| $L_r$ | 5.75 |

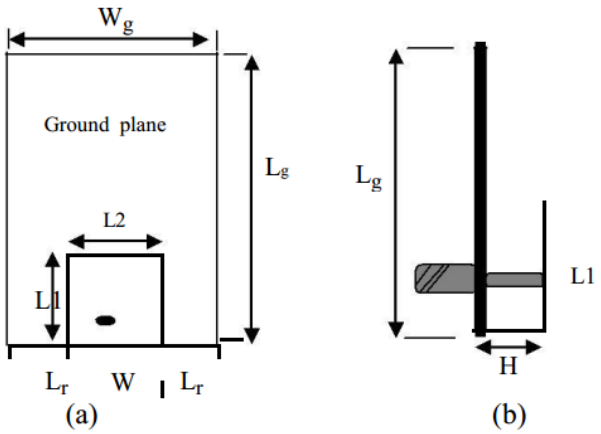



**Fig. 3:** Single band PIFA (a).Top view (b).Side view

## 3. Results and Discussions

This section explains the simulated outcome of a single band PIFA operating at the frequency of 2 GHz. The suggested PIFA provides the bandwidth around 120MHz. This antenna provides a reasonable return loss $S_{11}$ i.e. near to -10db at the required LTE therefore it is suitable for mobile phone application. The proposed PIFA antenna is simulated using Ansys HFSS tool and all the PIFA parameters are shown in Table I. The PEC (Perfect Electric Conductor) is used as a radiating patch, shorting plate and ground.

