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DESIGN OF PIFA FOR MOBILE AND UWB APPLICATIONS

Priyanka singh

Department of Electronics and Communication Engineering,
Madan Mohan Malaviya University of Technology, Gorakhpur, India

Abstract— In this paper, performance and characteristics of PIFA for mobile and UWB applications will be studied. PIFA is not considered as UWB antenna because of its narrow band characteristics. Several techniques are used for enhancing the bandwidth of PIFA. These techniques includes addition of parasitic elements, cutting slots in ground plane, changing width of feeding plates and shorting pins. These techniques are helpful in covering wide range frequencies. Simulated results are provided to verify the conclusion.

Keywords— UWB, PIFA, HFSS

I. INTRODUCTION

Recently, with increase in demand of covering wider frequency bands emphasis is led to study of UWB antenna.

PIFA is extended form of inverted-F antenna in which radiating wire is replaced with planar surface. The planar inverted-F antenna (PIFA) is one of the widely used antenna in mobile phones today. The PIFA consists of radiating patch, ground plane, a feed wire and short strip which short circuits the rectangular patch to the ground[1,2].The shorting mechanism makes it's a quarter wave resonator, which reduces the electrical length by 50% compared to a microstrip antenna. It is also defined as extended form of IFA in which radiating wire is replaced with planar surface for enhancing the bandwidth.This antenna has several advantages of small size,light weight,good operating bandwidth etc.It is not considered for UWB application due to its narrow band characteristics.

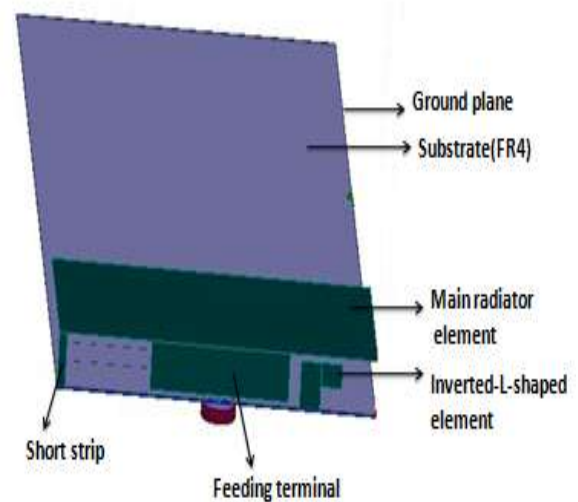
Several techniques are used for the bandwidth enhancement of PIFA .These techniques includes increasing feeding plate and short strip width, adding parasitic elements such as rectangular parasitic element, inverted-L-shaped parasitic element, adding slots in ground plane which produces lower frequency resonance, same types of slots can be added in patch also. Finally, a combination of these techniques is used for enhancing bandwidth of PIFA and their effects are studied[3,4].In this paper two proposed PIFA antenna are compared. In first proposed antenna ncludes inverted L shaped parasitic element ,radiating plate,shorting pin and slots on ground plane. FR4 substrate of thickness 0.13mm and permittivity 4.4 is used. The radiation patch connects to ground plane through a shorting plate and thick feeding terminal. The width of shorting plate and location of the

coaxial feed point is regulated to achieve the impedance matching with the 50Ω coaxial line.

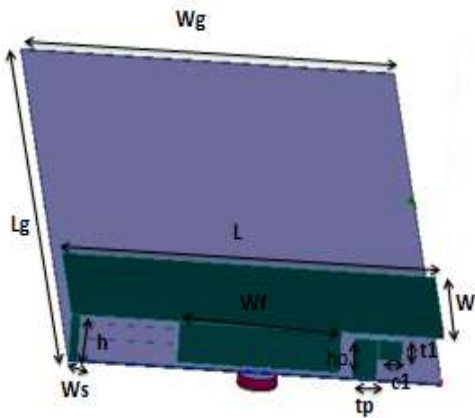
Second proposed antenna includes two parasitic elements, slots on ground plane, shorting pin and feed plate. FR4 substrate of thickness 1mm and permittivity 4.4 is used. The penalty incurred by using a lower profile is that the figure of merit $S_{11} < -10\text{dB}$ is diminished to $S_{11} < -6\text{dB}$. However, the second PIFA design presented in this paper satisfies the criterion of $S_{11} < -10\text{dB}$ in important parts of its bandwidth.

