

A NOVEL PLANAR INVERTED F ANTENNA FOR LTE & WLAN APPLICATIONS WITH METAMATERIAL SUPERSTATE

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Abstract: In this paper, a novel Planar Inverted F antenna (PIFA) for Long Term Evolution (LTE) wireless system application is presented. The antenna is proposed on Roger Duroid 5880 dielectric substrate. The total area occupied by the antenna is 44mm × 20mm and can be easily integrated in mobile handsets. The impedance bandwidth of the antenna ranges from 2.33-2.92 GHz covering the LTE & WLAN bands. Metamaterial superstate layer is also used and placed near the antenna. Its effects are analyzed and discussed. The antenna has low profile structure and hence can be easily mounted on mobile handsets. The antenna is simulated and optimized using Ansoft HFSS. The prototype of the simulated antenna has been fabricated and measured for the results verification.

Keywords: PIFA, Roger Duroid 5880, LTE.

I. INTRODUCTION

There is an upsurge for the requirement of mobile handsets that are small in size and more multifunctional. Therefore the future technology possesses Long Term Evolution (LTE) function for the transmission of voice and data over portable devices. LTE is the most extensively used communication system as a fourth generation wireless communication service [1].

Planar Inverted F Antenna (PIFA) is a low profile antenna and can be easily integrated in mobile handset. It is formed from linear Inverted F antenna (IFA) in which a wire radiator is replaced by a shorting plate to increase the bandwidth [2]. It has many advantages over other conventional antennas such as reduced size, low profile structure, easy to manufacture and low SAR value [3] [4].

The structure of PIFA consists of three elements; top radiating patch placed above the ground plane, shorting plate and a feeding technique for the radiating patch [5]. The commonly used feeding technique for PIFA is a co-axial probe. The function of shorting plate is to connect ground and the radiating patch [6],[8]-[11].

These days researchers are using one of the most important element of metamaterial which is Split Ring Resonator (SRR). SRR is a non-conducting unit with effective negative permeability which gave enhanced magnitude when made to resonate at a frequency [7]. The resonance frequency depends on the geometrical parameters. Figure 1 show a basic SRR unit cell structure.

In this paper a simple PIFA design for Long Term Evolution (LTE) for mobile phone application is proposed. The antenna resonates at a single frequency band 2.6 GHz with impedance bandwidth from 2.32-2.89 GHz.

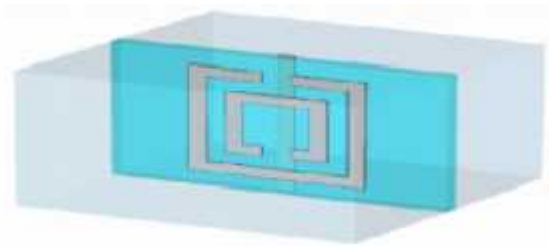


Figure 1 Basic Split Ring Resonator Cell

The antenna is designed on Roger Duroid 5880 substrate with thickness 0.8mm. In addition the size of the antenna is compact and can be easily mounted on handheld devices. The design and the results of the proposed design are discussed in a detailed manner.

The proposed antenna is fabricated and results are measured. Section II describes the geometry of the antenna Section III and IV describes the simulated results and conclusion respectively.

II. ANTENNA DESIGN

In this paper, the proposed design composes of five main elements, Ground plane, Radiating Patch, substrate, shorting plate with height 'h' and co-axial feed. Table I describes the specifications of the proposed antenna.

