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DIFFERENT VALUES OF SUBSTRATE MATERIAL FOR PLANAR INVERTED F - ANTENNA

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ABSTRACT

This paper is mainly focused on an analysis of an conventional PIFA for WLAN applications and it is optimized at 5.04GHz. The work carries by changing the relative permittivity value of the substrate material and analyzing the antenna parameters such as return loss, gain, directivity, input impedance and bandwidth. The entire design is simulated by using ANSYS HFSS tool.

Keywords - PIFA, WLAN, Relative Permittivity, Return loss

I. INTRODUCTION

To fulfill the demand of new generation communication system, development of antennas without the enhancement of bandwidth and power there is an increase in the capacity of data rate is necessary. The choice of choosing the antenna with the advantages of low profile, high gain and no backward radiation towards the user i.e. to minimize the SAR (Specific Absorption Rate) which is implemented by using PIFA (Planar Inverted F-Antenna) [1].

For obtaining the multiband operations different techniques have been implemented including a monopole antenna fed with a meandered coplanar waveguide, a meander-line monopole antenna with a backed micro strip line, coplanar waveguide fed with two resonant paths and a micro strip fed double T monopole antenna and many more and these mentioned techniques will support for dual band characteristics like Wi-MAX application (3.5/5.2 GHz) [2],[3].

To increase the bandwidth of PIFA antenna with the introduction of parasitic elements with proper height between the ground plane and patch and also the proper feeding techniques is used for proper impedance matching [4], [5].

The compact planar inverted –F antenna has been extensively used in mobile handset devices with having a very attractive features and increase in the data rate plays an important role for online games and no buffer in video in video streaming and the introduction of slot with different shapes like E, F, U and many more in the radiating patch will improve the resonant frequency and increase in bandwidth [6], [7].

The same type of slot in the ground plane can be used to increase the bandwidth at lower frequencies to mobile communications [8-11].

The PIFA can cover the number of frequency bands for proper dimension of length, width and height with different shapes slots at ground plane and patch.

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In this paper PIFA is designed for single resonant frequency at 5.04 GHz for WLAN applications with acceptable return loss, bandwidth and impedance matching.

II. ANTENNA DESIGN

A. CONVENTIONAL PIFA

PIFA stands for Planar Inverted F-Antenna. The antenna has the dimension in the range of λ/4. It has two conducting parallel plates which are connected to the ground plane and patch that resonates at λ/4, where λ is the operational wavelength.

The antenna resonant frequency depends on length and width of the patch and the equation given by

$$L_1 + L_2 + W = \lambda/4 \quad (1)$$

Where L_1 – Antenna Length 1 of PIFA

L_2 – Antenna Length 2 of PIFA

W – Antenna Trace Width

A simple antenna design with inverted F shape structure with shorting plate to increase the return loss, impedance matching, acceptable gain and directivity has been proposed and it is shown in Fig.1

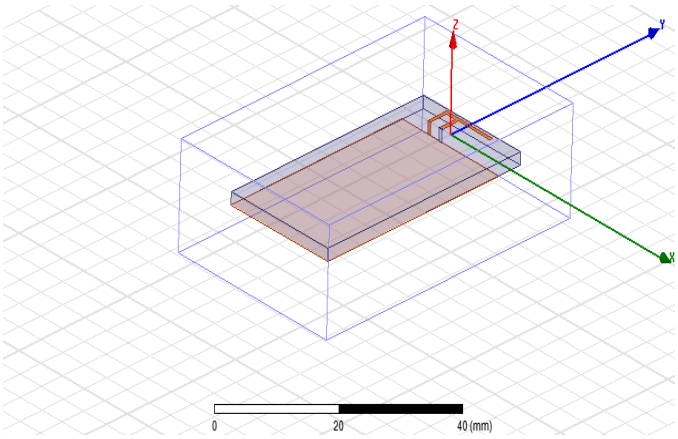

Fig.1Planar Inverted-F antenna

The proposed PIFA resonates with the dimensions of 11.1x3.57x1.57mm. The thickness of the substrate used is 1.5748mm and the technique used to feed the PIFA is Microstrip line feeding method. The parameters and the specifications used for the proposed techniques is shown in Table 1.

S.No.	Parameter	Dimensions (mm)
1.	Antenna Length 1	11.1
2.	Antenna Length 2	3.57
3.	Antenna Trace width	0.67
4.	Antenna Offset	2.01
5.	Substrate Thickness	1.5748
6.	Ground Plane Length	44.6
7.	Ground Plane Width	22.3

Table 1. Specifications of PIFA

A.1 SIMULATED RESULTS

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The Planar Inverted F antenna was analyzed and optimized with the HFSS 13 simulator software. The PCB material of Rogers RT/ Duroid 5880 (tm) is used for PIFA design. And, it can be tested up to 20GHz and the antenna resonates at 5.04GHz for WLAN application and the bandwidth is calculated at -10dB return loss and it is found to be 50MHz. In this design the PIFA resonates high return loss by changing the relative permittivity value from 2.1 to 2.3. For the relative permittivity value of 2.3; the return loss at -24.5dB; impedance matching at 56.92Ω, gain and directivity are obtained as 3.974dB and 3.99 dB respectively. The bandwidth is independent of relative permittivity.