II. ANTENNA GEOMETRY

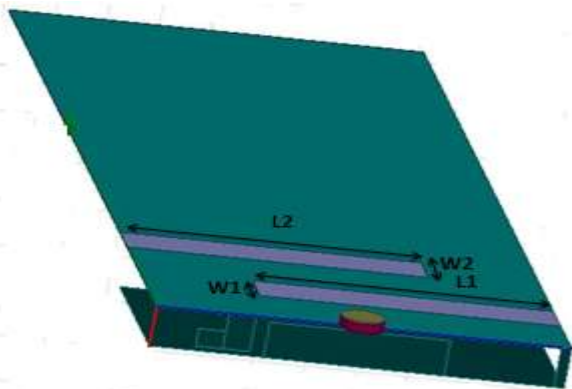
The geometry of the proposed PIFA is shown in Fig.1and Fig2 The antenna is constructed with rectangular patch, ground plane, rectangular parasitic element, inverted-L shaped parasitic element, short strip and thick feeding terminal. Ground plane is $100 \times 40\text{mm}^2$ close to the commonly found smartphones dimensions. There is FR4 substrate of thickness 0.13mm and 1mm and permittivity 4.4.Substrate is between the ground plane and feed plate.The space between the top plate and the substrate is filled with air (free space).Thick feeding terminal is used it provides a single very large bandwidth and slots are used in ground plane. Slots helps to increase electrical size without any increase in physical size. Slots are placed just below the rectangular patch, but one of the slot is



outside the boundary of rectangular patch.



(a)

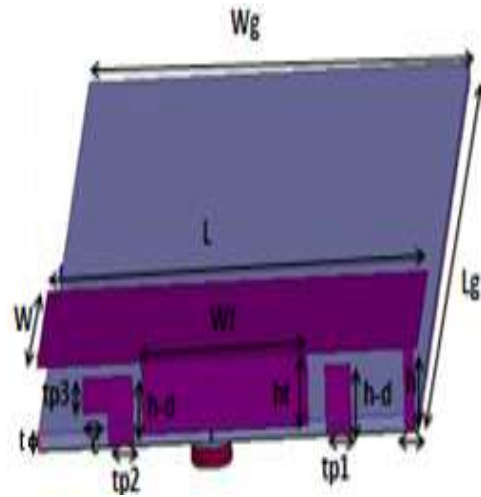
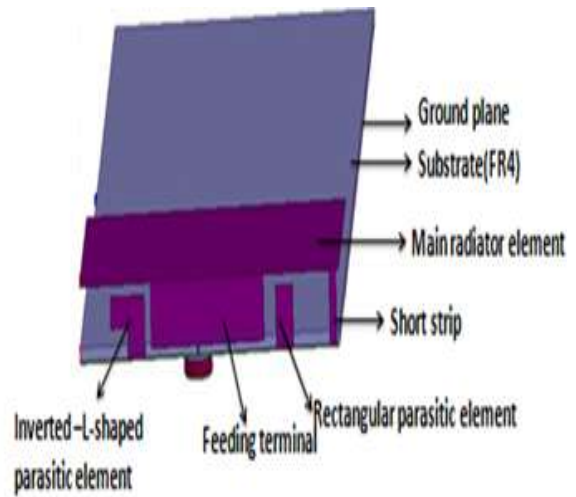


(b)

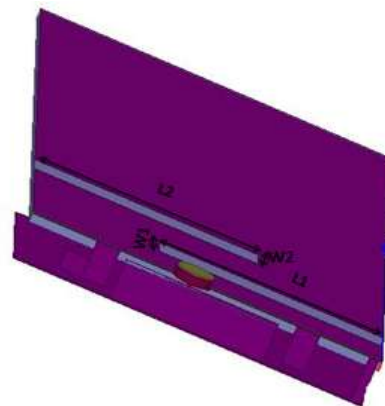
Fig.1.Geometry of proposed antenna1. (a)Front view (b) Back view

