Low Profile Planar Inverted-F Antenna for Mobile Devices Covering LTE/WLAN Applications

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Abstract— A Planar Inverted-F Antenna for LTE2300 (2.3-2.4 GHz), WLAN (2.4-2.484 GHz), and LTE2500 (2.5-2.69 GHz) bands has been presented in this paper. The proposed structure has a dimension of 18 x 13 mm^2 over the ground plane of size 100 x 50 mm^2 which can easily be implanted in the small space available within the mobile device. The proposed structure is having an impedance bandwidth ranging from 2.16 GHz to 2.726 GHz covering all the desired frequency bands. The antenna has a resonating frequency at 2.395 GHz. For getting the impedance bandwidth we are taking -8 dB as the reference return loss. The input impedance plot of the proposed antenna along with the radiation pattern of the antenna at 2.4 GHz and 2.55 GHz are presented. The peak realized gain of the proposed antenna varies from 4.17 dB to 4.84 dB in the desired operating band.

Keywords: broad frequency bands, impedance bandwidth, low-profile geometry, Planar Inverted-F Antenna, LTE/WLAN,

I. INTRODUCTION

The rapid decrease in size of personal communication devices has lead to the need for more compact antennas. At the same time, expansion of wireless systems has increased the applications for multi-functional antennas that operate over broad frequency bands or multiple independent bands. In the past few years, new designs based on planar inverted-F antennas (PIFA) have been used for handheld wireless devices because of its low-profile geometry. The PIFA can be considered a direct extension of the inverted-F antenna that has the horizontal wire radiating element replaced by a plate to increase its usable bandwidth. PIFA designs invoke the quarter-wavelength operation. Additionally, the PIFA offers very high radiation efficiency and sufficient bandwidth in a compact antenna.

Technique like use of reduced ground plane can to be employed to further increase the bandwidth [1], [2]. Multi-frequency capability with the antenna structure can be achieved by exciting various resonant modes using branched structure, created by cutting slots in the radiating element [3]-[6]. Several PIFA structures have been developed in the past to cover various communication frequency bands [7]-[15].

In this paper a Planar Inverted-F Antenna for LTE2300, WLAN, and LTE2500 has been presented. The proposed structure is having an impedance bandwidth ranging from 2.16 GHz to 2.726 GHz covering all the desired frequency bands. The antenna has a resonating frequency at 2.395 GHz frequency. Section 2 of the paper gives the details of the proposed structure. Results and discussion are included in section 3 of this paper.

II. ANTENNA DESIGN

The antenna structure is designed with Ansoft's HFSS [16]. The antenna is designed at the top right corner of FR4 substrate of size Ws x Ls mm^2. The antenna element is at a height of 4 mm above the substrate. At the bottom side of the substrate, ground plane is placed. The antenna element is connected to the ground plane by a shorting strip of width Wsh. The shorting strip is placed along the width of the substrate. In order to get the resonance at the desired frequency, slot loading is done in the antenna patch. The antenna is fed by a coaxial cable at a place where impedance matching is proper. The top view and side view of the proposed antenna structure is given in Fig. 1 and Fig. 2 respectively. Fig. 3 shows the detailed dimensions of the antenna patch. The optimized parameters of the proposed structure are given in Table 1.

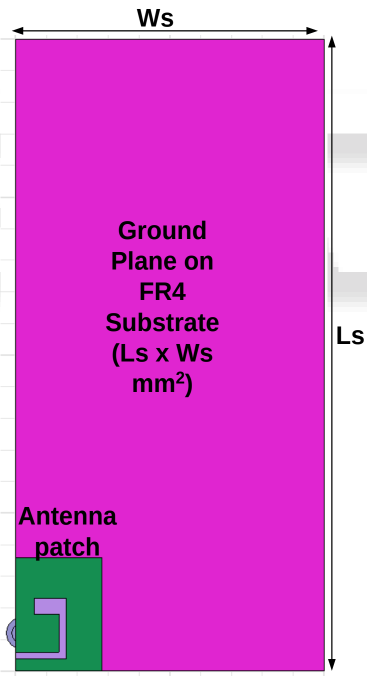

Fig. 1: Top view of the proposed antenna structure.

