# Design and Simulation of Cutting Slot Dual-Band PIFA Antenna for GSM System

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*Abstract*—**In this paper, a new design of a dual band Planner Inverted –F Antenna (PIFA), for GSM systems is presented. The PIFA antenna be consist of ground plane, patch antenna, feeding port and shorting plate connected to the ground plate. The designed antenna has been simulated with the help of the CST 2010 software. The simulated results calculated for the resonant frequency, return loss, radiation pattern and gain are presented and discussed. The bandwidths of 99MHz and 168MHz for GSM900 and GSM1900 respectively. A gain of 1.852dB and 4.88dB is obtained in lower and higher frequency respectively.**

***Keywords-component; PIFA antenna ;Dual band antenna ;GSM900 and GSM1900 systems***

## I. INTRODUCTION

Wireless communications have progressed very rapidly in modern years, and many mobile devices are becoming smaller and smaller. To meet the miniaturization requirement, the antennas employed in mobile terminals must have their dimensions reduced accordingly [1]-[8]. Planar antennas, such as microstrip and printed antennas have the attractive features of low profile, small size, and conformability to mounting hosts along with very promising candidates for satisfying this design consideration. Planar antennas are very attractive for applications in communication devices for wide mobile telecommunications similar to GSM, wireless local area network, aeronautics and embedded systems [2]. Mobile telephone antennas that can be integrated into the handset offer several advantages compared to conventional external antennas such as monopoles or helix [2]–[3]. They are easily broken off, reduce power absorption by head, and are less sensitive to the geometry of the handset. A appropriate candidate for an integrated antenna is the planar inverted F antenna (PIFA)[4], but it is still considered too large for applications at 900 MHz Additionally, in lots of parts of the world mobile telephone systems have been allocated spectrum centered around both 900 MHz (cellular systems) and 1900 MHz (personal communication systems) with the corresponding demand that mobile telephones operate in both bands[5]-[6]. Here we investigate the design of an integrated compact antenna suitable for mobile telephones operating at 900 MHz we also describe a modification to this design that allows it to be used at dual frequencies in the 900- and 1800-MHz mobile telephone bands.

## II. ANTENNA DESIGN

The antenna is designed using CST Microwave Studio 2010 software[9]. The specifications of key elements for the design of the rectangular planar inverted -F antenna is listed in Table1.

TABLE I. SPECIFICATIONS OF (PIFA) PARAMETERS.

| | |
|---|---|
| Shape | Rectangular |
| Frequency of operation | GSM900 & GSM1900 |
| Dielectric constant of substrate | 4.3 (FR4) |

| | |
|---|---|
| Height of dielectric substrate | 1.6mm |
| Feed method | Prove feed |
| Air gap | 8mm |

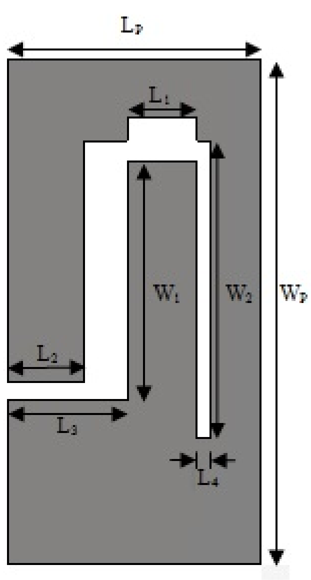
## III. ANTENNA GEOMETRY

The geometry of the proposed antenna is shown in Fig. 1. It composed of ground planes, patch antenna, feeding post, and shorting plate connecting the ground plane. As a design procedure, the initial patch size is to be determined to obtain certain resonant frequency ($f_r$) using the following equation[7].