Table 1: Design Specifications of Proposed Antenna

Parameter	Specification
1. Shape of antenna	Rectangular
2. Operating Frequency	2.6 GHz
3. Dielectric Substrate	Roger Duroid 5880, $\epsilon_r = 2.2$
4. Feed Mechanism	Co-axial probe feed
5. Height of Antenna	3.8mm
6. Height of Metamaterial Superstate	15 mm

Figure 2 shows the configuration of the proposed antenna for LTE mobile system application. The proposed antenna is designed on Roger Duroid 5880 ($\epsilon_r = 2.2$ and loss tangent= 0.0009). The dimensions of the dielectric substrate are 44mm × 20mm × 0.8mm. The antenna consists of a square radiator of dimensions 18mm×18mm. The square radiator and the ground plane are separated by air gap with height 3.8mm. The top radiator and the ground plane are printed on PEC Copper plate. Therefore the total area occupied by the proposed antenna is 44mm × 20mm, which can be easily integrated in handheld wireless devices. The geometry of the antenna resembles a

conventional PIFA structure and provides enough bandwidth from 2.33-2.92 GHz to cover WLAN & LTE Band 7 applications. The antenna is fed through co-axial probe feed and is designed and optimized using High Frequency Structure Software (HFSS). Figure 2 shows top and side view of proposed antenna.

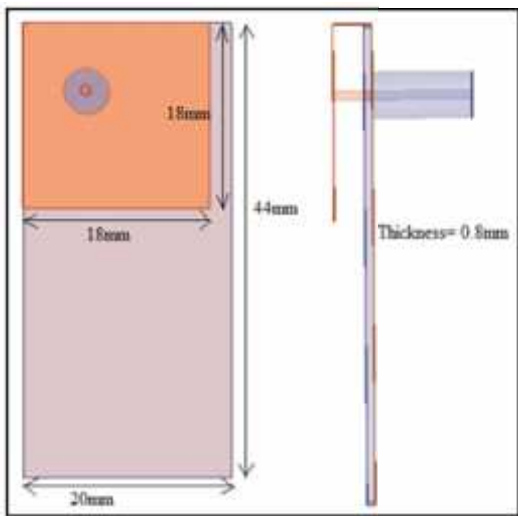


Figure 2. Top and Side view of Proposed Antenna

Figure 3 shows prototype model of the fabricated antenna. The total volume occupied by the antenna is 44mm × 20mm × 3.8mm. The air substrate with dielectric constant, $\epsilon_r = 1$ contains the height of the antenna. The shorting plate connecting the ground and the top radiating patch is made from PEC strip. The purpose of using shorting plate is to reduce the size of antenna. In this design it has been seen that the size of the ground plane is reduced by 80% as compared to conventional PIFA having ground plane of dimensions 40mm × 120mm. Therefore the fabricated antenna can be easily positioned within the mobile devices and other compact wireless devices. The 50 connector is fed at the top square patch. The location of shorting plate and feed point is varied accordingly to get the desired results.

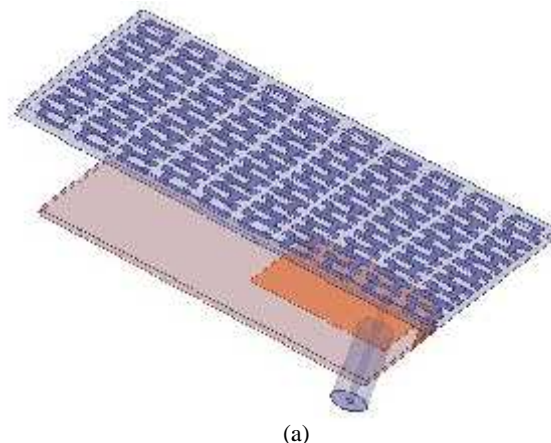


Figure 3. Top and Side view of Fabricated Antenna

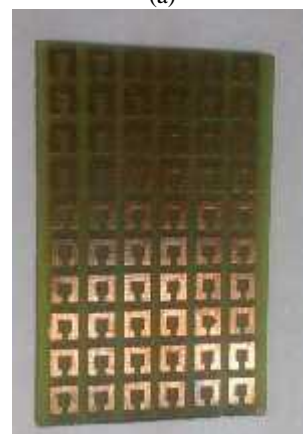
PIFA WITH METAMATERIAL AS SUPERSTRATE

Figure 4 denotes a PIFA with a layer of metamaterial lens as superstrate. The antenna resonates at 2.38 GHz (suitable for LTE application) with return loss of - 15.38 dB. The material used as substrate is FR4 which is easily available for fabrication and has a permittivity of 4.4. The overall volume of the antenna is very less and can be easily integrated into present generation handheld devices. It was observed from the obtained results that the resonant frequency obtained for the design was much higher than the

resonance for conventional PIFA of same size.