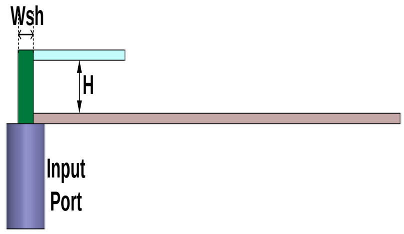

Fig. 2: Side view of the proposed antenna structure.

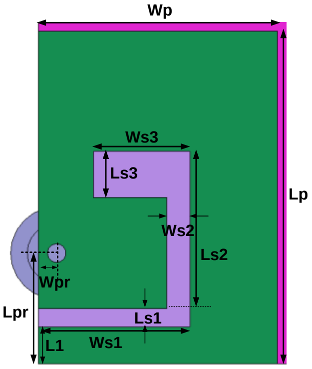

Fig. 3: Detailed dimensions of antenna patch.

Table. 1: Optimized antenna dimensions

Parameter	Size (mm)	Parameter	Size (mm)
Ws	50	Ws1	8.25
Ls	100	Ls1	1
H	4	Ws2	1.25
Wsh	2	Ls2	8.5
Wp	13	Ws3	5.25
Lp	18	Ls3	2.5
Wpr	1	L1	2
Lpr	6		

III. RESULTS AND DISCUSSION

The simulations are performed in Ansoft's HFSS [16] (considering SMA connector) to optimize the shape parameters of the antenna for the desired operating bands.

A. Return Loss

The return loss characteristics of the proposed antenna are shown in Fig. 4. The impedance bandwidth of the proposed design is from 2.16 GHz to 2.726 GHz covering LTE2300 (2300 -2400 MHz), WLAN (2.4- 2.484 GHz) and LTE2500 (2500 -2690 MHz) bands. At 2.395 GHz frequency, resonance is better. This is because of proper impedance matching at this frequency. For getting the impedance bandwidth we are taking -8 dB as the reference return loss, which is acceptable for mobile phone applications.

B. Input Impedance (Z_{in})

The input impedance of the proposed structure for the operating frequency range is shown in Fig. 5. It can be seen that the resistive part (real) of the impedance is varying near 50 Ω and the reactive part (imaginary) is varying near 0 Ω. This behaviour is desirable to get proper impedance matching at the port.

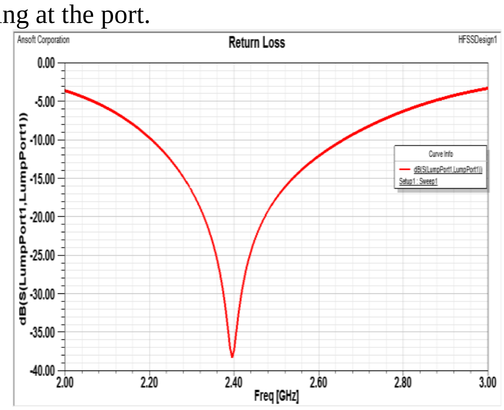

Fig. 4: Return loss characteristics of the proposed antenna.

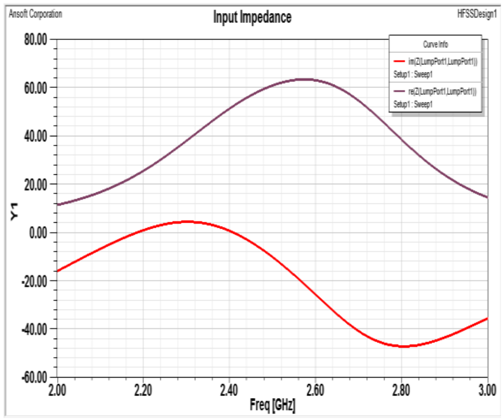

Fig. 5: Input impedance of the proposed antenna.