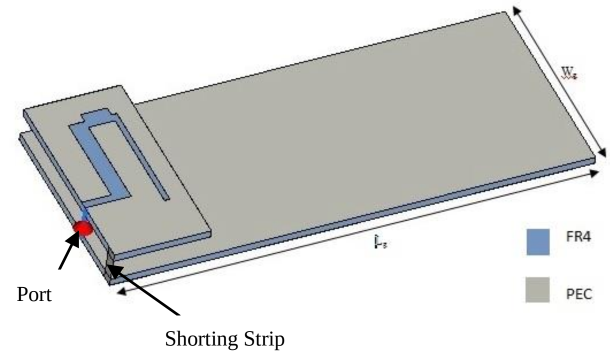
$$f_r = C/4(L+W) \quad \ldots\ldots\ldots\ldots..(1)$$

Where C, L and W are velocity of light, length and width of the patch element respectively.

The dimension of the proposed PIFA is 20mm ×40 mm and is located 8mm above the ground plate. The size of ground plate is 100mm× 40mm×1.6mm and is metalized on the front surface to provide an RF ground. The proposed PIFA antenna is optimized to operate at resonant frequency of 0.9GHz and 1.9GHz to cover the dual-band of GSM900 and GSM1900. The proposed antenna is fed by 50Ω coaxial probe feeding structure.




(a)




(b)

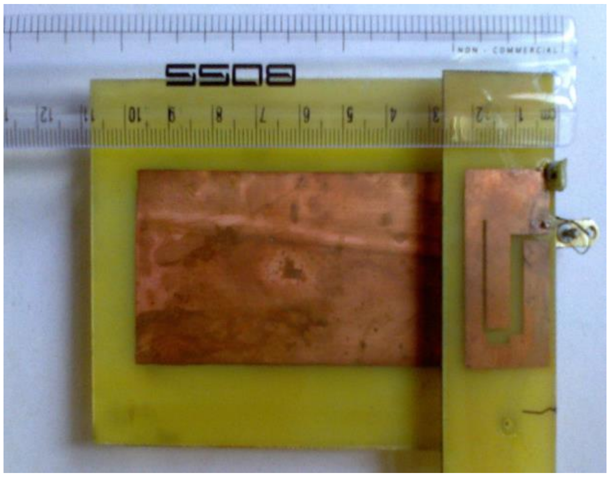
Figure(1). Geometry of proposed PIFA antenna(a)patch antenna, (b)3-d view of PIFA antenna.

The PIFA has been designed with a specification mentioned in table 2.

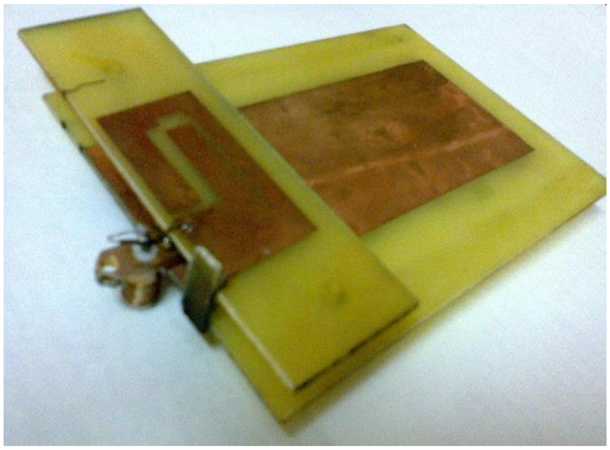
| Parameter | Value(mm) |
|---|---|
| $L_P$ | 20 |
| $W_P$ | 40 |
| $L_g$ | 100 |
| $W_g$ | 40 |
| $L_1$ | 5.5 |
| $L_2$ | 6.1 |
| $L_3$ | 9.5 |
| $L_4$ | 1.1 |
| $W_1$ | 20.5 |
| $W_2$ | 23.5 |
| $W_S$ | 2.358 |

After the simulation, the antenna has been fabricated. The Printed Circuit Board (PCB) of FR4 with a copper coating of 0.038 mm has been used for both ground and patch. The fabricated antenna is pictured in figure (2). After etching and soldering, the antenna has been examined with the Network Analyzer.