Table 1.1 Optimized Design Parameter of the Proposed Antenna1

Parameter	Value(mm)	Parameter	Value(mm)
Lg	100	W2	5
Wg	40	Hp	4
L	40	tp	2.6
W	20	t1	2
L1	29	c1	2.6
W1	5	Ws	1
L2	29	Wf	17.4



(a)



(b)

Fig 2. Geometry of proposed antenna 2. (a)Front view (b) Back view



Table 1.2 Optimized Design Parameter of the Proposed Antenna2

Parameter	Value(mm)	Parameter	Value(mm)
Lg	100	W2	4.5
Wg	40	h-d	4.2
L	40	tp1,tp2	2.6
W	20	tp3	2.1
L1	25.6	c	2.6
W1	4.5	Ws	1
L2	25.6	Wf	17.4

III. PARAMETRIC STUDY

Study is carried out by changing one parameter at a time to observe its effects on the characteristics of the PIFA while all other parameters are held constant.

A. Parametric study for proposed antenna1.

Parasitic element position is varied from 5mm to 7mm and best result is shown at 6.5mm in fig.3.1. Length of slot in ground plane is varied from 28mm to 29mm and best result is shown at 29mm in fig.3.2. Height of radiation patch is varied from 4.2mm to 4.5mm and best result is shown at 4.5 in fig.3.3

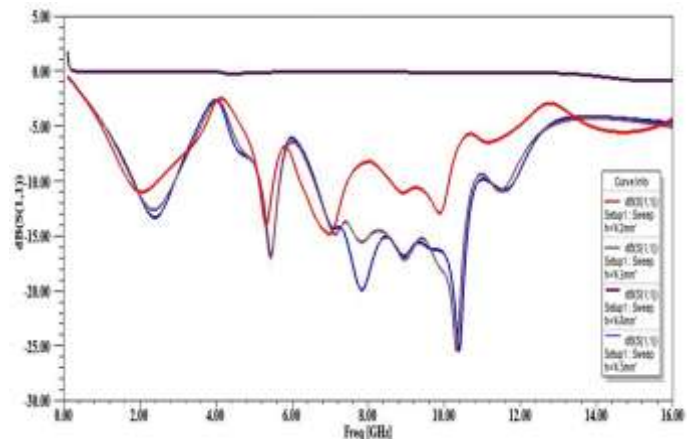


Fig.3.3 Simulated S11plot with variation of height of radiation patch

B. Parametric study for proposed antenna2

Feed position is varied from 17.4mm to 18.2mm and best result shown at 18.2mm in fig.4.1. Length of slot size in ground plane is varied from 22mm to 25.6mm and best result is shown at 25.6mm in fig.4.2. Position of parasitic element is varied from 7mm to 10mm and best result is shown at 10mm in fig.4.3.