(a)



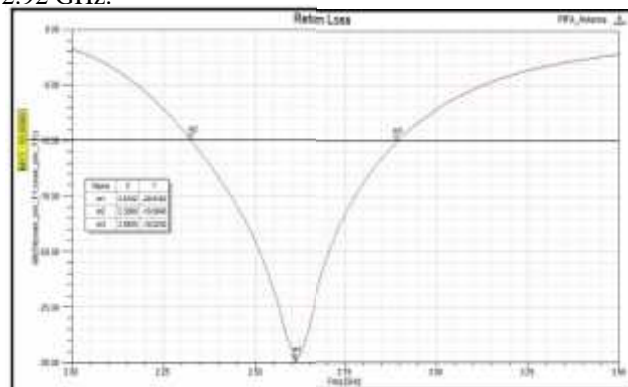
(b)

Figure 4 (a) 3D View of Proposed Antenna with Metamaterial Superstrate (b) Fabricated Metamaterial Layer

III. RESULT AND DISCUSSIONS

In this section, the performance of proposed and fabricated antenna is discussed. The proposed antenna is designed using Ansoft High Frequency Structure Simulator (HFSS) software. The result of fabricated antenna is measured using Network Analyser MS46322A. Various parameters such as return loss, VSWR, radiation pattern and gain of the simulated antenna are discussed in this section.

Figure 5 shows the simulated return loss of the proposed antenna. According to the results, the proposed antenna operates at 2.6 GHz frequency with return loss - 27.16 dB to cover the LTE & WLAN bands. The proposed antenna has a bandwidth of 590 MHz ranging from 2.33-2.92 GHz.



(a)

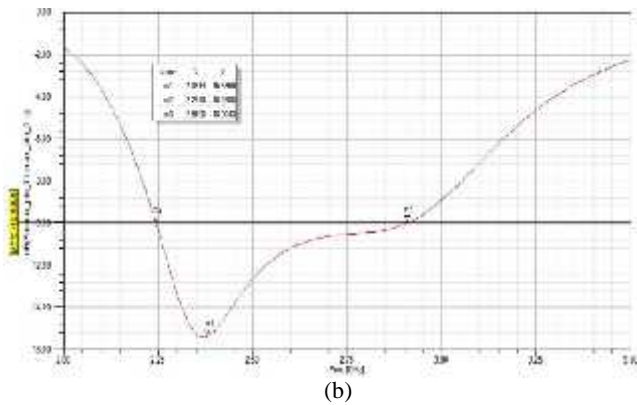


Figure 5 Simulated Return Loss Plot of Proposed Antenna (a) Without Metamaterial Superstrate, (b) With Metamaterial Superstrate

As shown in the figure above that after using the metamaterial superstrate above the proposed antenna at a height of 15mm from the ground plane enhances bandwidth and gain parameters.

Figure 6 shows Voltage Standing Wave Ratio (VSWR) of the proposed antenna design. The value VSWR should be less than 3. As shown in figure 5, the value of VSWR of the proposed antenna is 0.76 dB at resonant frequency. Hence the mismatching between the load and the antenna is very less.