(a)

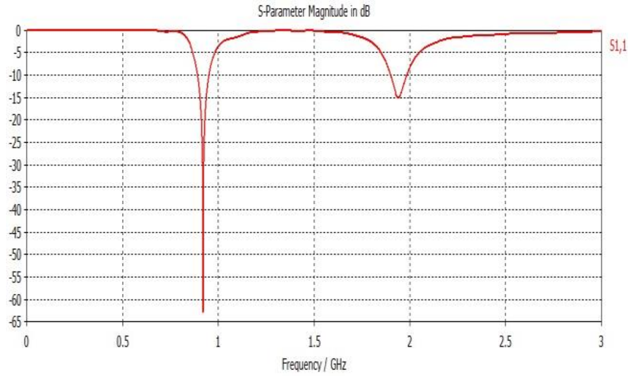


(b)

Figure (2). Picture of fabricated antenna (a) Top view, (b) 3-d view.

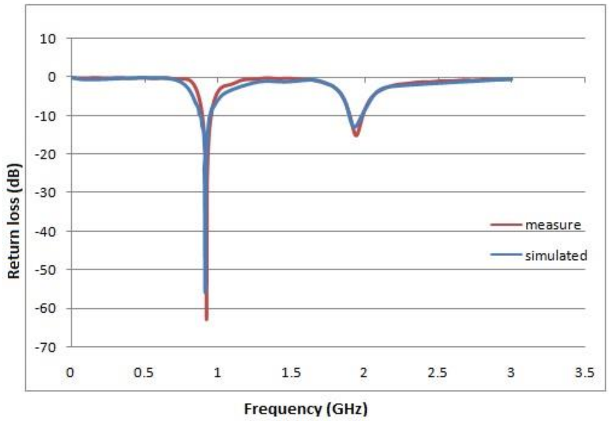
## IV. SIMULATION AND EXPERIMENTAL RESULTS

The proposed antenna has been analyzed and optimized using 3D Electromagnetic Field Simulator (CST Microwave Studio 2010). The corresponding return loss (S11) parameter of the proposed antenna is shown in Fig.3. Fig 4 shows comparison between the return loss of the simulated result by CST and measured result by using spectrum analyzer of the proposed antenna from 0 to 3 GHz, using a 50Ω SMA (Sub Miniature version A) connector at port 1. Obviously, two dips are clearly seen at frequencies of 0.921 GHz and 1.941 GHz. The lower mode has an impedance bandwidth ( -6dB return loss) of 99 MHz (0.874-0.973 GHz), or about 12.3% with respect to the resonance frequency of at 0.921 GHz, while for the higher mode, a wider continuous bandwidth has been reached to be 168 MHz (1.86-2.03 GHz), or about 9.13% with respect to resonance frequency of 1.941 GHz. The obtained bandwidths can sufficiently cover the bandwidth requirement for GSM900 and GSM1900.




Figure(3).simulated result of proposed antenna.

The following plot shows the S – parameters as a function of frequency. The minimum acceptable value of S-parameter is -10dB and the -15dB is a better acceptable result. In this paper the two bands are obtained at 0.921GHz, and 1.941GHz with value of S11 are -62.78dB, and -15.03dB.




Figure(4).simulated and measured result of proposed PIFA antenna.

The corresponding return loss (S11) parameter of the proposed antenna and combine result of simulated and measure result is shown in figure(4). The measured results are almost similar to the simulated results. The differences between the simulated and measured results are mainly because of the fabrication inaccuracies and due to some losses.

The effect of varying the air gap (h) from 5mm to 11mm on the return loss is shown in Fig.(5) for GSM900 and GSM1900.

