Development of Dual Band Planar Inverted-F Antenna for Wireless Applications

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ABSTRACT
A dual-band Planar inverted-F antenna (PIFA) for wireless applications has been presented in this paper. The proposed antenna is compact in size and design on FR4 substrate.The antenna consists of a slotted radiator supported by shorting walls and a small ground plane.Square shaped slot in radiating patch have been used to introduce dual band operation into the proposed antenna. The structure is designed and optimized to operate at 2.02GHz and 6.1GHz with achievable bandwidths 15.53% and 14.23% a respectively. These two bands cover the existing wireless communication frequency bands from 1.9-6.5GHz. Good return loss, antenna gain and radiation pattern characteristics are obtained in the frequency band of interest. Structural dimensions of the proposed antenna are optimized by using HFSS EM solver. Details of the dual-band PIFA characteristics are presented and studied.

Keywords
Planar Inverted-F Antenna (PIFA), Return Loss, Gain, Bandwidth.

1. INTRODUCTION
In the past decades, cellular communications become a ubiquitous part of modern life. The desire of people to be able to communicate effectively while being mobile has become an incentive for mobile communications integration in terrestrial and satellite wireless systems [1]. The mobile communication industry has already developed enormously bringing fast and reliable infrastructure. Wireless communication systems are still in the centre of extensive academic and technological research and development, with constant demand of more compact, faster and more reliable devices and services[2].

In recent years, the demand of compact, smaller than palm size communication devices has increased significantly. Communication system demands for antennas to exhibits some standard properties such as reduced size, moderate gain broadband and multiband operation [3, 4]. With the increasing interest in covering various frequency bands, attention was drawn toward the study of multiband antennas. For multiband antennas, achieving maximum possible frequency bands with suitable return loss and radiation pattern are desirable [5].

Planar Inverted-F Antennas are widely used in a variety of communication systems especially in mobile phone handsets [6]. Also PIFAs have features such as small size, light weight, low-profile, simple fabrication and relatively low specific absorption rate (SAR). Due to low absorption of energy in the human body, this antenna provides good efficiency. In recent years there have been a number of PIFA designs with different configuration to achieve single and multiple operations by using different shapes of slots. Planar inverted-F antennas (PIFA) can cover two or more standard frequency bands and due to their thin planar structures [7]. Truncated corner technique, meandered strips and meandered shapes have been used to create multiple band operations. Several techniques have been used to improve the bandwidth of PIFA antennas [8-10].

The introduction of various resonant elements in order to create a multiband PIFA antenna is a common approach. Another method for the addition of parasitic patchs with resonant lengths close to the frequency band where the improvement in the bandwidth is required [11] The inclusion of slots in the ground plane and in the radiating structure has also been used to enhance the bandwidth. These antennas are generally designed to cover one or more than one frequency bands such as Global System for Mobile Communication (GSM 900 and 800), Global Positioning System (GPS 1400 and 1575), Personal Communication System (PCS 1800 and 1900), Digital Communication System (DCS 1800), Universal Mobile Telecommunication System (UMTS 2000), 3G IMT, 4G LTE (700, 1700, 2600), WLAN and WiMAX etc [12-13].

In this work compact PIFA is proposed and presented for various wireless applications. The effects of different shorting wall width are studied. The proposed antenna satisfies the return loss, VSWR and bandwidth for applications within frequency range from 1.9-6.5 GHz. The measured reflection coefficient, radiation pattern, VSWR and Gain are characterized.

2. DESIGN AND STRUCTURE
Figure 1 shows the geometry of proposed antenna with detailed dimensions given in Fig 1. The antenna designed on FR4 substrate with a dielectric constant $\varepsilon r=4.4$ and a loss tangent of 0.02 and thickness of the substrate h=1.57mm have been used to design planar inverted-F antenna. Air is used as dielectric between FR4 substrate and top radiating patch The dimensional parameters of the proposed antenna are detailed in Table 1. The square shaped slot of suitable dimensions are cut in the antenna element to get the required bandwidth. Radiating element slot has been used for producing miniaturization, dual and wide band operation. The proposed antenna has a very small size and is physically thin.

The antenna element is fed by a coaxial probe at the suitable location to get better impedance matching.The thickness of copper used in prototype is 0.16mm.The radiating element of PIFA is grounded with a shorting strip.The optimization and simulations of the antenna is carried out using High Frequency Structure Simulator (HFSS).HFSS employs the Finite Element Method (FEM),adaptive meshing, and brilliant graphics to give you unparalleled performance and insight to 3D EM problems.HFSS can be used to calculate parameters such as S-Parameters, Resonant Frequency and Fields [3]. The 3D model of proposed antenna generated in the HFSS is shown in Figure 2.The antenna impedance matching is achieved by controlling the distance between the feed-line and shorting strip. Optimized dimensions of the antenna are given in the Table 1.