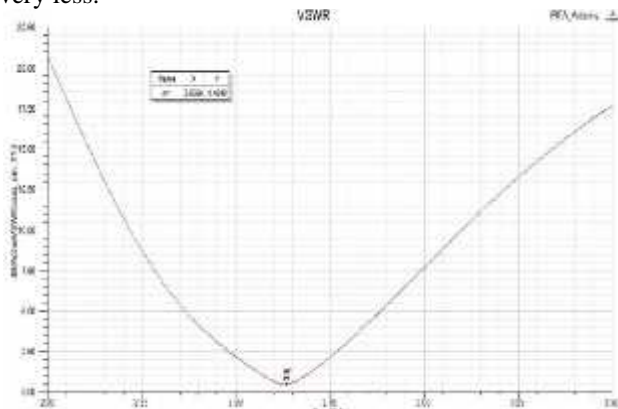


Figure 6. Simulated VSWR of the proposed antenna

Figure 7 shows the radiation characteristics of the proposed antenna across the bandwidth of 2.33- 2.92 GHz. As shown in the figure 7, the antenna exhibits nearly omnidirectional radiation pattern.

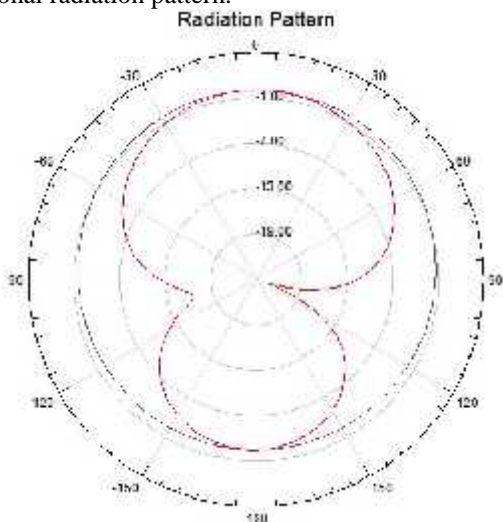
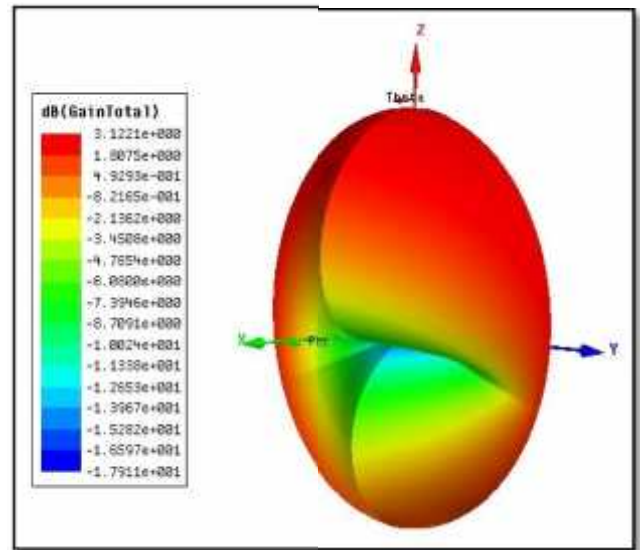
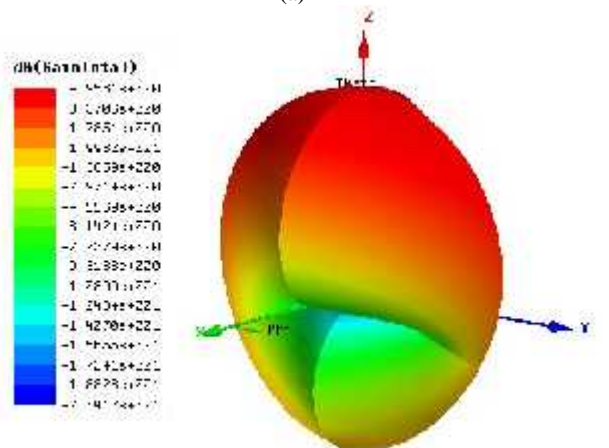


Figure 7 Simulated Radiation Pattern of the proposed antenna

The simulated peak gain across the impedance bandwidth is shown in figure 8. As seen from the results, the total peak gain is 3.12 dB. The gain after using metamaterial superstrate increases to 4.95 dB which is towards the higher side for PIFA antenna. Hence the proposed antenna shows good gain performance.

