Compact Wideband Planar Inverted F-Antenna (PIFA) for Mobile Communication

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ABSTRACT

In this paper a low profile and wideband Planar Inverted-F Antenna (PIFA) for mobile communication is presented. The antenna shows a wide range of frequency from 1.54 GHz to 2.47 GHz and with improved impedance matching covering GPS, DCS, PCS, 3G, 4G and WLAN/Bluetooth bands with VSWR less than 2. The size of top patch of the proposed antenna is 25 x 15 x 0.035 mm^3, height of the path from the ground plan is 4mm which makes it compact and a coming candidate for wireless communication devices. The antenna is designed and simulated using ANSYS v17 High Frequency Structure Simulator (HFSS) Software and shows improve gain with Omni-directional radiation pattern.

Keyword: - *PIFA Antenna, SAR, GSM1800, GSM1900, UMTS, LTE2300, WLAN, Bluetooth.*

1. INTRODUCTION

In the past few years, there has been away some growth in the fields of wireless technology. In order to contain latest mobile services, internet access, video streaming etc, operators require additional bandwidth and dealer are forced to design multi-tasking terminals. In order to meet these requirements, the antenna designers are required to design a low profile antenna such that they can provide the multi standard performance in terms of wideband/multiband frequency range [5].

Therefore Planar Inverted F Antenna (PIFA) comes out as a promising candidate in this field. Planar Inverted F Antenna is a low profile antenna with mechanically robust structure and shows wideband/multiband properties. The Specific Absorption Rate (SAR) in PIFA is very low as compared to other conventional antennas and hence less electromagnetic radiations are illuminated towards user's body and thus increasing antenna's output. Moreover Planar Inverted F Antennas (PIFA) provides good radiation pattern and low to moderate gain. Apart from different advantages, Major limitation of Planar Inverted F-Antenna is narrow bandwidth. In order to achieve a wide bandwidth different techniques such as large ground plane, thick substrate, slots on ground and on patch etc are given in reference paper[4][5]. PIFA is kept exactly above the battery in the housing of back cover of wireless communication devices like cell phone. Therefore the height of the antenna should not be greater than 6 mm in order to make slim handsets [1] [2][5].

In multiple feed Planar Inverted F Antenna (PIFA), various design complexities are included in designing an antenna with multiple frequencies and wide bandwidth whereas a single feed antenna is comparatively easier to design for multiple frequencies and wide bandwidth since each radiating element is contained with its own feed. However multiple feed antennas is not preferred for practical applications due to increase of mutual coupling between separate radiating elements of PIFA. The internal antenna has been using instead of the external antenna the main reason of that is the internal antenna has a good relation with SAR rate, on the other hand the size of wireless communication devices became smaller like cell phone. Recently there are many types of the internal antennas for example planar inverted F-Antenna (PIFA), fractal antenna and monopole antenna. Those kinds of antennas can cover a single band, dual band, wideband and multiband depend on the design of the antenna.

In this paper proposed antenna is compact, low profile and single feed wideband Planar Inverted F Antenna (PIFA) is presented. The antenna provides a wide bandwidth coverage over multiple frequency bands such as GPS (1575 MHz), DCS (1800MHz), PCS (1900MHz), 3G (2100 MHz), 4G (2300 MHz) and WLAN/ Bluetooth (2400-2484 MHz). The proposed antenna design has compact structure, involving a volume of 58x40x4 mm3. In this design, two slots are cut on the ground plane and by adjusting the position of the slots satisfactory results can be obtained. These slots helped us to get wideband planar inverted F-antenna. In this planar inverted F-antenna shorting plate is placed between radiating patch and ground plane. This antenna is designed and simulated using ANSYS v17 High Frequency Structure Simulator (HFSS) software. This proposed wideband planar inverted F-antenna with bandwidth more than 30% and this bandwidth cover an important range which could cover GPS, GSM, UMTS, LTE, WLAN and Bluetooth frequency bands of wireless communication devises like cell phone.

Section II describes the design of proposed planar inverted F-Antenna (PIFA). Different parameters such as return loss, radiation pattern, gain and VSWR are characterized in section III. The comparison of proposed antenna and PIFA [5] is given in section IV. The conclusion of this work is given in section V.