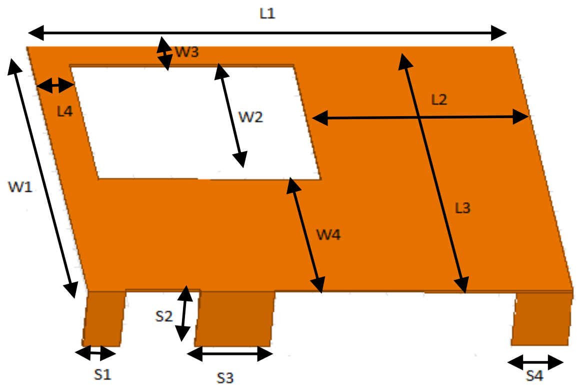

Fig. 1 : Radiating Element of Proposed antenna

Table 1. Dimensions of Proposed Antenna

Sr.No.	Parameter	Dimensions(mm)
1	Length of Patch, L1	26
2	Width of Patch, W1	25.6
3	Width of First Supporting Wall, S1	2
4	Height of Supporting Wall, S2	3.57
5	Width of Second Supporting Wall, S3	3
6	Width of Shotining Strip, S4	2
7	Distance b/w Right Corner and slot, L2	12
8	Distance b/w Left corner and slot, L4	2
9	Width of Radiating Element, L3	20
10	Distance b/w top corner and slot, W3	2
11	Distance b/w lower corner and slot, W4	11.6

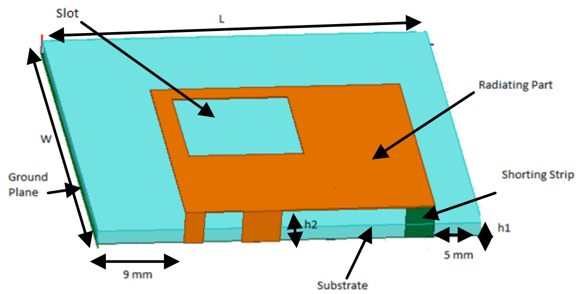

Fig. 2 : 3-D Model of proposed PIFA Generated in HFSS

3. RESULTS AND DISCUSSION

3.1 Return Loss

The simulated return loss (S11) characterstics of the proposed antenna is shown in Fig.3. From the graph it can be seen that resonant frequencies achieved are 2.06GHz and 6.11GHz with return loss of -24.05dB and -44.45dB. Therefore, the proposed antenna covers the corresponding bandwidths defined by S11 < -6 dB for the two bands are 15.53% (1.917-2.233GHz) for 2.06 and 14.23% (5.6-6.53GHz) for 6.1GHz. These bandwidths satisfy the requirements for various wireless applications.

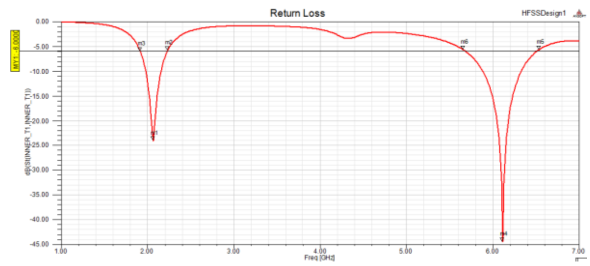

Fig. 3 : Return Loss Graph of Proposed PIFA

3.2 VSWR

Voltage Standing Wave Ratio (VSWR) is a ratio of peak voltage on the minimum amplitude of voltage of standing wave . The VSWR is always a real and positive number for antennas [7]. The smaller the VSWR is, the better the antenna is matched to the transmission line and the more power is delivered to the antenna. It is illustrated in Fig. 4 that at 2.06GHz VSWR is 0.9dB at 6.1GHz VSWR is 0.8dB Also it is observed from the results that at these resonant frequencies the Voltage Standing Wave Ratio is below 2dB which is desirable for most of the wireless applications.

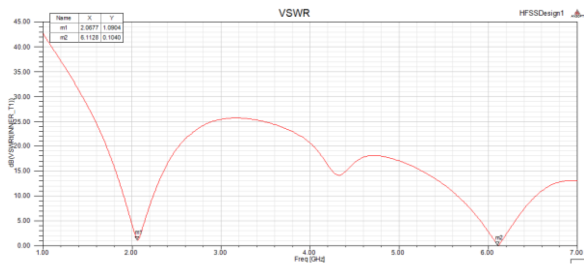

Fig. 4 : VSWR plot of the proposed antenna

3.3 Radiation Pattern

It can be seen from the plot of Fig.5, that the antenna is a good radiator with almost omnidirectional radiation which supports multiple standards.

