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Planar Inverted-F Antenna Design for GSM900 and GSM1800 Frequency Bands for Mobile Handset

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***Abstract*-- This paper Aim to design and simulate a miniaturized Planar Inverted-F Antenna (PIFA) using HFSS for the use in GSM900 band and DCS1800 band. The simulation will involve the characterization of the designed antenna and the computing of different antenna parameters like S11 parameter, resonant frequency, SWR, bandwidth impedance in feeding point, gain, 2D and 3D diagram pattern, Fields distribution describes the design and simulation by HFSS simulator of a probe-fed Planar Inverted-F Antenna (PIFA) for the use in GSM900 band [890 MHz - 960 MHz] and DCS1800 band [1710 MHz - 1880 MHz].**

I. Introduction

An antenna is defined by Webster's Dictionary as "a usually metallic device (as a rod or wire) for radiating or receiving radio waves." The *IEEE Standard Definitions of Terms for Antennas* (IEEE Std 145–1983) defines the antenna as "a means for radiating or receiving radio waves". In other words the antenna is the transitional structure between free-space and a guiding device. The guiding device or transmission line may take the form of a coaxial line or a hollow pipe (waveguide), and it is used to transport electromagnetic energy from the transmitting source to the antenna or from the antenna to the receiver. In the former case, we have a transmitting antenna and in the latter a receiving antenna. To receiving or transmitting energy, an antenna in an advanced wireless system is usually required to optimize or accentuate the radiation energy in some directions and suppress it in others. Thus the antenna must also serve as a directional antenna in addition to a probing device. Antenna is one of the most critical components for wireless communication systems [1].

1.1. Mobile Antenna

The aim of this chapter is to give theory and expressions related to the mobile antenna structures that are common to mobile handheld devices. The selected mobile antenna antennas structures are the planar inverted-F antenna (PIFA). Loop and monopole antennas are also used in mobile phones[2]. In this chapter, design considerations for the mobile antennas and antenna matching circuits are also introduced.

The explanation starts with a monopole antenna which then is bent to make inverted L antenna. Finally the L shaped antenna is modified to make an inverted F antenna [3].

II. Platform Used

HFSS 11.1 is used in this dissertation to design and simulate the proposed antenna. HFSS is an interactive software package for calculating the electromagnetic behavior of a structure. The software includes post-processing commands for analyzing this behavior in detail[4] .

Using HFSS, one can compute:

- Basic electromagnetic field quantities and, for open boundary problems, radiated near and far fields.
- Characteristic port impedances and propagation constants.
- Generalized S-parameters and S-parameters renormalized to specific port impedances.
- The eigenmodes, or resonances, of a structure.

User is expected to draw the structure, specify material characteristics for each object, and identify ports and special surface characteristics. HFSS then generates the necessary field solutions and associated port characteristics and S-parameters [5].

III. 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 × 40 mm. The substrate used is air. Dielectric constant of air is 1.0006[6]. The antenna is fed through a lumped port. S_f is the width of the rectangular port. A shorting strip of width S_s 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.

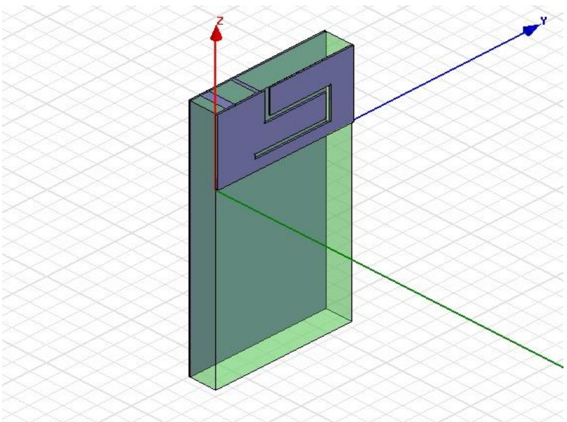

Fig. 1. 3D view of designed antenna

Fig. 2 shows the detailed diagram of the PIFA top patch[7]. To make a PIFA antenna work on multiple bands many methods can be used. The method used here is making slot cuts. The slots result in spur lines that develop various current paths. The path of the current helps in guessing the expected resonant frequencies. The electrical length of the antenna generates the lower band while the upper resonance is realized by an induced mode on the inner element.

