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Design of Compact Planar Inverted-F Antenna for Wireless Communication

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Abstract: *In this paper, we present a new form of planar inverted-F antenna (PIFA) for wireless communication. Recently, the need of compact antennas has been increased. PIFA have been used in compact applications. But narrow bandwidth is the major drawback of the Conventional PIFA. In order to overcome drawback of PIFA, slots have been introduced on the radiating element. Overall size of the proposed design is 30mm×20mm×2mm. Here shapes like E-Slot, I-slot, F-slot, I-slot have been introduced in the radiating element of PIFA. The insertion of slots with various forms on the radiation element allows the creation of new resonances frequencies. By introducing slots in PIFA, it supports GSM, Wi-max and UWB frequency bands. The antenna simulation was conducted using CAD FEKO.*

Keywords: *Planar Inverted F-Antenna (PIFA), FEKO, S-Parameter, Frequency Enhancement, Bandwidth, Impedance.*

1. INTRODUCTION

With the rapid development of wireless communications, portable wireless device has become more complex. The antenna space on the circuit board was limited and the antenna had height restrictions. Hence a compact antenna without ground clearance was demanded in recent years. The planar inverted-F antenna (PIFA) is popular for wireless communications because of its low profile, simple design, low-cost, and convenient fabrication. It is well known that the bandwidth of the PIFAs is proportioned to the substrate thickness. A new built-in quad-band handset antenna for covering GSM900, DCS1800, PCS1900, and UMTS2000 bands has been proposed, the simulation is based on the finite-difference time-domain (FDTD) method [3]. A compact multiband planar monopole antenna has been designed which covers the (GSM /DCS /PCS /UMTS /Bluetooth /WLANs /Wi-MAX) frequency bands [4]. A prototype is designed and built featuring behavior suitable for low frequencies (GSM850 and GSM900) and for high frequencies .Spanning from DCS1800 to Bluetooth, and including, for instance, PCS1900, UMTS2000, and other possible systems. The frequency range is between 900 to 1800GHz [11]. There are some common methods to enhance the bandwidth of the Conventional PIFA.They are: capacitive loading, adding chip resistor loading dielectric with high permittivity, introducing slots. In this paper the shapes like E-slot, I-slot, W-slot and F slot have been introduced in the radiating patch of the Conventional PIFA through this the bandwidth and efficiency have been improved.

The paper is organized as follows. Section II gives the structure and design parameter of the Conventional PIFA and the PIFA with slots. In the section III it is briefly discussed about the results of the conventional PIFA and PIFA with Slots. Finally in the section IV the summary of the work is provided.

2. ANTENNA DESIGN

Antenna design for mobile handsets can be of two types- internal and external. One of the main disadvantage of external antenna is it is very close to the user's head and the radiation is directly incident on the head making the absorption rate high. Internal antenna can be installed on the side of the PCB i.e. opposite to the human head thus avoiding the human interference. One of the techniques to obtain multiband behavior for handset antennas is to create several resonant paths. The specification of the internal antenna depends strongly on the design of mobile phones and changes have to be made for each design. Moreover the internal antenna is difficult to design than its counterpart because the designer must consider characteristics such as feed point, ground position, radiation pattern, etc.

2.1. Design of PIFA Using CAD FEKO

The Fig.1 the given below is the design of the conventional PIFA which have been taken from the FEKO simulation software.

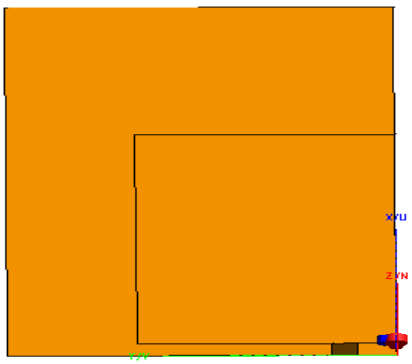

Figure 1: PIFA in CAD FEKO

Here the feed pin and substrate are place in between the ground plane and radiating patch of the antenna.

Table 1. PIFA Dimensions

Parameters	Value in mm
Lg	50
Wg	30
Lp	30
Wp	20
Lf	1
Wf	2
Ls	2
Ws	2

The design values of PIFA have been given in the Table 1.The Lg and Wg are length and width of the ground plane respectively. Lp and Wp are length and width of the radiating patch respectively. Lf and Wf are length and width of the feed respectively. Ls and Ws are length and width of the shorting pin respectively.

2.2. Design of PIFA with E Slot Using CAD FEKO

This figure is the design of PIFA with E-Shape slot on the radiating patch which used to enhance the frequency range of the PIFA.

