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Analysis on the effect of change in dimension of capacitive load resonant frequency of PIFA

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Abstract: **This paper presents a planar inverted F-antenna which works on 900 MHz and 1800 MHz This paper analyses the changes in resonant frequency with the change in dimension of capacitive loading slot. It is observed that there is an apparent shift in the resonant frequency when the length of the slot is changed. As shown in fig. 1 the designed antenna is about the dimension of a standard mobile phone. Largest dimension of the antenna is 40 mm 80 mm. The patch is 8 mm above the ground plane. Dimension of the patch is 20mm x 40 mm. The substrate used is air (dielectric constant=1.0006). The design and simulations are done by using HFSS..**

Keywords: **specific absorption rate, return loss, input impedance.**

1. Introduction

An antenna is “usually a metallic device (as a wire or rod) for radiating or receiving radio waves.” The antenna is also defined as “a means for radiating or receiving radio waves”. Planar inverted F-antenna is a type of mobile antenna. There are three types of mobile antenna.

A. Monopole antenna
B. Inverted F-antenna
C. Planar inverted F-antenna

MONOPOLE ANTENNA

Monopole antenna is considered as a straight wire with desired features such as low cost, less weight and high efficiency which has made it widely used in cellular phone handsets and its dimensions plays a significant role in the overall performance of the antenna.

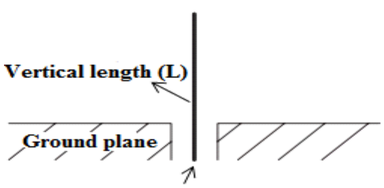

Figure 1 Monopole Antenna

INVERTED F-ANTENNA:

Inverted f-antenna is derived from monopole antenna with the aim of providing good matching and most importantly to decrease the size of the monopole antenna. It also contains a shorting strip that act as an inductor.

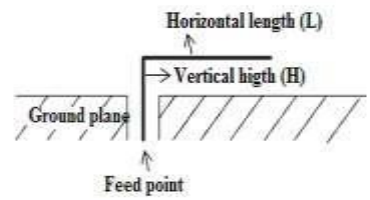

Figure 2 Inverted F antenna

PLANAR INVERTED F-ANTENNA:

Inverted F-antenna (IFA) antenna would be introduced first for better understanding of PIFA antenna. Essentially, IFA antenna is derived from monopole antenna with the aim of providing good matching and most importantly, to decrease the size of the monopole antenna for easy integration into the small mobile terminals. The PIFA antenna can be described as the modification of the IFA antenna. It can be achieved by removing the radiating linear horizontal strip of the IFA antenna and replace it with a rectangular planar or patch element which is often placed parallel to the conducting ground plane. A planar inverted F antenna can be derived from a micro strip patch antenna as in the fig.

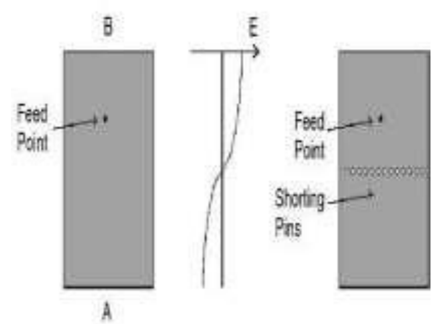

Figure 3 Evolution of PIFA from Micro strip patch

2. Capacitive Loading

In electronics, capacitive loading is the practice of designing the input impedance of an electrical load or the output impedance of its corresponding signal source to maximize the power transfer or minimize signal reflection from the load.

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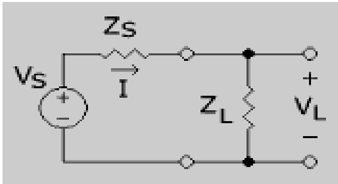

Figure 4 Impedance Matching

in the case of complex source impedance and load maximum power transfer is obtained when

*

Where the asterisk indicates the complex conjugate of the variable and represents the characteristic impedance of a transmission line.

Minimum reflection is obtained when

The concept of impedance matching found first application in electrical engineering, but is relevant in other applications in which a form of energy, not necessarily electrical, is transferred between a source and a load.

3. Antenna Geometry

As shown in fig. 1 the designed antenna is about the dimension of a standard mobile phone. Largest dimension of the antenna is 40 mm 80 mm. The patch is 8 mm above the ground plane. Dimension of the patch is 22 mm x 40 mm. The substrate used is air. Dielectric constant of air is 1.0006. The antenna is fed through a lumped port. is the width of the rectangular port. A shorting strip of width is kept 9 mm away from the feeding port. Shorting strip serves the purpose of matching the impedance of the feed to that of the antenna. Also it helps to keep the size of the overall patch smaller.