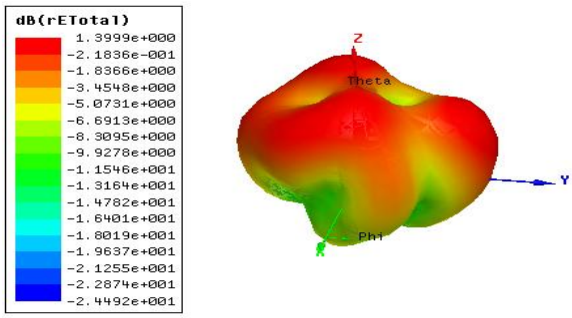

Fig. 5 : Radiation Pattern of proposed PIFA

3.4 Gain

The gain and efficiency are the two important parameters of the antenna. The overall gain of the antenna obtained after simulating the PIFA structure is shown in Fig. 6. A peak gain of 3.70 dB has been achieved.This value of gain achieved by the proposed structure is moderate value and considered to be good for the overall performance of the antenna.

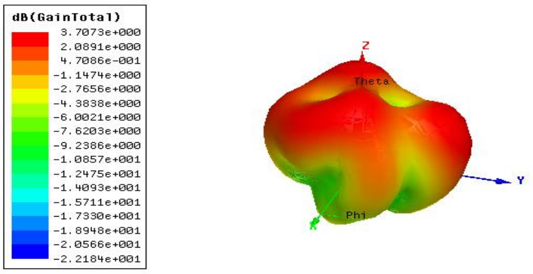

Fig. 6 : 3-D Polar plot showing Gain

4. CONCLUSION AND FUTURE SCOPE

In this paper a dual band Planar Inverted-F Antenna, has been presented which covers the frequencies between 1.9-6.5GHz. The proposed antenna has a simple configuration and is simply printed on FR4 substrate. It has been found that making slots in the radiating patch and slits in the ground plane provides a simple multiband PIFA with enhanced bandwidth. The proposed antenna can covers UMTS, DCS, PCS, GPS, 3G, 4G, and an additional frequency bands, and provides good return loss, VSWR and radiation patterns.

In future, different type of feed techniques can be used to analyze the overall performance of the antenna. Extensively and exclusively focusing on the area of different design methods especially in enhancing the impedance bandwidth and the efficiency can be considered thoroughly.

5. REFERENCES

[1] X.Zhang and A.Zhao, "Enhanced Bandwidth PIFA Antenna with a Slot on Ground Plane", Progress In Electromagnetics Research Symposium, China, March 23-27, 2009.

[2] N.Ojaroudi, H.Ojaroudi and N.Ghadimi, "Quad-Band Planar Inverted-F antenna for Communication Systems" Progress In Electromagnetic Research Letters, Vol.-45, 51-56, 2014

[3] H.F .Abu Tarboush, R. Nilavalan and T. Peter, "Multiband Inverted-F Antenna With Independent Bands for Small and Slim Cellular Mobile Handsets" IEEE Transactions On Antenna and Propagation, Vol.- 59, NO. -7, 2011

[4] S. Kakkar and S. Rani, "A novel Antenna Design with Fractal-Shaped DGS Using PSO for Emergency Management", International Journal of Electronics Letters, vol. 1, no. 3, pp. 108-117, 2013.

[5] Y.Shin Wang, M.C. Lee, and S.J Chung, "Two PIFA-Related Miniaturized Dual-Band Antennas" IEEE Transactions on Antenna and Propagation, Vol.- 55, NO. 3, 2007

[6] N.Kumar and G.Saini, "A Multiband PIFA with Slotted Ground Plane for Personal Communication Handheld Devices" International Journal of Scientific and Research Publications, ISSN 2250-3153

[7] S. Kakkar, S. Rani and A. P. Singh, On the Resonant Behaviour Analysis of Small-Size Slot Antenna with Different Substrates, International Journal of Computer Applications, pp. no. 10-12, 2012

[8] Z.Li and Y.R.Samii, "Optimization of PIFA-IFA Combination in Handset Antenna Designs" IEEE Truncations On Antenna and Propagation, Vol.- 53, NO. -5, 2005

[9] S. Rani and A. P. Singh, "On the Design and Optimization of New Fractal Antenna Using PSO", International Journal of Electronics, vol. 100, no. 10, pp. 1383-1397, 2012.

[10] A.Cabedo and J.Anguera, "Multiband Handset Antenna Combining a PIFA, Slots, and Ground Plane Modes" IEEE Transactions on Antenna and Propagation, Vol.- 57, NO.-7, 2009

[11] [11] N.Kumar and G.Saini, "A Multiband PIFA with Slotted Ground Plane for Personal Communication Handheld Devices" International Journal of Scientific and Research Publications, ISSN 2250-3153

[12] N.Khan, 2014, "Design of Planer Inverted-F Antenna" International Journal of Advanced Technology in Engineering and Science, Vol.-02, Issue No. 05.

[13] R.R. Raut Dessai and H. G. Virani, 2013 "Triple Band Planar Inverted F-Antenna For LTE, Wi Fi And WiMax Applications" International Journal of Engineering Research & Technology Vol. -2, Issue 3.