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Multiband PIFA for Wi-Fi and 5G mobile Communication Application

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Abstract - *In this paper a Multiband PIFA for Wi-Fi and 5G mobile communication application is proposed. The PIFA proposed here is compact in dimension, in order to increase electrical length slots are introduced in the radiating patch, which further helps in gaining multiple bands and higher gain at higher frequencies, also it helps in increasing the bandwidth. The antenna proposed has a overall volume of 0.80cm³ .the substrate used here ids FR4 with relative permittivity of 4.4.The model is created and analyzed using simulation software HFSS. Different antenna parameters are analyzed and discussed in the paper including structure of the proposed antenna, return loss, multi-band frequencies, bandwidth, and simulated distribution of current density, radiation patterns are presented.*

Key Words: **PIFA ,altenate slots,antenna radiation,antenna efficiency,antenna gain,Wi-Fi, 5G**

1. INTRODUCTION

There has been tremendous growth acknowledged in wireless communication in past a decade. Mobile wireless communication was meant to be for voice calling and short messaging services but every now and then some new services are integrated in the existing infrastructure to make communication more happening and lively. With current advancement there is a trend of slim mobiles with almost functionality equivalent to a computer. Now if mobile phones need to be slim then there is a great requirement for a single antenna to be multifunctional because using multiple antennas for multiple function end up in making device bulky, which will lose its very importance of being mobile, hence there is a need of very compact antenna which can acquire multiple signals for multiple functionality. In order to reduce the size of conventional microstrip antenna for the purpose, a planar inverted F antenna (PIFA) can be used. A PIFA can be able to reduce the size of patch by half. This is achieved by dropping a shorting pin or shorting plate right in the middle of the conventional patch where impedance goes to zero as shown in the fig.1. The impedance of the patch is matched with feed by adjusting the distance between shorting pin and feed. The feed used here is co-axial feed which is adjusted between short and open terminal to get proper matching. One disadvantage of using shorting post is it reduces bandwidth to half. In order to increase the electrical length alternate slots are used which enhances antenna efficiency and also helps in creation of multiple bands.

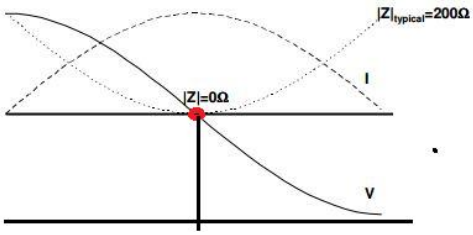

Fig -1: PIFA Concept

For a PIFA patch design the dimensions of the patch is comparable to quarter wavelength, so the thumb-rule is

$$Lp + Wp - W = \frac{\lambda}{4}$$

where, Lp= antenna patch length and Wp= antenna patch width and W= antenna shorting plate width
The resonant frequency of PIFA is given by:

$$f_0 = \frac{c}{4(w+b)\sqrt{\varepsilon_r}}$$

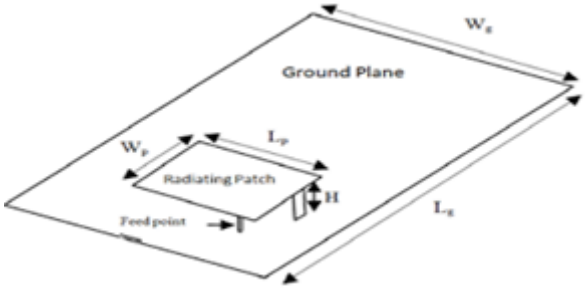

Fig -2: Conventional PIFA

2. SLOTTED PIFA DESIGN

Slots are used in this design for multiband creation and achieving high gain and efficiency. This type of antenna is use, where it can resonate broadband and produces circular, horizontal and vertical polarizations. It also achieves high radiation efficiency which is more compared to that of other antenna in communication industry. The idea here is to design a compact antenna but technically dimensions cannot be shorten beyond Chu's limit which states about electrical length. Slots here are introduced in an alternate fashion near the edges which increases it electrical length and increases efficiency and bandwidth. Initially PIFA is designed without slots which did not produce sufficient results and hence slots were introduced to get better results.

Creating slots helps in physically making antenna compact while helped in increasing electrical length to satisfy Chu's limit.