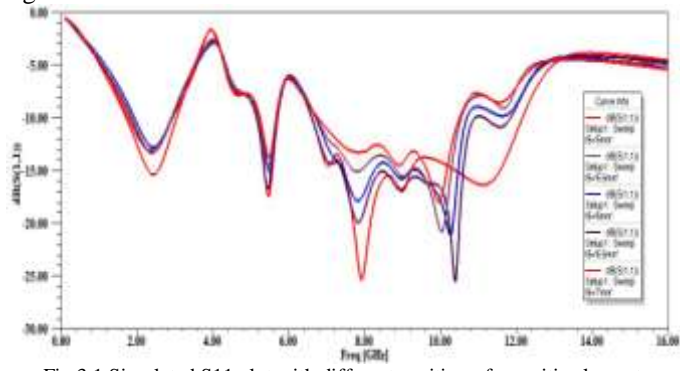


Fig.3.1 Simulated S11 plot with different position of parasitic element

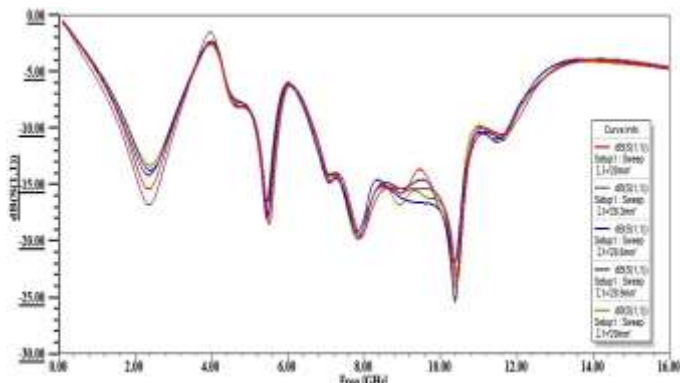


Fig.3.2 Simulated S11 plot with variation of length of slot in ground plane

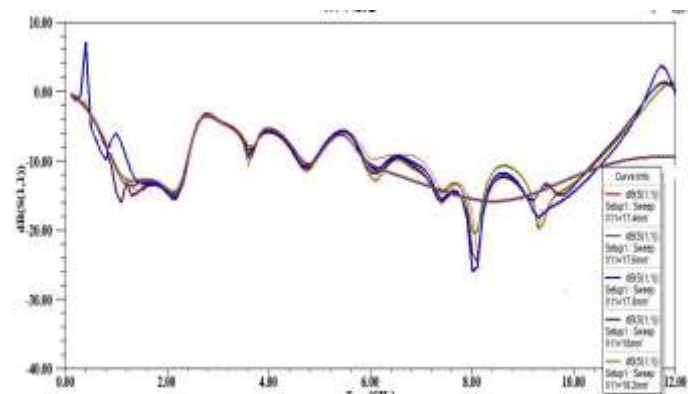


Fig.4.1 Simulated S11plot with different feed position

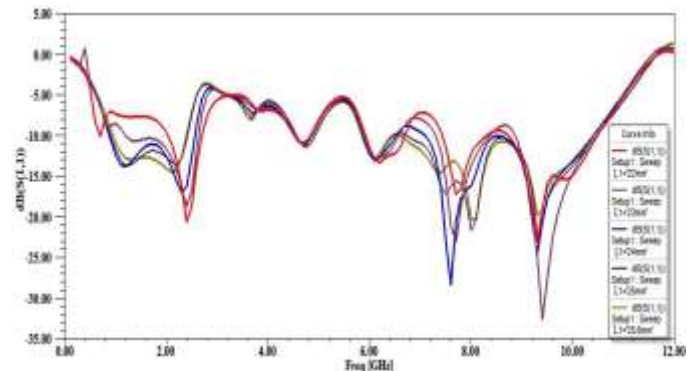


Fig.4.2 Simulated S11plot with variation of length of slot size in ground

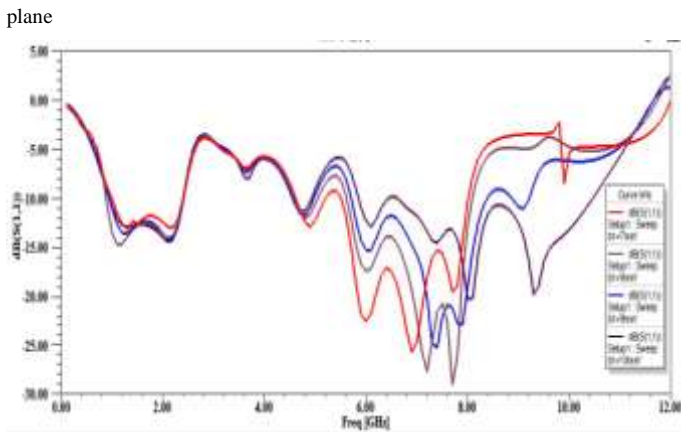


Fig.4.3 Simulated S11 plot with different position of parasitic element

IV. SIMULATED RESULTS

The simulation of proposed antenna in this paper is done with the help of high-frequency structure simulator (HFSS). The width of shorting pin, width and position of feeding terminal, width and length of slots in ground plane, position of rectangular parasitic element and inverted-L-shaped parasitic element were modified for required bandwidth.