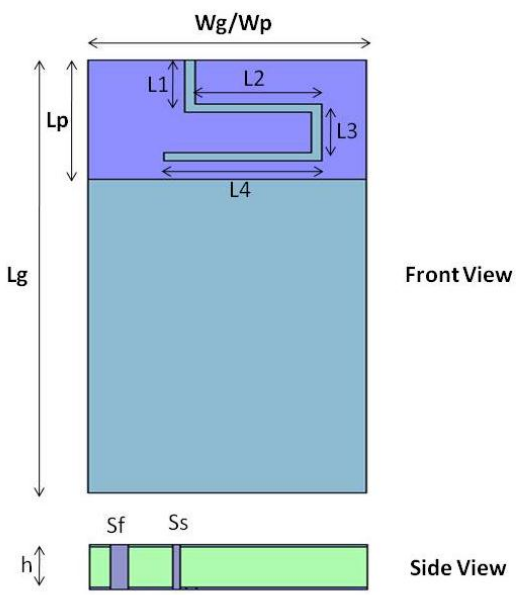

Fig. 2 Dimensions of the PIFA patch

Fig 1 shows the top view and side view of the designed antenna.

Table 1 shows the value of the notations used in fig. 2.

Table 1 :
Value of Notations

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

IV. DESIGN METHODOLOGY

This chapter discusses the design process of the antenna, especially how the patch is created[8].

Step I: Create a box of dimension 0.2 mm x 40 mm x 22 mm as shown in fig 8. This is the base shape of the rectangular patch. 0.2 mm is the thickness of the patch.

Fig. 3 Step I: Original Patch

Step II: Create a strip of dimension 14 mm away from the left edge of the patch as shown in fig.4. The dimension of the strip should be 0.2 mm x 1.5 mm x 9.5 mm.

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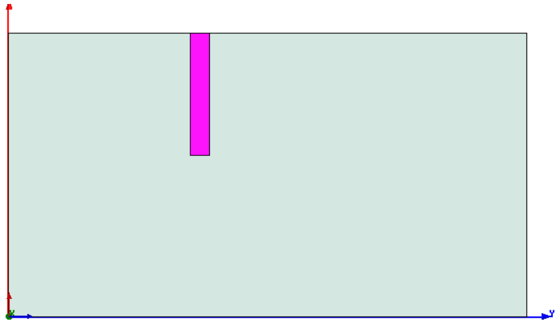

Fig. 4 Step II: Slot 1

Step III: Create second strip 8 mm away from top edge of the patch as shown in fig 5. Dimension of the strip should be 0.2 mm x 19.5 mm x 1.5 mm.

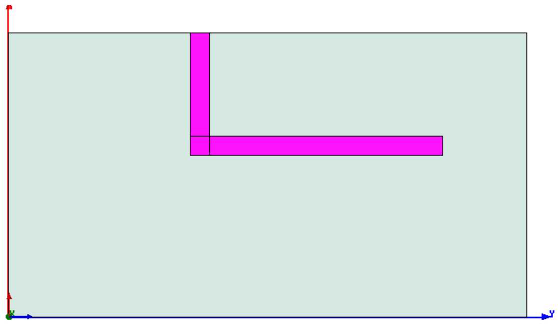

Fig. 5 Step III Slot 2

Step IV: Create third strip 32 mm away from left edge and 8 mm away from the top edge of the patch as shown in fig 6. Dimension of the strip should be 0.2 mm x 1.5 mm x 10.5 mm.

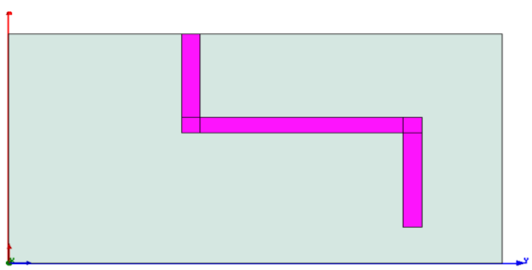

Fig. 6 Step IV Slot 3

Step V: Create fourth strip 11 mm away from left edge and 17 mm away from the top edge of the patch as shown in fig 7. Dimension of the strip should be 0.2 mm x 22.5 mm x 1.5 mm.