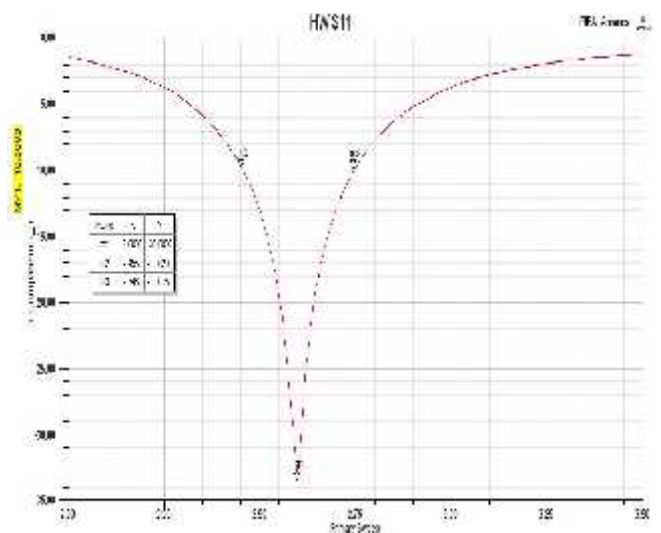


(a)



(b)

Figure 8 Simulated 3D Gain (a) Without Metmaterial (b) With metamaterial



(a)

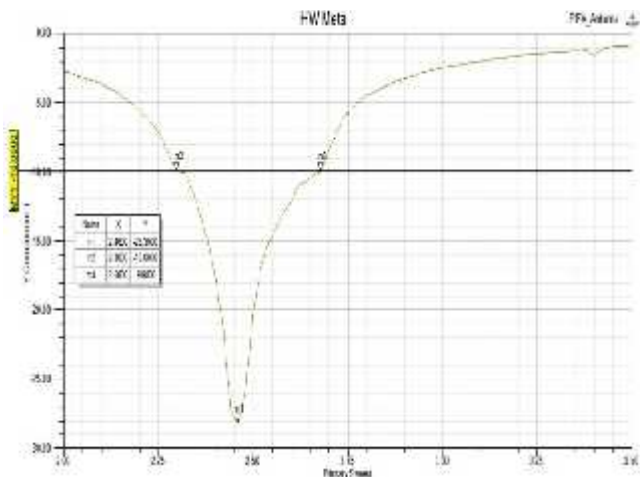


Figure 9 Measured S11 Plot (a)Without Metamaterial Lens
(b)With Metamaterial Lens

Figure 9 shows comparison between simulated and measured results. The simulated and measured results are in excellent agreement with each other. The result of the antenna is measured using Network Analyzer MS46322A. Therefore the fabricated and proposed antenna shows good performance and can be used in handheld devices such as mobile phones.

As shown in figure 9, metamaterial superstate enhances antenna parameters like bandwidth, resonance, gain etc. The comparison is given in the table below:

Table 2: Performance Comparison between Proposed PIFA antenna with and without Metamaterial Layer

Antenna	Frequency (GHz)	Bandwidth (MHz)	Peak Gain (dB)
Proposed Antenna	2.62	590	3.12
Proposed Antenna with Metamaterial	2.38	670	4.95

It is clear from the table above that there is considerable amount of enhancement in bandwidth and peak gain of the antenna. Gain increased by 1.83 dB by using metamaterial superstate layer and bandwidth is enhanced by 80 MHz. It has also been observed that resonant frequency shifts to the lower side of frequency spectrum.

IV. CONCLUSION

This paper presents the design of novel single band Planar Inverted F Antenna for LTE mobile application. The antenna resonates at 2.62 GHz with -27.16 dB return loss. The size of the antenna is compact, 44mm × 20mm, and can be easily integrated in mobile handsets. Effect of metamaterial superstate is also analyzed and discussed. The proposed PIFA shows good radiation pattern and impedance bandwidth of 590 MHz. The antenna is easy to fabricate and is suitable for handheld devices.

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