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STUDY AND DESIGN OF SINGLE SLOT AND DUAL SLOT PIFA ANTENNAS

Amrita Dixit[1], Nitin Kathuria[2], V.K.Pandey[3]

[1]*PG Student in Digital communication, JSS Academy of Technical Education, Noida (India)*

[2]*Assistant Professor, Department of ECE AIMT, Greater Noida (India)*

[3] *Professor& Dean, Department of ECE NIET, Greater Noida (India)*

ABSTRACT

A comparative study and design of single slot and dual slot on a ground plane of PIFA antenna presented. Simulations is done using HFSS Design tool which works on the principle of Finite Element Method. Created slots on the ground plane have different functions at different frequencies ie at Low Frequencies it acts as a resonance circuit and at high frequencies it acts as parasitic radiators. Antenna are designed and simulated for both low frequencies (GSM850 and GSM900) and high frequencies spanning from DCS1800 to Bluetooth, and also including PCS1900, UMTS2000, and other possible systems. Comparison of bandwidth is done for single slot and Doulble slot PIFAAntenna. Simulation done is on the basis of Varying the feed Point in order to find out the Triband PIFA Antenna with mathched Impedance.

Index Terms: PIFA, Triband, Quadband, RF Antenna.

I. INTRODUCTION

The future generations of mobile phones will need to operate over as much frequency bands as possible, such as GSM850, GSM900, DCS1800, PCS1900, UMTS, WIMAX and Bluetooth, among others. In general, the PIFA determine the number of frequencies bands, while, in the absence of slots, the ground plane (also referred as PCB: Printed Circuit Board) dimensions determine bandwidth, particularly at the lower frequencies [1], [2]. Most of the work has been done on antenna design [9], but the ground plane (both its dimensions and its modification [3]–[11]) offers another design variable.

The antenna design is mainly determined by the PCB dimensions, which are fixed by the size of the handset or wireless device. An important limitation is the antenna height, which should be small for the new generation of ultra-slim phones that are now appearing into the market. Moreover, the new mobile phones incorporate all kinds of extra services, such as photo-video cameras, big displays to watch television and several speakers for high-fidelity audio which reduce the available space to fit the antenna. Therefore new techniques are needed in order to achieve a maximum bandwidth with an antenna that occupies the smallest space possible.

To enhance the bandwidth of a handset antenna, [6] propose the insertion of a slot on the ground plane of a mono-band PIFA. Such a slot tunes the PCB to resonate at a frequency similar to that of the PIFA, in order to finally obtain a broad-band behavior, covering the GSM850–900 band.

A possible drawback of the design is the fact that the PCB is full of slots, which may interfere with the placement of electronic components such as the battery, the display, RF chips, etc. Another example of an antenna design that uses a slotted ground plane is found in [9], where it is used to improve a conventional design for a dual-band operation antenna (GSM900-DCS1800) to a quad-band design (GSM850-GSM900-DCS1800-DCS1900). In this case, the slot on the ground plane has a double function. On one hand it tunes the PCB to resonate at low frequencies[1] (around 900 MHz), improving the bandwidth; on the other hand, since the slot is comparable to $\lambda/4$ at high frequencies, with enough coupling to the PIFA, the bandwidth at high frequencies is improved. The slot is placed underneath the PIFA to create enough coupling with it at high frequencies and to facilitate component integration [10]–[11].

Slots on the ground plane have been used as antennas with sufficient bandwidth to cover a specific frequency band [8] to modify the fundamental resonant mode in order to obtain a bandwidth enhancement at low frequencies (GSM850–900) and, at the same time, to act as a parasitic element of the antenna. Thus, a bandwidth enhancement is achieved at high frequencies (DCS1800–1900). In this paper, a new slot is added to the ground plane to enhance even more the bandwidth at high frequencies, reaching the UMTS and Blue-tooth bands.

This paper is organized as follows: Section II shows the new antenna structure, and section III discusses the simulated experimental results for its bandwidth, efficiency, and radiation patterns. Finally, the conclusions are detailed in Section IV.

II. ANTENNA STRUCTURE

Beginning from a reference antenna design proposed in [9] operating at the GSM850, GSM900, DCS1800 and PCS1900 bands, a deeper study has been performed to achieve an antenna capable to operate at the UMTS and Bluetooth bands too.

The geometry of the proposed PIFA with a slotted ground plane is shown in Fig. 1. The radiating element consists of two branches: the narrower and inner one, which is tuned to operate around 900 MHz, and the wider and outer one, which is tuned to operate at frequencies around 1900 MHz. The PCB layer has a FR-4 composite (fiberglass substrate,ε=4.4), and its size is 100 mm $\times$ 40 mm to emulate the PCB of a typical mobile phone.