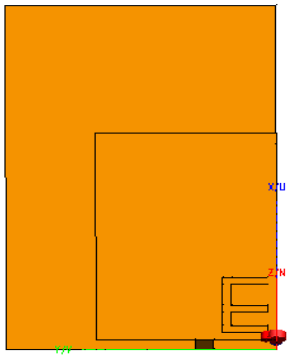

Figure 2: PIFA with E slot in CAD FEKO

Table 2: PIFA with E Shape Slot Dimensions

Parameters	Value in mm
Lg	50
Wg	30
Lp	30
Wp	20
Lf	1
Wf	2
Ls	2
Ws	2
A1	8
B1	5

The design value of PIFA has been given in the Table 2. Here from the table Lg and Wg are length and width of the ground plane respectively. Lp and Wp are length and width of the radiating patch plane respectively. Lf and Wf are length and width of the feed respectively. Ls and Ws are length and width of the shorting pin respectively.A1 and B1 are the slot dimension.

2.3. Design of PIFA with W Slot Using CAD FEKO

The Conventional PIFA with W shape slot on the radiating patch have been given in the fig.3

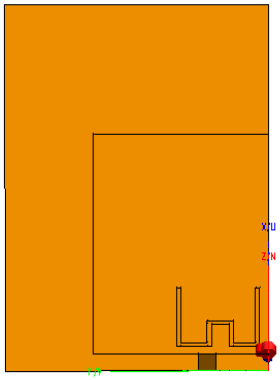

Figure 3: PIFA with W slot in CAD FEKO

Table 3: PIFA with W Shape Slot Dimensions

Parameters	Value in mm
Lg	50
Wg	30
Lp	30
Wp	20
Lf	1
Wf	2
Ls	2
Ws	2
A1	3
A2	3
B1	3
B2	8

The design values of PIFA have been given in the table. Here from the table.3 Lg and Wg are length and width of the ground plane respectively. Lp and Wp are length and width of the radiating patch plane respectively. Lf and Wf are length and width of the feed respectively. Ls and Ws are length and width of the shorting pin respectively. A1, B1 and A2, B2 are slot dimensions. The slot width and length have give in the form, here the B2 which represent the length of the W shape slot which shown on the Fig.3.Then the width of the slot have been represented using A1,A2 and B2 parameters.

2.4. Design of PIFA with I Slot Using CAD FEKO

The Conventional PIFA with I shape slot on the radiating patch have been given in the fig.4

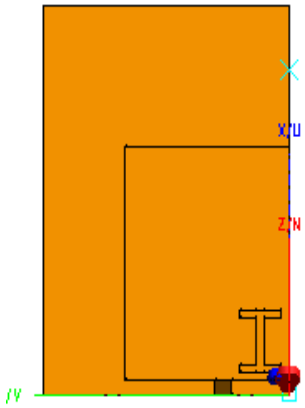

Figure 4: PIFA with I slot in CADFEKO

Table 4: PIFA with I Shape Slot Dimensions

Parameters	Value in mm
Lg	50
Wg	30
Lp	30
Wp	20
Lf	1
Wf	2
Ls	2
Ws	2
A1	8
B1	5

The Table 4 which shows the value of I shape slot which have been placed over the radiating patch of the PIFA.

2.5. Design of PIFA with F Slot Using CAD FEKO

The Conventional PIFA with F slot have been given in the fig.5, through with frequency range can be increased.

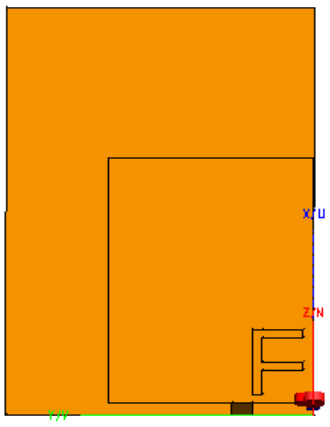

Figure 5: PIFA with F slot in CADFEKO

Table 5: PIFA with F Shape slot Dimensions

Parameters	Value in mm
Lg	50
Wg	30
Lp	30
Wp	20
Lf	1
Wf	2
Ls	2
Ws	2
A1	8
B1	5

The design value of PIFA has been given in the table.5. Here from the table Lg and Wg are length and width of the ground plane respectively. Lp and Wp are length and width of the radiating patch plane respectively. Lf and Wf are length and width of the feed respectively. Ls and Ws are length and width of the shorting pin respectively.A1 and B1 are slot dimension.