2. ANTENNA DESIGN

Configuration of the proposed antenna is shown in Figure 1, 2 and 3. The geometry consists of a Planar Inverted F Antenna (PIFA) with two slots cut on ground plane. Detailed Dimension of proposed antenna is given in table 1. The dimensions of radiating patch of the proposed antenna are 15x25x0.035mm3. The antenna is positioned on FR4 substrate with dimensions 58x40x1.6 mm^3. The dimensions of the ground plane and the substrate are compact such that they can be easily positioned in the housing of wireless devices such as mobile phones. A shorting plate with dimensions 3.4x4x0.07mm3 is used to short the ground plane and radiating patch of planar inverted F-antenna. The antenna is electrified using co-axial feed which is placed near the shorting plate and at edge of the antenna. The resonant frequency of planar inverted F-Antenna (PIFA) can be calculated using following expressions:

$$L1 + L2 - W = \lambda/4 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where,
L1 & L2 are width and length of top radiating patch of planar inverted F-Antenna (PIFA),
W is width of shorting plate.
The ground plane, shorting plate and radiating patch provides two resonant frequencies while the position of slots is used to provide a wideband impedance bandwidth performance of 1.54GHz to 2.47GHz and another band 5.09GHz to 5.32GHz. The performance of the antenna is well-knew in terms of return loss, VSWR, gain and radiation pattern.