3. PROPOSED ANTENNA STRUCTURE AND DESIGN CONSIDERATIONS

The rectangular patch antenna is designed and simulated for 2.4GHz as center frequency for various feeding techniques. The schematic diagram of the antenna design is shown below:

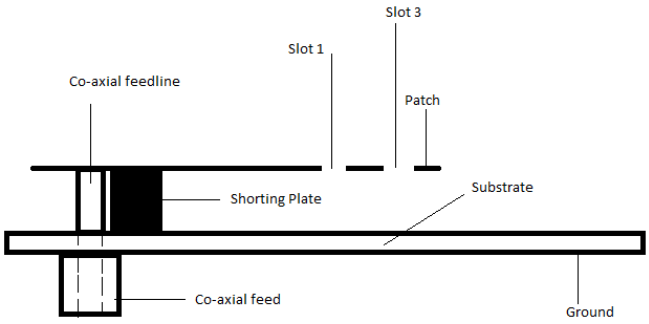

Fig -3: Side-view of PIFA with slots

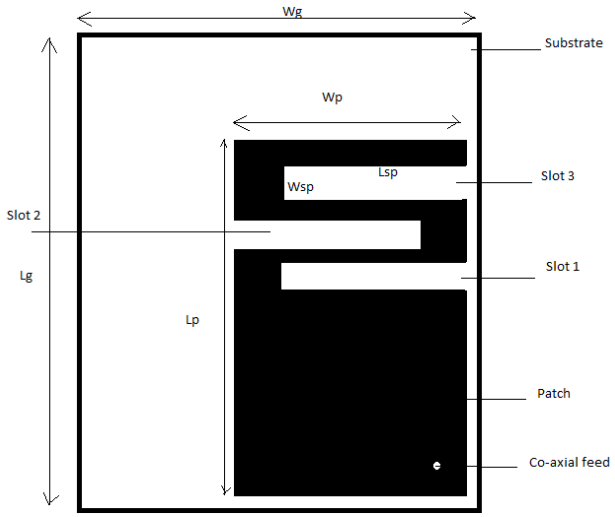

Fig -4: Top-view of PIFA with slots

The dimensions of the antenna are mentioned in table-1 where slot width is mentioned, slots are arranged in alternately so as to enhance electrical length of the patch. As mentioned the substrate used here is FR4 substrate with relative permittivity of 4.4 and thickness of the substrate is kept 1.58mm.the width of the slot is kept 3mm and it is kept at distance of 4mm from the edge of patch. The feed is kept near shorting plate at a distance of 2.5mm. The feed is kept on moving to different positions between short and open to get a proper matching impedance for maximum power transfer. The thickness of top radiating patch is kept 0.3mm.Slots are kept at the edges of the patch to get the maximum radiating efficiency.

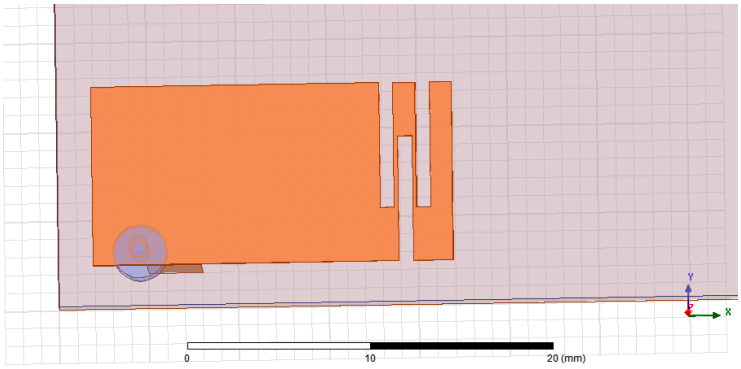

Fig -5: Top-view model of PIFA with slots

Table :1

Parameters	Dimensions (in mm)
Ground length(Lg)	50
Ground Width(Wg)	40
Patch Length(Lp)	20
Patch Width(Wp)	10
Shorting plate Width(W)	3
Shorting plate height (h')	4.58
Substrate thickness (h)	1.58
Patch slot width (Wsp)	0.78
Patch slot length (Lsp)	0.8

4. RESULTS AND DISCUSSION

4.1. PIFA without any slot.

PIFA without any slot is shown in the fig.6, corresponding return loss is shown in chart.1 3D plot for frequency 2.2 GHz and 5.8GHz is shown in fig.7 and fig.8 respectively.

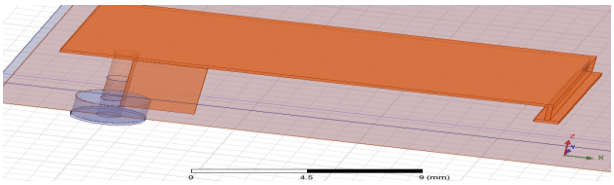

Fig -6: Top view of without slots PIFA

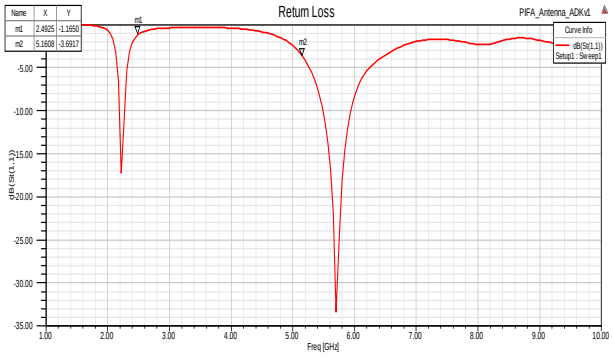

Chart -1: Return loss of PIFA with slots

. **Fig -7**: Radiation pattern for 2.2GHz

. **Fig -8**: Radiation pattern for 5.5GHz

4.2. PIFA antenna with two slots

PIFA with two slot is shown in the fig.9 corresponding return loss is shown in chart.2. 3D plot for frequency 2.3 GHz and 5GHz and 7.2 GHz is shown in fig.10 and 11 respectively.