3. RESULTS AND DISCUSSIONS

To show the influence of the slots on the patch plane, simulations of the ordinary PIFA without slots were conducted. The height of the upper patch was fixed from the ground plane, and the other parameters were kept constant except for the slot on the patch plane. Resonance is achieved at the lower band (1.5GHz) by the PIFA and at the higher band (15.1GHz) by introducing slots on the patch plane.

Bandwidth is calculated using the formula

$$\text{Bandwidth}=F_H - F_L/F_c$$

Where

F_H-Higher Frequency

F_L-Lower Frequency

F_C-Centre Frequency

3.1. S- Parameter

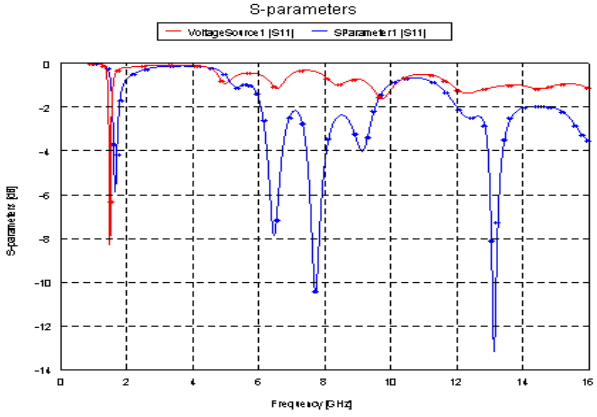

Figure 6: Comparison of Conventional PIFA and PIFA with E-slot

By introducing slots in the conventional PIFA the resonant frequency improved up to 13.1GHz.

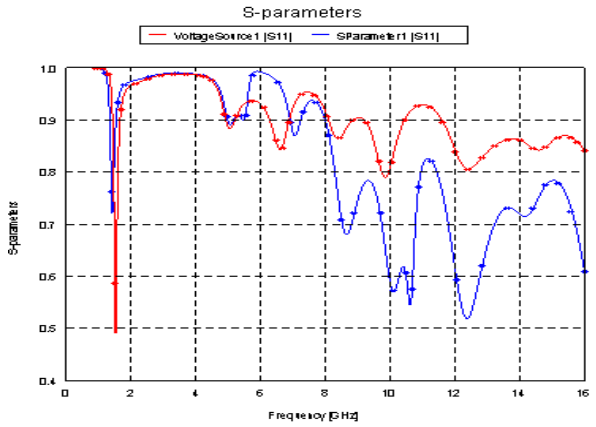

Figure 7: Comparison of Conventional PIFA and PIFA with W-slot

The Bandwidth of conventional PIFA is 1.5GHz. When W-shaped slot is introduced on the radiating patch plane, the bandwidth will be improved to 12.3GHz whereas when E-shaped slot is introduced on the patch plane, the frequency increased up to 13.1GHz.

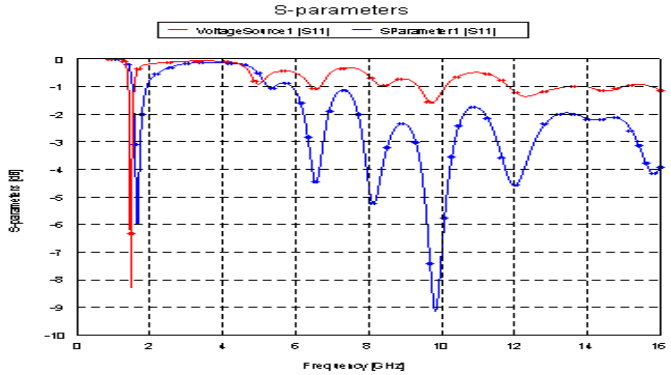

Figure 8: Comparison of Conventional PIFA and PIFA with I-slot

When I-shaped slot is introduced on the patch plane, the bandwidth will be improved up to 9.8GHz whereas when F-shaped slot is introduced on the radiating plane, the frequency will be 15.1GHz.