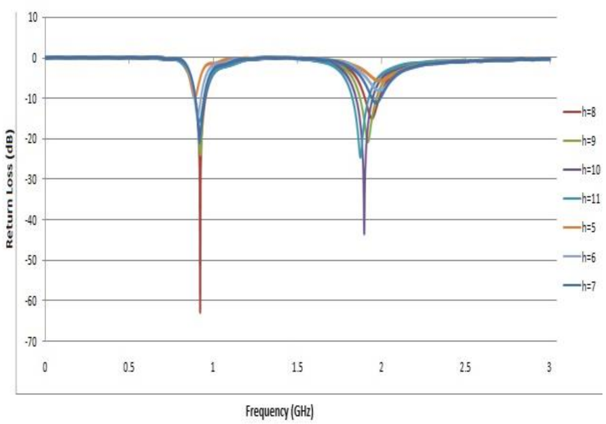
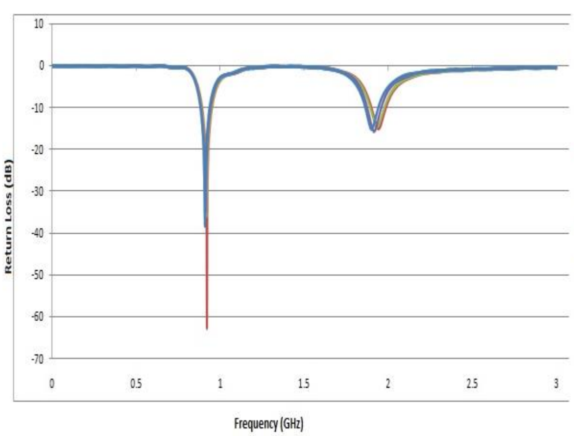



Figure (5). Simulated return loss as a function with variation in the height of proposed antenna.

From Fig.(5), it is clear that the optimal air gap is 8mm for the antenna.

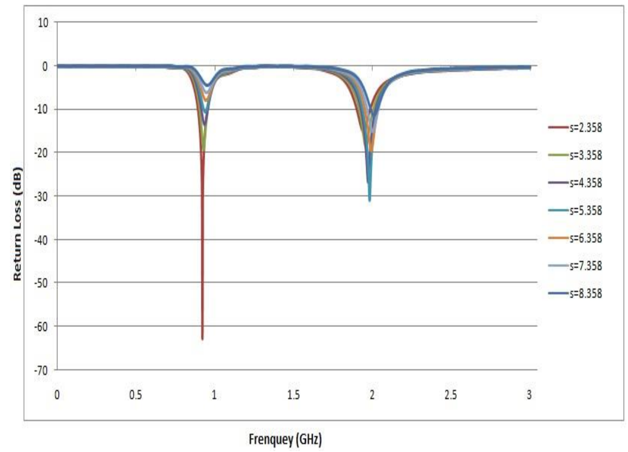
The effect of varying the position (p) of port from 8.5mm to 12.5mm on the return loss is shown in Fig.(6) For GSM900 and GSM1900.




Figure(6). Simulated return loss as a function with variation in the position of port of proposed antenna.

The effect of the short wall width (s) on the return loss is also investigation.

The simulation result is shown in Fig.(7) for GSM900 and GSM1900. From Fig.(7), the optimized width chosen for proposed PIFA antenna is 2.358mm.




Figure(7) Simulated return loss as a function with variation in the width of shorting strip of the proposed antenna.

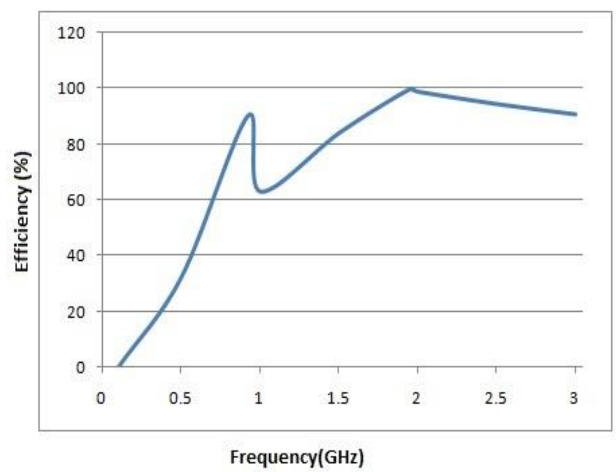
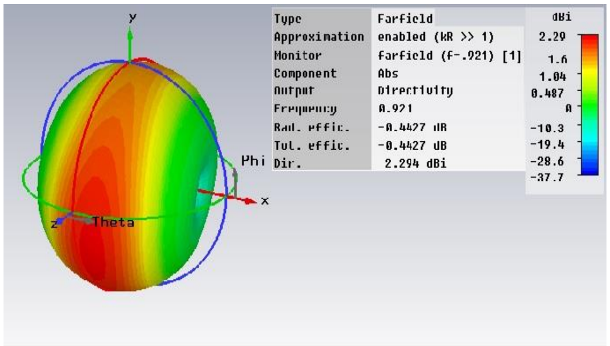