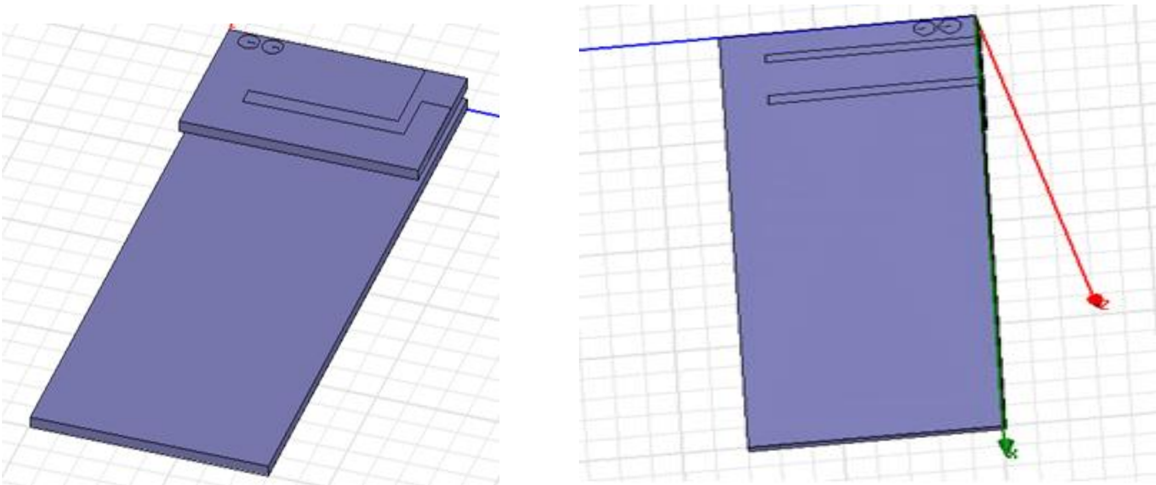


Fig. 1 Simulated Design

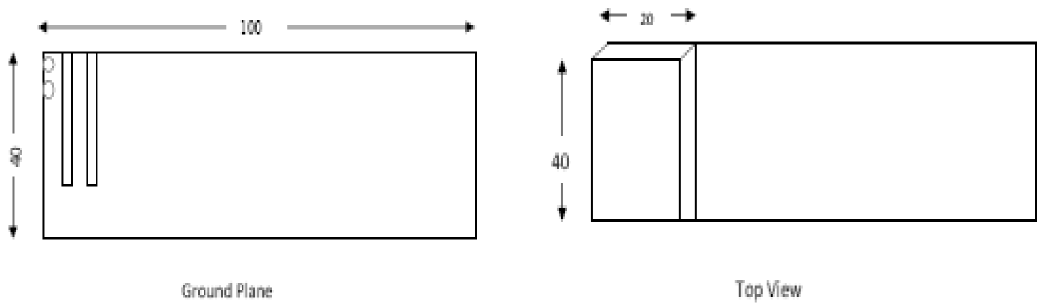


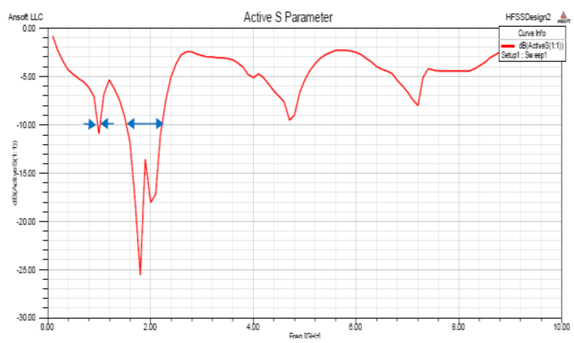
Fig. 2 Design Parameters

Table 1: Antenna Parameters with Dimensions.

S.No	Antenna Parameter	Length(mm)	Width(mm)
1	Ground	100	40
2	Patch	20	40
3	Pin	5	1
4	Feed	5	1
5	Slot 1	35	2
6	Slot 2	35	2

III. SIMULATION RESULTS

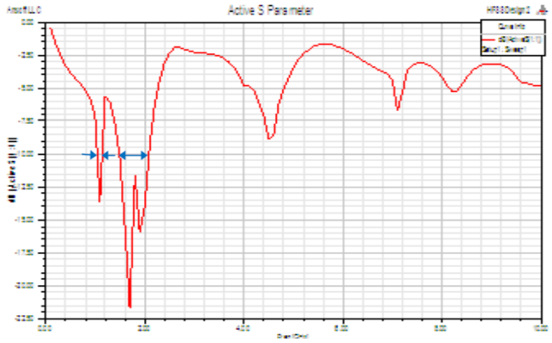
A, PIFA handset antenna on a slotted ground plane has been designed. The introduction of a slot on the PCB structure causes an alteration of the surface current distribution. Slot #1 is de-signed and placed to force a longer electrical path at low frequencies; thus, the resonant frequency of the fundamental mode of the PCB can be decreased. This positively affects the final frequency behavior because it results in a bandwidth enhancement [10] due to the resonance of the PCB itself at the GSM900 band. The slot length is tuned to make the PCB resonate at a frequency similar to that of the PIFA. This fact can be observed in the input impedance behavior on the Smith chart: a loop appears which improves the bandwidth in comparison with the original PIFA without slot #1.