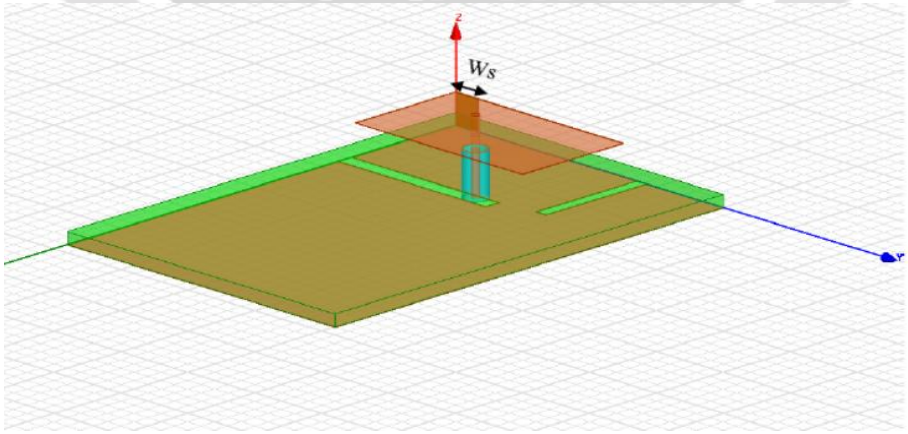

Fig -1: 3D view of proposed antenna

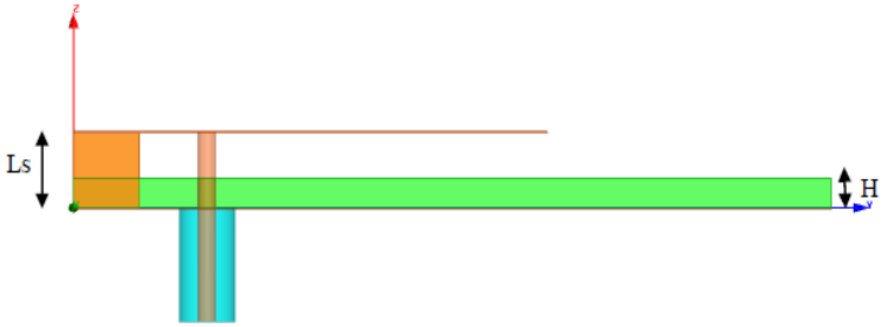

Fig -2: side view of proposed antenna

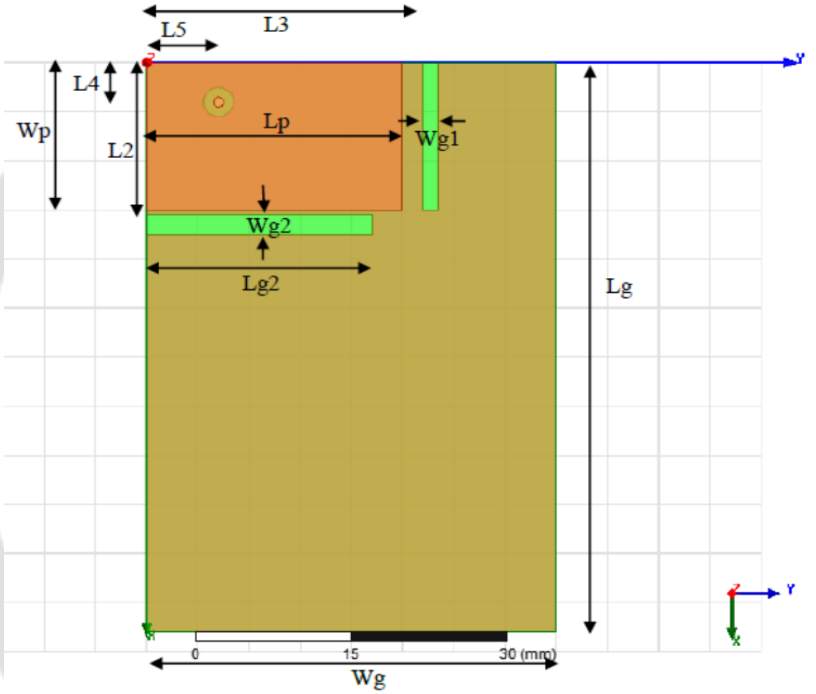

Fig -3: top view of proposed antenna

Table -1: Detailed Dimensions of Proposed PIFA

Parameter	Value(mm)	Parameter	Value(mm)
Lg	58	Wg1	1.5
Wg	40	Lg2	22
Lp	25	Wg2	2
Wp	15	L1	0
Ls	4	L2	15.5
Ws	3.4	L3	27
H	1.6	L4	4
Lg1	15	L5	7

3. RESULT

The performance of the planar inverted F-Antenna is well-knew in different parameters of antenna like return loss, Voltage Standing Wave Ratio (VSWR), gain and radiation pattern.

3.1 Return Loss

The simulated return loss plot of the proposed planar inverted F-Antenna (PIFA) is shown in figure 4. From the plot it can be illustrated that the antenna resonates at 1.61 GHz, 2.35 GHz and 5.34 GHz with return loss -22.15, -32.85 and -44.10 respectively covering GPS L1 (1575 MHz) DCS-1800 (1710.2- 1784.8 MHz), PCS-1900 (1850.2-1909.8 MHz), 3G (1885-2100 MHz), 4G (2110-2400 MHz) and WLAN/ Bluetooth (2.40-2.484 GHz) frequency bands. The proposed PIFA shows a wide frequency range from 1.46 GHz to 2.5 GHz showing impedance bandwidth of 1.0 GHz