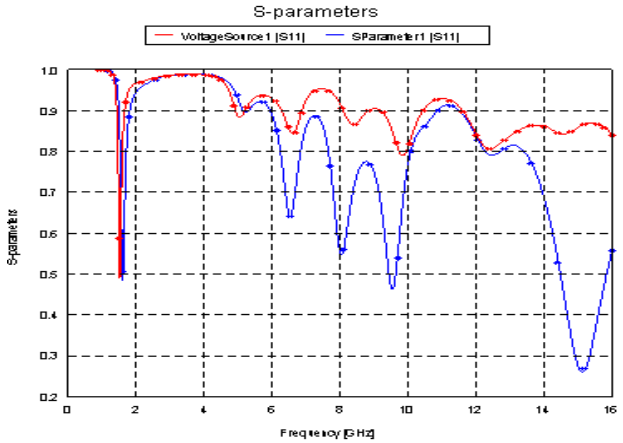

Figure 9: Comparison of Conventional PIFA and PIFA with F-slot

The Conventional PIFA has only one resonant frequency (1.5GHz), but by introducing E-Slot in PIFA we can get resonant frequencies as 6.3GHz, 7.9GHz and 13.1GHz.As same as by introducing the I-Slot we can get resonant frequencies as 6.3GHz, 8.1GHz and 9.9GHz.

3.2. Proposed Bandwidth and Resonant Frequency Performance of the Antenna

Table 6 Bandwidth Performance

Antenna	Bandwidth (%)
PIFA	7.3
PIFA with W-slot	8.6
PIFA with E-slot	9.6
PIFA with I-slot	10
PIFA with F-slot	9.3

In the Table.6, the bandwidth comparison between the PIFA and PIFA with Slots is made and the bandwidth performance is shown.

In the Table 7, the resonant frequencies of each slot have been given, through this the supporting band of frequency each slots can be examined .The F shape slots which has the higher band of about 15.1GHz and also as the lower band of about 1.5GHz.

Table 7 Resonant Frequencies

Antenna	Resonant Frequencies(GHz)
PIFA	1.5GHz
PIFA with W-slot	8.6, 10.8 and 12.3GHz
PIFA with E-slot	6.3, 7.9 and 13.1GHz.
PIFA with I-slot	6.3, 8.1 and 9.9GHz.
PIFA with F-slot	8.1, 9.5 and15.1GHz.