Simulated return loss of proposed antenna1 is shown in Fig5. It covers GPS(1.22 and 1.57GHz), DCS(1.8GHz), PCS(1.9GHz), Bluetooth and Wi-Fi(2.4-2.5GHz), 5GHz WLAN and major part of UWB frequency range. Simulated return loss of proposed antenna 2 is shown in fig.6. It covers LTE 700MHz, GSM(800-900 MHz), GPS(1.22 and 1.57 GHz), DCS (1.8 GHz), PCS (1.9 GHz), Bluetooth and WiFi (2.4-2.5GHz), 5GHz WLAN and major part of UWB frequency range.

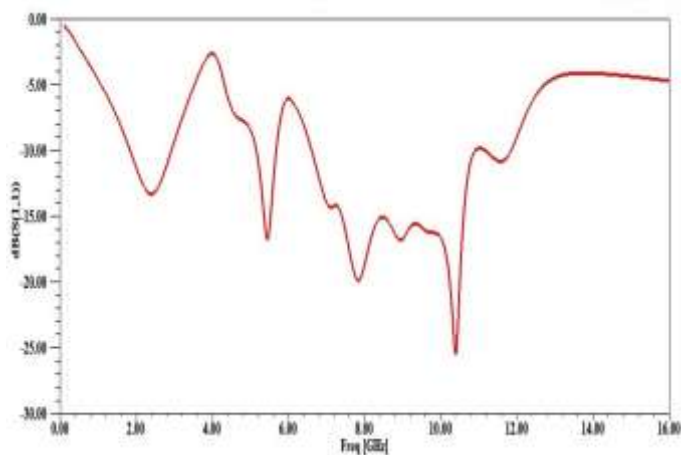


Fig. 5. Simulated S11 plot of the proposed antenna1

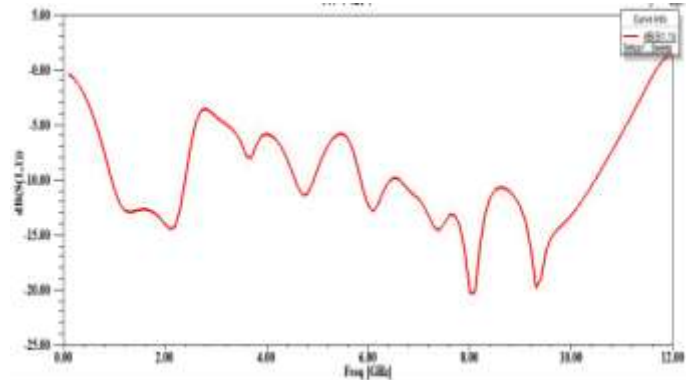


Fig. 6. Simulated S11 plot of the Proposed Antenna2.

V. CONCLUSION

A study on development of PIFA with addition of parasitic elements for mobile and UWB applications is presented in this paper. By addition of inverted -L-shaped parasitic element proposed antenna covers DCS(1.8 GHz), PCS(1.9 GHz), Wi-Fi and Bluetooth(2.4 and 2.5 GHz), 5 GHz WLAN and a major part of the UWB frequencies(4.4-12.4GHz). With addition of both parasitic element which is rectangular parasitic element and inverted-L-shaped parasitic element the proposed antenna covers wide frequency band which includes LTE 700MHz, GSM(800-900 MHz), GPS(1.22 and 1.57 GHz), DCS (1.8 GHz), PCS (1.9 GHz), Bluetooth and Wi-Fi(2.4-2.5GHz), 5GHz WLAN and a major part of UWB(3.3 to 11GHz). In addition, the detailed parametric analysis of designed antenna is also carried out to study the effects of various antenna parameters.

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