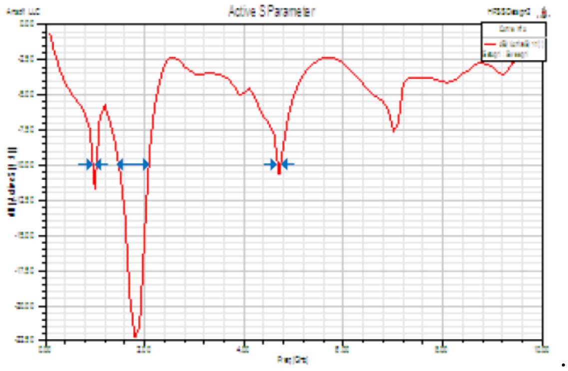
A. Covers Two Frequency Band of Bandwidth 100 Mhz and 600 Mhz.

Besides, the geometries of slot #1 and #2 are esigned to be $\lambda/4$ resonators at high frequencies, coupling their radiation to the PIFA: one slot radiates around 1.9 GHz and the other around 2.3 GHz. Thus, the antenna takes advantage of the slots as radiators that couple with the PIFA in order to enhance the bandwidth.

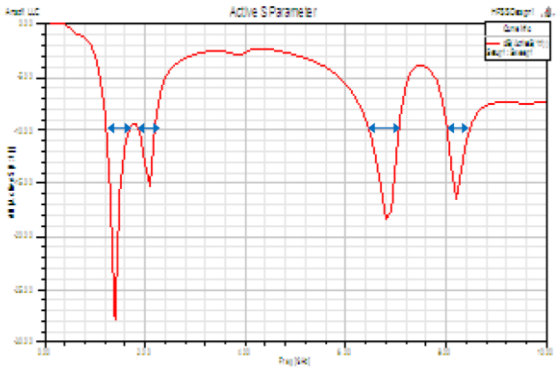
HFSS software has been used to simulate those physical behaviors difficult to observe in practice,



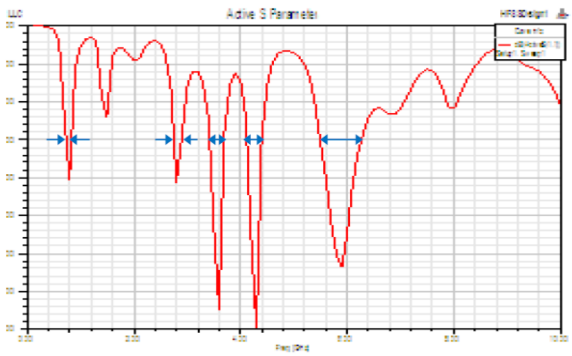
B. Covers Two Frequency Band of Bandwidth 200 Mhz and 800 Mhz



C. Covers Three Frequency Band of Bandwidth 200 Mhz, 600mhz and 50 Mhz.



D. Covers Four Frequency Band of Bandwidth 200 Mhz, 300mhz, 600 Mhz and 400 Mhz.



E. Covers Five Frequency Band of Bandwidth 100 Mhz, 100mhz, 300mhz, 300mhz and 700 Mhz.

Fig.3: (A, B, C, D, E) Return Loss For 10db Bandwidth for Single and Two Slot Antenna With Variable Feed Pointss

Table 2: Frequency Band and Bandwidth of Single And Two Slot Antennas with Variable Feed Points

S.No	No. of Slots	Frequency Band (GHz)	Bandwidth (MHz)
1	1	0.9-1.0 1.6-2.2	200 600
2	2	1.0-1.2 1.3-2.1	200 800
3	2	0.9-1.1 1.5-2.1 4.25-4.30	200 600 50
4	2	1.2-1.4 1.9-2.2 4.4-5.0 6.0-6.4	200 300 600 400
5	2	0.7-0.8 2.8-2.9 3.5-3.8 4.1-4.4 5.6-6.3	100 100 300 300 700

IV. CONCLUSION

In this paper, a built-in multiband handset antenna covering the GSM850 and GSM900 bands, and the continuous bandwidth spanning from the DCS1800 to the Bluetooth bands, has been presented by the variation in number of slots and position of feed point.

In this new antenna, a slotted ground plane is used to improve the bandwidth at both low and high frequencies without increasing the volume of the antenna. At low frequencies, the slot is below resonance, but forces the ground plane mode to be excited so as to increase the bandwidth at low frequencies; on the other hand, the slots are comparable to $\lambda/4$ at high frequencies, and therefore they enhance the bandwidth.

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