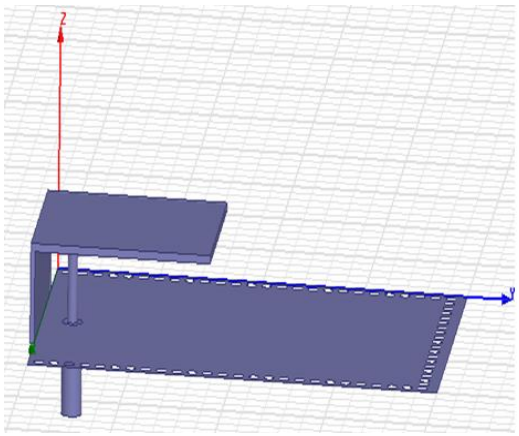



**Fig. 4:** PIFA antenna layout in Ansys HFSS

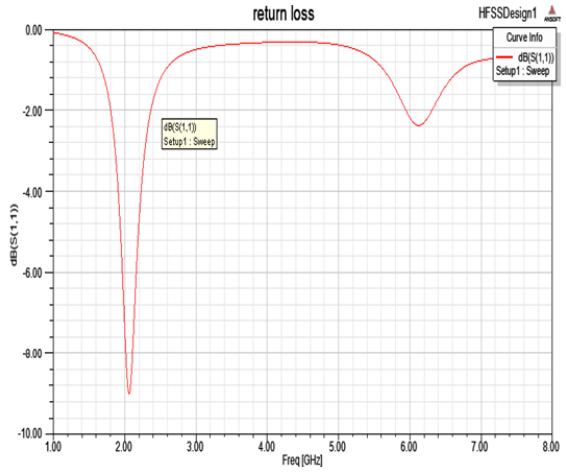



**Fig. 5:** Return loss at resonance frequency 2 GHz

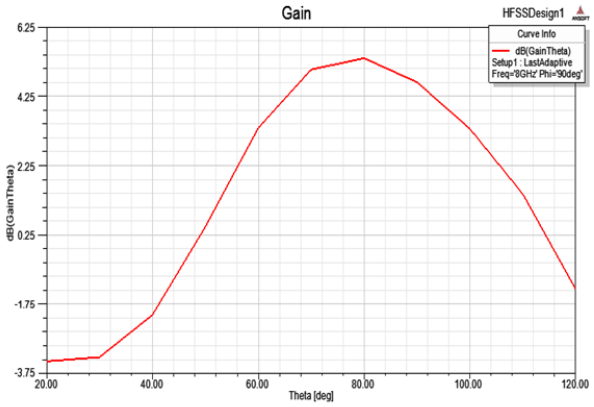



**Fig. 6:** Gain at resonance frequency 2 GHz

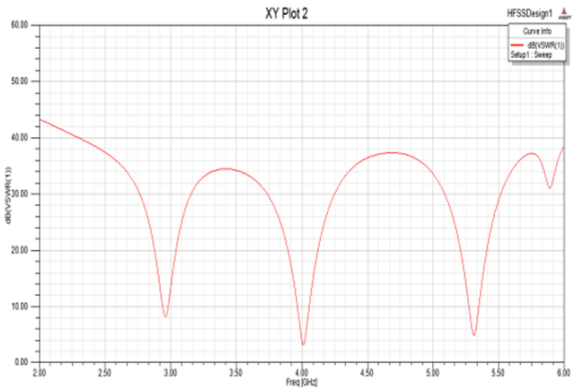



**Fig.7:** VSWR of the PIFA

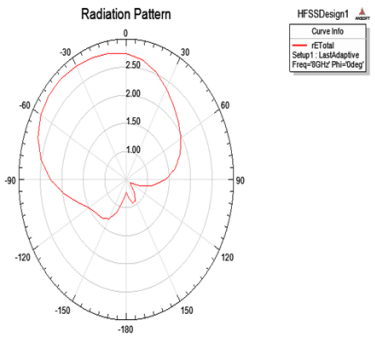



**Fig. 8:** Radiation pattern of the PIFA

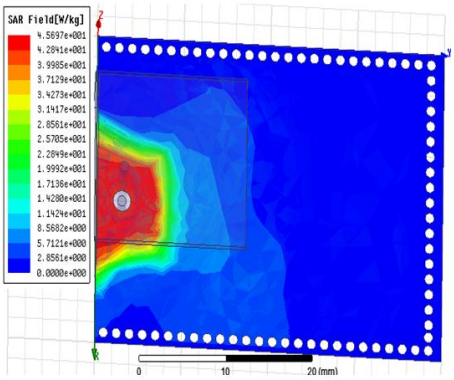



**Fig.9:** Specific absorption rate (SAR)

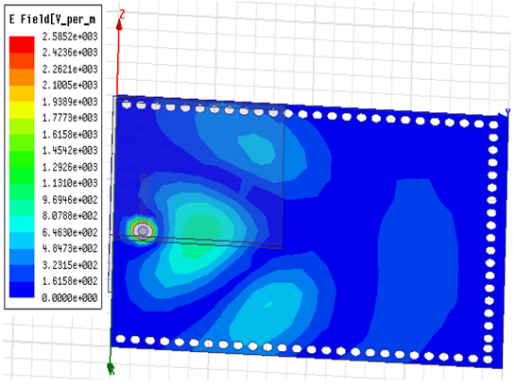



**Fig. 10:** E- field Distribution at 2 GHz

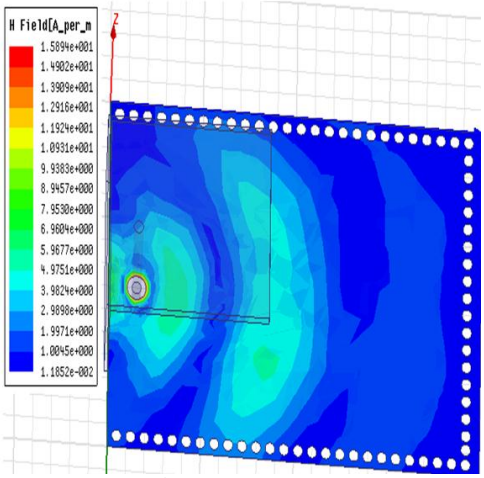



**Fig. 11:** H- field Distribution at 2GHz

A dielectric material is filled in the gap between the top radiating patch and bottom patch. Because of dielectric material between the top and bottom patch there is effect on gain and bandwidth [12]. The height of shorting plate from the ground plane is chosen as 4mm to improve the bandwidth, based on PIFA theory the parameter height related to the bandwidth. The impedance bandwidth will be better for larger value of height, H, [13]. Fig. 5,6,7,8 shows the return loss, gain, VSWR, radiation pattern of the suggested single band PIFA at frequency 2GHz. Fig. 9,10,11 shows the SAR( specific absorption rate) value, E-field distribution and H-field distribution for the suggested PIFA antenna.

## 4. Conclusion

A novel single band PIFA with SIW was accessible and proposed for LTE cellular phone application at 2 GHz. The bandwidth of PIFA can be improved by many methods. The efficient method is by increasing the height, H of the air gap. This antenna provides impedance bandwidth of 120MHz and gain around 5.9db for the height, H=4mm. In the future, by introducing a parasitic element close to the main radiating element this single band PIFA structure will transform to produce the multi band frequencies.

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