The comparison values for return loss, gain, directivity and input impedance are shown in the Table 2

Material Name	Rogers RT/ Duroid 5880 (tm)			
Bandwidth (MHz)	50			
Relative Permittivity	**Return Loss (dB)**	**Gain (dB)**	**Directivity (dB)**	**Input Impedance (Ω)**
2.1	-19.5	4.042	4.057	64.38
2.2	-22	4.015	4.026	60.35
2.3	-24.5	3.974	3.99	56.92

Table 2. Comparison of Return loss, Gain, Directivity and Input Impedance

The return loss of PIFA versus frequency graph is shown in figure 2.

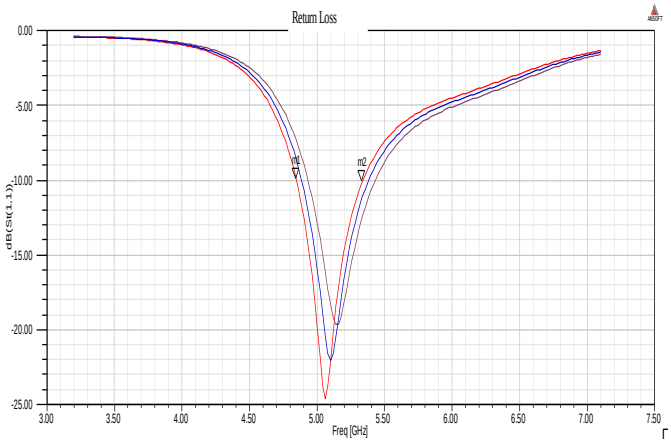

Fig 2. Return loss of PIFA

The maximum gain of 3.94 dB is achieved with the VWSR value of 1.1424 indicating a good impedance matching (perfect matching VSWR=1) which implies that almost all the input power is transmitted

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to the PIFA antenna. The bandwidth of 50MHz is achieved in lower band with the VSWR value of 1.9322 and upper band with the VSWR value of 1.910. The gain of PIFA is shown in figure 3.

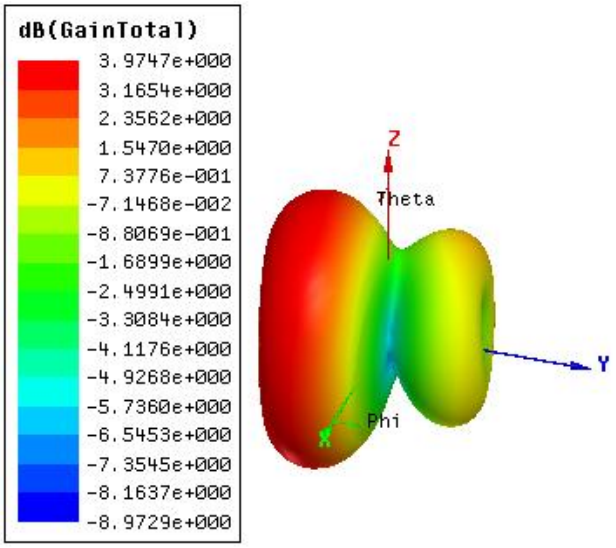

Fig 3. Gain (dB) of PIFA

The efficiency of the PIFA is calculated by the known value of gain and directivity and it is given by

$$G = \eta \times D \qquad (2)$$

$$\eta = G / D$$

Where G – Gain of PIFA

η – Efficiency of PIFA

D – Directivity of PIFA

The maximum efficiency of 98.9% and directivity of 3.99 dB is achieved at the resonate frequency of 5.04GHz. The directivity of PIFA is shown in figure 4.

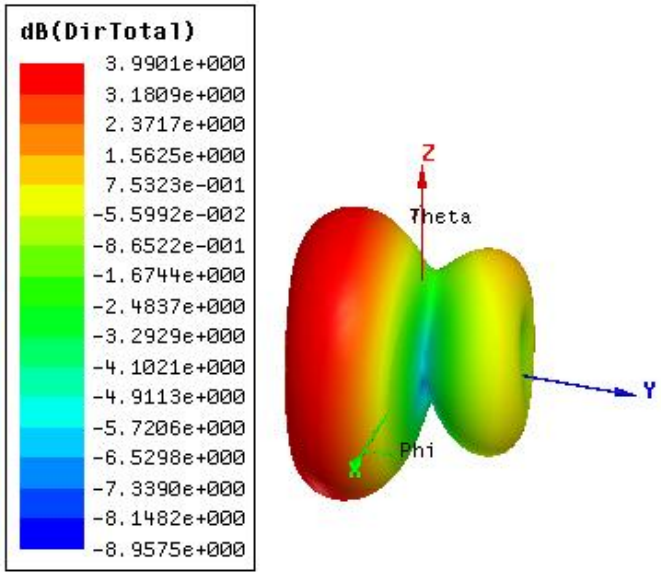

Fig 3. Directivity (dB) of PIFA

III. CONCLUSION

This paper gives an idea and analysis of different value of substrate material. From the result obtained it is clear that the value of Return loss is increased and input impedance is matched nearly 56.92Ω by changing the material value from 2.1 to 2.3. Higher relative permittivity will give high return loss with acceptable gain and directivity. Further it can be increased to multiband resonant frequency with high return loss by adding different shape of slot in the patch and ground plane.

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