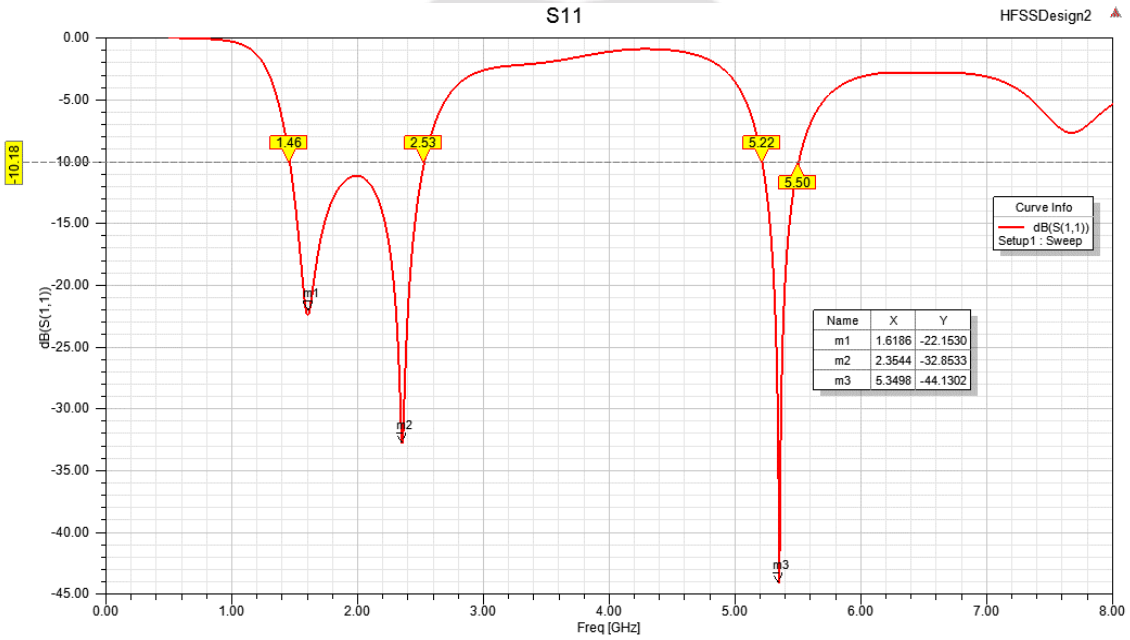

Fig -4: Return Loss of proposed PIFA

3.2 Voltage Standing Wave Ratio (VSWR)

The Voltage Standing Wave Ratio (VSWR) obtained from proposed Planar Inverted F Antenna (PIFA) is less than 1 which shows that there is perfect matching between antenna and co-axial feed line. The acceptable value of VSWR is less than 2. The VSWR is 1.30 and 0.41 at 1.60 GHz and 2.35 GHz respectively.

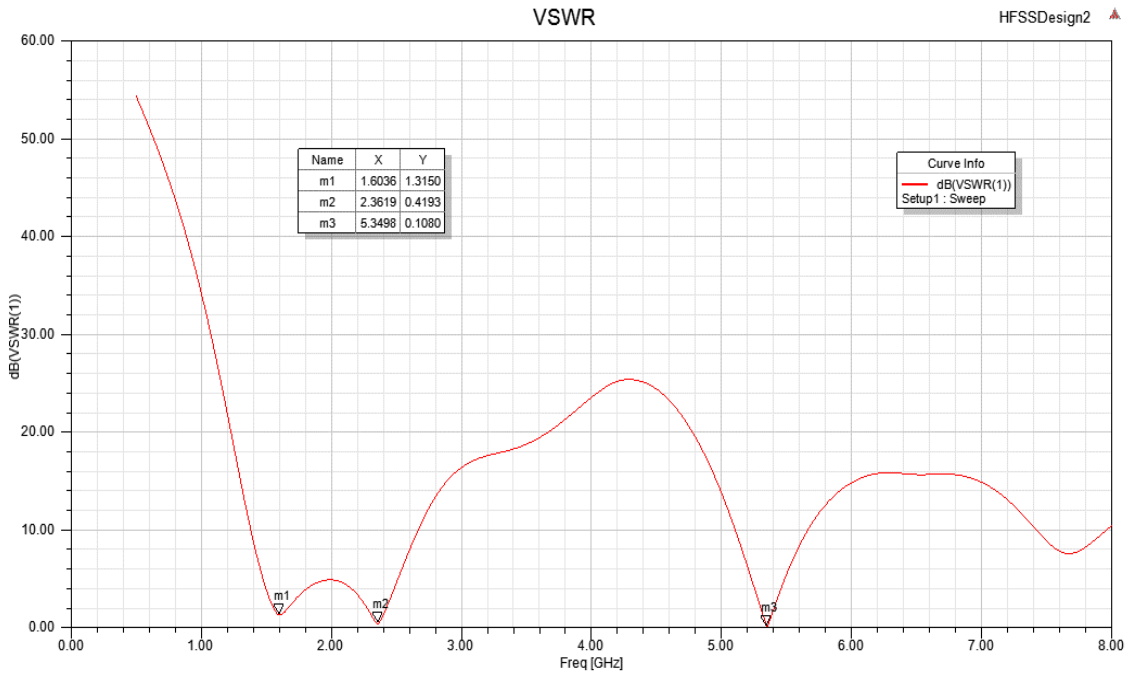

Fig -5: VSWR of proposed PIFA

3.3 Gain

The average peak gain achieved by the proposed planar inverted F-antenna is 3.13 dB which is considered best in case PIFA. Figure 6 shows simulated 3D gain plot of the proposed PIFA