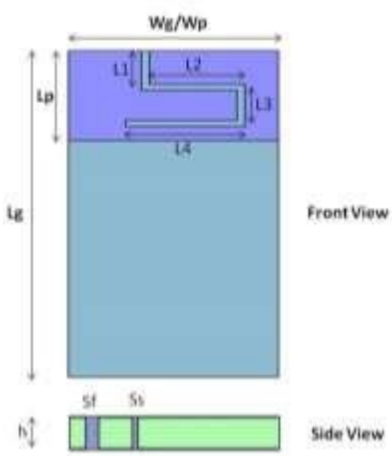

Figure 5 Antenna Dimension

The designed antenna contains a capacitive load in the form of a stub at the centre of the patch. Following section proves that how the change in the dimension of this stub affects the resonant frequencies.

Table 1 Antenna Dimension

Notation (length)	Size (mm)
Wg	40
Lg	80
Wp	40
Lp	22
h	8
Ss	1
	2.5
L1	9.5
L2	18
L3	10.5
L4	22.5

4. Effect of variation in the dimension of capacitive stub on S11

Design and simulation are done on HFSS 11.1.1. It is one of the many standard EM-CAD tools.

By varying the length of the stub it is observed that frequency increases with decrease in stub length. As shown in table 2.

Table 2 Resonant Frequency vs. Stub length

S.No	L2	L4	F1 (GHz)	F2 (GHz)
1	17	21.5	0.907	1.865
2	18	22.5	0.899	1.804
3	19	23.5	0.876	1.735

Return loss gives an estimate of the loss of power in the signal returned or reflected by discontinuity in transmission line (i.e. S11 parameter). Return loss of an antenna tells how much supplied power is not used by the antenna. The proposed planar inverted F antenna has return loss of 16.8747 dB at 900 MHz and -20.6357 at 1800 MHz

Figure 6 show the graphs of return loss that also helps to observe resonant frequency. The antenna simulation is done by varying stub length where S.No.1 (a) has L2=17mm and L4=21.5mm, S.No.2 (b) has L2=18mm and L4=22.5mm & S.No.3 (c) L2=19mm and L4=23.5mm.

It is proved from table 1 that a variation of 1 mm in the capacitive stub dimension results in a change of about 60 MHz in the resonant frequency.

Literature survey and simulation results strengthen this fact.

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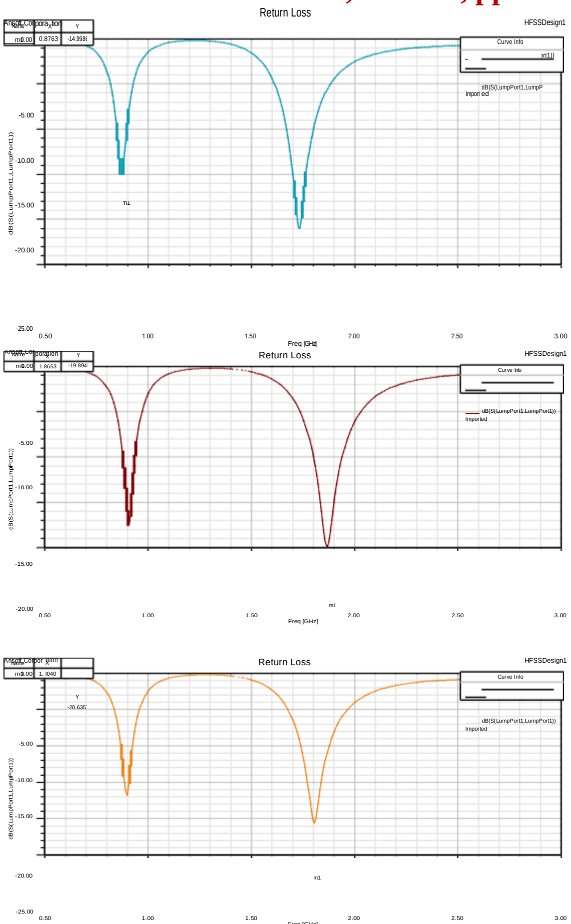

(a)

(b)

(c)

Figure 6 Return loss (refer Table 1) (a) S No. 1 (b) S. No. 2 (c) S. No. 3

Conclusion

The work presented here successfully proves that in capacitive loaded PIFA one can customize the operating frequencies by varying the dimension of the patch and the dimension of the capacitive slot. This work may prove useful to the people who are trying to design a multiband planar inverted-F antenna.

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