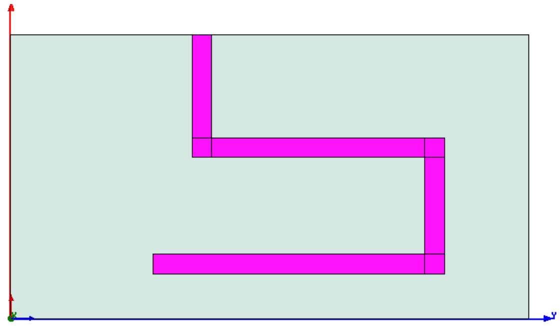

Fig. 7 Step V Slot 4

Step VI: Select all the above drawn slots and unite them as shown in fig 8.

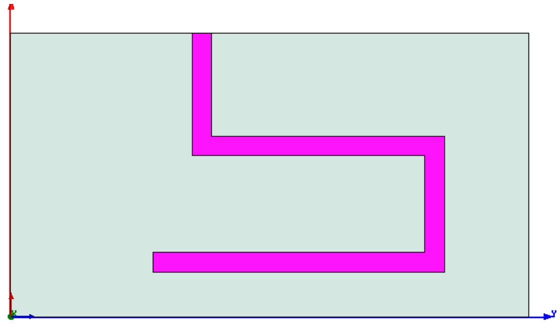

Fig. 8 Step VI United stripes

Step VII: Subtract this united shape from the original patch to get the shape as shown in figure 9. This will result in the desired slotted patch.

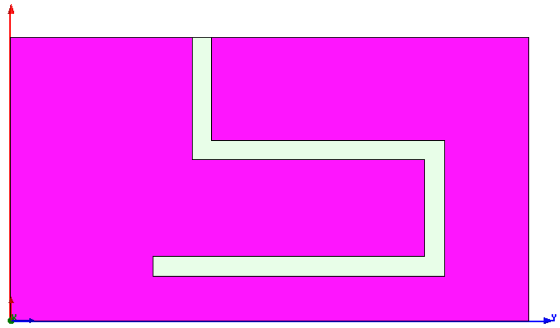

Fig. 9 Step VII Created slot in patch

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V. SIMULATION RESULTS

5.1 Return Loss:

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)[9]. 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. (Fig 10)

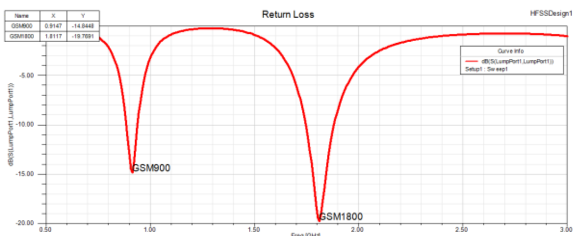

Fig. 10 Return Loss at GSM900 and GSM1800

Radiation Pattern

Fig.11 shows the E plane and H plane radiation pattern of the designed antenna. It is the plot of radiation intensity on a polar plot. It can be observed that the radiation pattern in nearly omnidirectional.

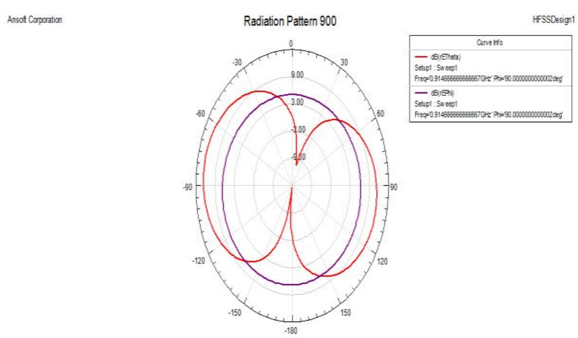

Fig. 11 Polar Radiation Pattern at 900 MHz

VI. CONCLUSION

The present work focuses on design and simulation of a miniaturized Planar Inverted –F Antenna (PIFA) using HFSS.The analysis on various parameters like S11 parameter, resonant frequency, SWR, bandwidth impedance in feeding point, gain, 2D and 3D diagram pattern is undertaken.

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