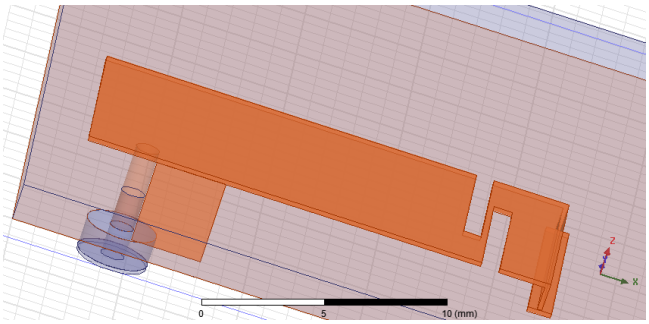

Fig -9: Top view of two slots PIFA

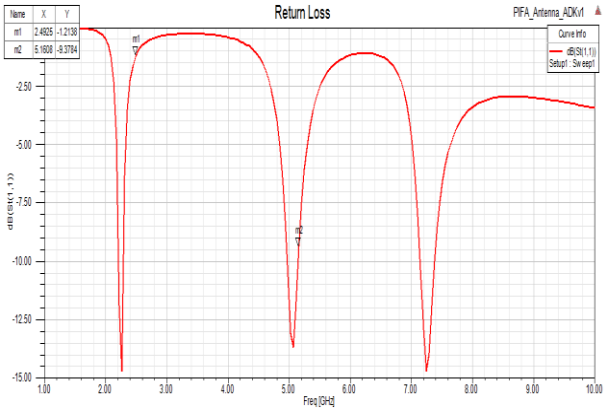

Chart -2: Return loss of PIFA with two slots

Fig -10: Radiation pattern for 2.3GHz for two slots PIFA

Fig -11: Radiation pattern for 5GHz for two slots PIFA

4.3. PIFA with three slots

PIFA with three slot is shown in the fig.12, corresponding return loss is shown in chart.3. 3D plot for frequency 2.4 GHz 5.7GHz is shown in fig.13and 14 respectively.

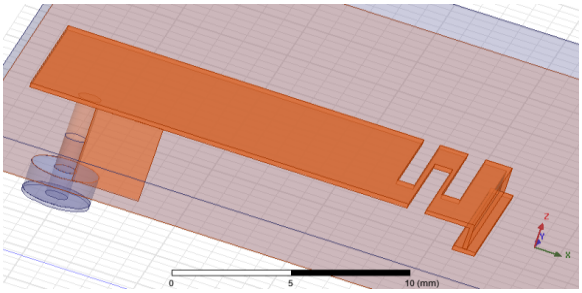

Fig.12 Top view of three slots PIFA

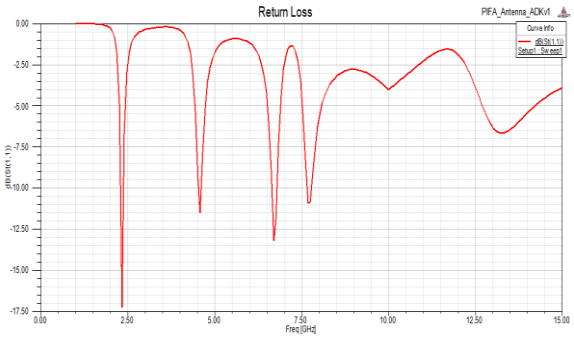

Chart -3: Return loss of PIFA with three slots

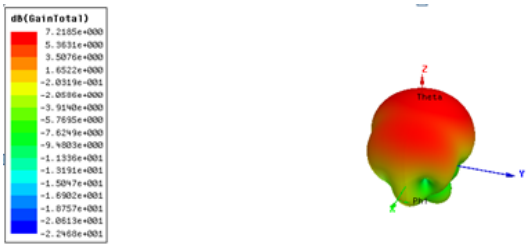

Fig -13. Radiation pattern for 2.2GHz for three slots PIFA

Fig -14. Radiation pattern for 4.8GHz for three slots PIFA

5. CONCLUSION

The main objective of this paper is to achieve a new structure that supports both ISM bands and supports 5G communication above 6GHz, .The antenna designed is compact in nature and because of its simplicity it is conformal to any type of surface. Continuous iteration using more slots shows increment in numbers of bands. But band started reducing for more than three slots. Also capacitive load helped in bandwidth enhancement.

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