C. RADIATION PATTERN

The radiation patterns of the proposed antenna are plotted in XZ-plane (phi = 0^0) and in YZ-plane (phi = 90^0) at 2.4 GHz and 2.55 GHz, and are shown in Fig. 6 and Fig. 7 respectively. At 2.4 GHz, main beam is located at theta = 35^0 with a null at theta = -120^0 and there is a presence of back lobe in the YZ-plane. Almost similar radiation pattern is obtained at 2.55 GHz.

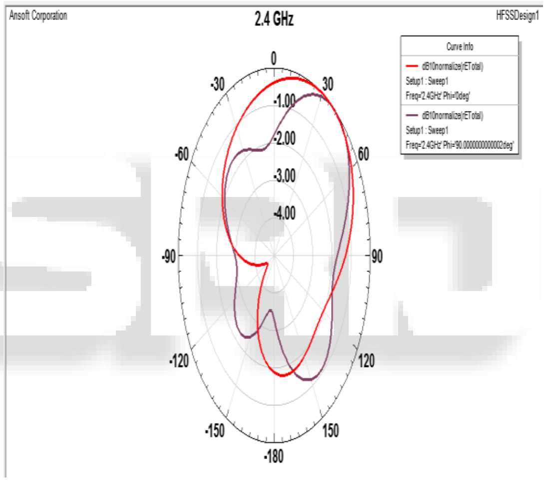

Fig. 6: Radiation pattern of the proposed antenna at 2.4 GHz.

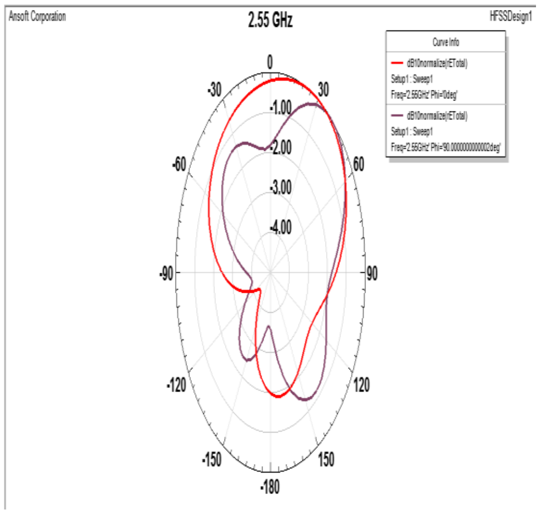

Fig. 7**:** Radiation pattern of the proposed antenna at 2.55 GHz.

D. PEAK REALIZED GAIN

The Peak Realized Gain of the proposed antenna is plotted against frequency and is shown in Fig. 8. The value of Peak Realized Gain varies from 4.17 dB to 4.84 dB in the desired operating band.

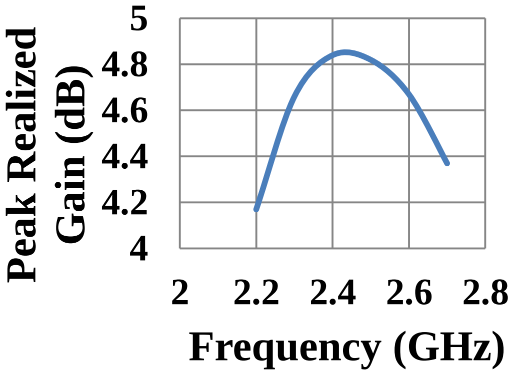

Fig. 8: Plot of Peak Realized Gain.

IV. CONCLUSION

A Planar Inverted-F Antenna for LTE2300/WLAN/LTE2500 applications has been designed and presented in this paper. The proposed structure has a dimension of 18 x 13 mm^2 over the ground plane of size 100 x 50 mm^2 which can easily be implanted in the small space available within the mobile device. The proposed structure is having an impedance bandwidth ranging from 2.16 GHz to 2.726 GHz covering all the desired frequency bands. Antenna has a resonating frequency at 2.395 GHz frequency. For getting the impedance bandwidth we are taking -8 dB as the reference return loss, which is acceptable for mobile phone applications. The input impedance plot of the proposed structure is presented. The radiation pattern of the antenna at 2.4 GHz and 2.55 GHz are also presented. The peak realized gain varies from 4.17 dB to 4.84 dB in the desired operating band.

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