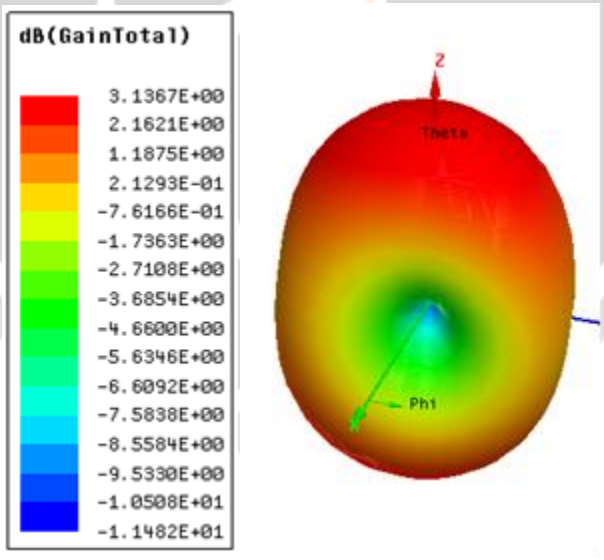

Fig -6: Simulated 3D total gain of proposed antenna

3.3 Radiation Pattern

The radiation pattern of proposed wide band planar inverted F-antenna is shown in figure 7. As seen from the figure, the radiation pattern of proposed antenna is Omni-directional and hence is suitable for internal antennas for wireless communication devices like cell phone.

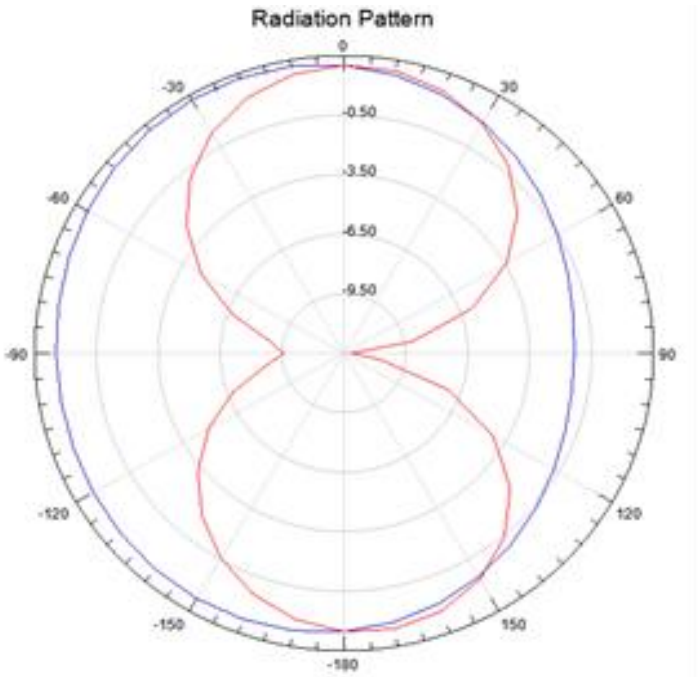

Fig 7: Simulated Radiation Pattern of proposed Antenna

3.4 RESULTS COMPARISON

Table 2 Comparison between proposed PIFA and conventional PIFA [5]

	Gain (dB)	**Size of ground plan(mm^2)**	**Frequency band covered**
PIFA [5]	2.71	66.69x40	GPS L1 (1575 MHz), DCS-1800 (1710.2- 1784.8 MHz), PCS-1900 MHz (1850.2-1909.8 MHz), 3G (2100 MHz), 4G(2300 MHz), WLAN/Bluetooth (2.40-2.48 GHz)
Proposed PIFA	3.13	58x40	GPS (1575 MHz), DCS (1800MHz), PCS (1900MHz), 3G (2100 MHz), 4G (2300 MHz) and WLAN/ Bluetooth (2400-2484 MHz), (5220-5500MHz)

4. CONCLUSIONS

In this paper, a compact, low profile and single feed wideband Planar Inverted F Antenna (PIFA) is presented. The antenna provides a wide bandwidth coverage over multiple frequency bands such as GPS (1575 MHz), DCS (1800MHz), PCS (1900MHz), 3G (2100 MHz), 4G (2300 MHz) and WLAN/ Bluetooth (2400-2484 MHz). In this design, two slots are cut on the ground plane and by adjusting the position of that is give us better result satisfactory of band as well as resonance frequency. These slots helped us to get wideband coverage of planar inverted F-antenna. This planar inverted F-antenna shows Omni-directional radiation pattern and a maximum gain of 3.13 dB that is shown in figure 6. That is higher than conventional antenna as well as reduce the size of the ground plane of the proposed PIFA.

5. REFERENCES

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