Figure (8), Variation of efficiency with frequency of the proposed antenna in 0-3 GHz.

from Fig(8), the efficiency of antenna are 90.30% at 0.921GHz and 99.64% at 1.941GHz

## V. RADIATION PATTERNS, DIRECTIVITY AND RADIATING FIELD OF ANTENNA

Directivity is the same as gain, but with one difference. It does not include the effect of power loss (inefficiency) in the antenna. If an antenna were lossless (100% efficient), then the gain and directivity (in a given direction) would be same. The directivity for this antenna is 2.294 dBi, and 4.895 dBi at the frequency of 0.921GHz, and 1.941 GHz respectively. The farfield associated with the radiated field in the space from the antenna.

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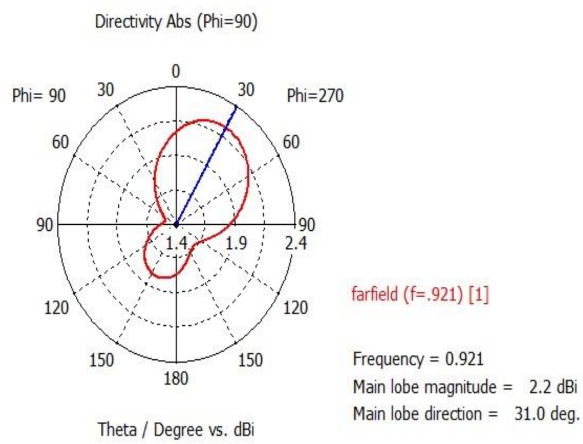


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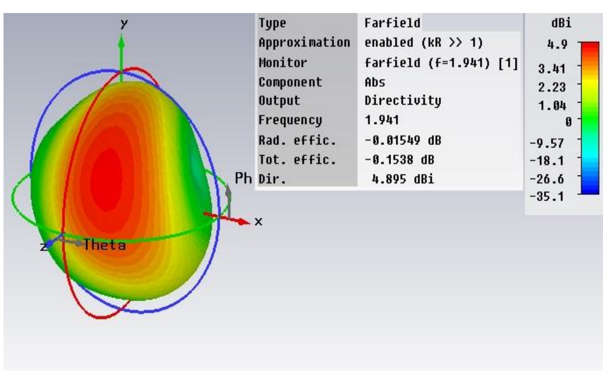


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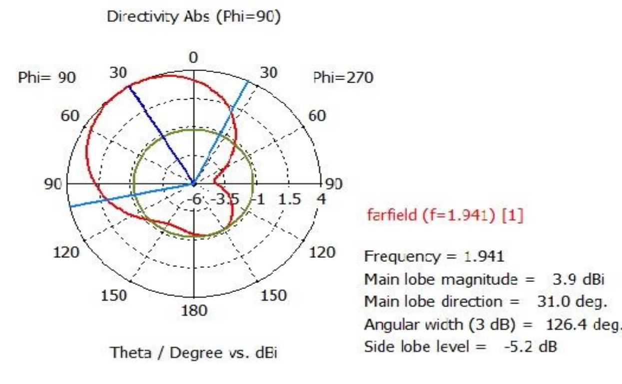


(d)

Figure(5). Simulated radiation pattern for the proposed Antenna at (a)3-D at 921MHz (b) polar plot at 921MHz (c)3-D at 1.941GHz (d)polar plot at 1.941GHz

## VI. CONCLUSION

In this paper, a novel multi-band PIFA has been designed and manufactured to satisfy the requirements of GSM900 and GSM1900 services at the same time. Simulation and measurement results have shown that the antenna has stable radiation pattern, high efficiency, and high gain in all the operating frequency bands. It is also investigated that the air gap, width of shorting strip and the position of port are a frequency dependent parameter which effects the bandwidth and return loss of the antenna.

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