3.2. Impedance

The impedance of each Slot have been compared with the conventional PIFA

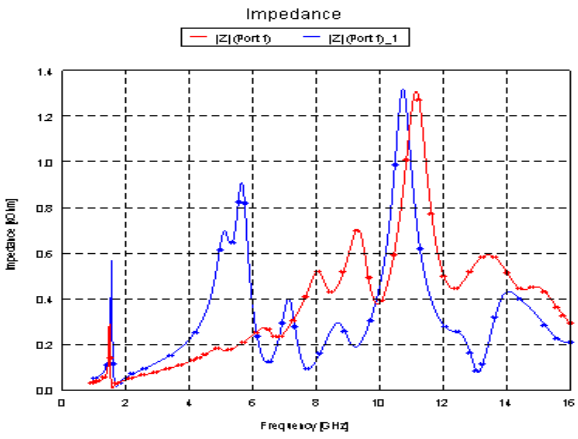

Figure 10: Impedance Comparison between Conventional PIFA and PIFA with E-slot

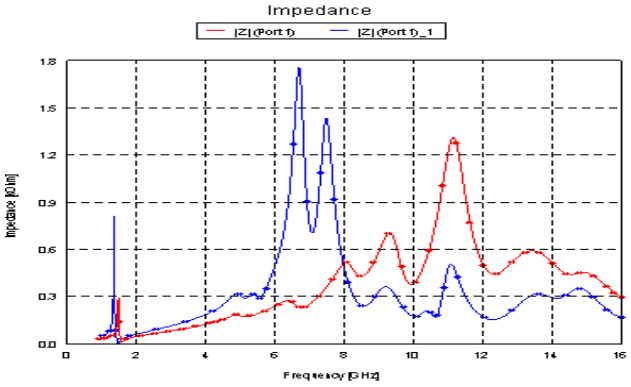

Figure 11: Impedance Comparison between Conventional PIFA and PIFA with W-slot

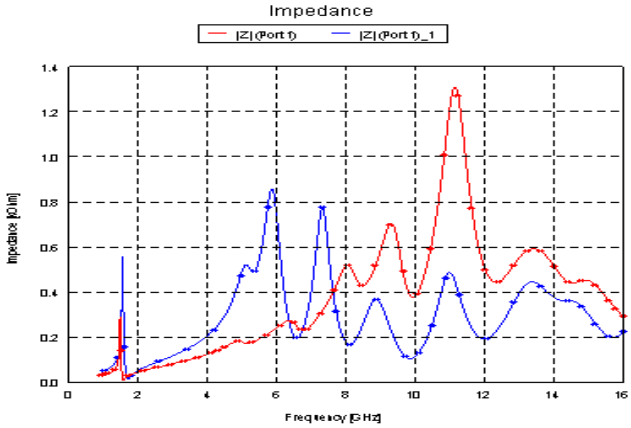

Figure 12: Impedance Comparison between Conventional PIFA and PIFA with I-slot

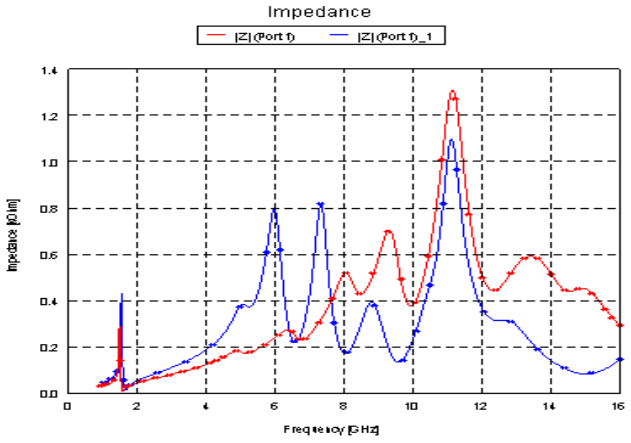

Figure 13: Impedance Comparison between Conventional PIFA and PIFA with F-slot

The impedance comparison is made between the Conventional PIFA and PIFA with slots. The PIFA with slots has the impedance value of about 1.3Ω.

4. CONCLUSION

From the stimulation results the effect of the slots has been given. In this new antenna, slots are used to improve the bandwidth at both low and high frequencies without increasing the volume of the antenna. This new design has been compared with the same design without the slots PIFA with Slots can support GSM, Wi-Max and UWB frequency bands. Its resonant frequency can be controlled by adjusting the inductance of the loop structure, formed by the feed line and shorting pin. Thus, the conventional PIFA has 1.5GHz as output and the conventional PIFA with slot has 15.1GHz as output which operate using the same feeding voltage source.

References

[1] Yamina Belhadef, Nourediene Boukli Hacene,"Design of New Multiband Slotted PIFA Antennas"- July 2011.

[2] T. Phairat and T. Chanchai," Design of an UWB Quasi Rhomboid Shaped Element Bowtie Antenna for MIMO Applications"- Proceedings of the World Congress on Engineering 2011 Vol II WCE 2011, July 6 - 8, 2011.

[3] T. E. Elfergani, Abubakar Sadiq Hussaini,R. A. Abd-Alhameed, C. H. See,M. M. Abusitta, H. I. Hraga, A. G. Alhaddad, and Jonathan Rodriguez," Frequency Tuned Planar Inverted F Antenna with L Shaped Slit Design for Wide Frequency Range"- Progress In Electromagnetics Research Symposium Proceedings, Marrakesh, Morocco, Mar. 20-23, 2011

[4] C. I. Lee, W. C. Lin, Y. T. Lin, and Y. T. Lee," A Novel H-shaped Slot-coupled Antenna for the Integration of Power Amplifier"- Progress In Electromagnetic Research Symposium Proceedings, Cambridge, USA, July 5-8, 2010

[5] Kekun Chang, Guan-Yu Chen, Jwo-Shiun Sun, and Y. D. Chen," PIFA Antenna with Coupling Effect for Bandwidth Enhanced Design and Measurement"- Progress In Electromagnetics Research Symposium Proceedings, Xi'an, China, March 22-26, 2010

[6] Jaume Anguera, Iván Sanz, Josep Mumbrú, and Carles Puente, "Multiband Handset Antenna with a Parallel Excitation of PIFA and Slot Radiators"- IEEE Transactions On Antennas And Propagation, Vol. 58, NO. 2, February 2010.

[7] R. Sanchez-Montero, S. Salcedo-Sanz and J. A. Portilla-Figueras, "Hybrid pifa-patch antenna optimized by evolutionary programming"-2010

[8] D.-B. Lin, I-T. Tang, M.-Z. Hong," A Compact Quad-Band Pifa By Tuning The Defected Ground Structure Formobile Phones"- Progress In Electromagnetics Research B, Vol. 24, 173–189, 2010

[9] W.-J. Liao, S.-H. Chang, and L.-K. Li," A compact planar multiband antenna for Integrated mobile devices"- Progress In Electromagnetics Research, Vol. 109, 1-16, 2010

[10] Annie George and S. Shabu."Optimization of Planar Inverted F antenna for a Microwave Life Detection System"- 10th National Conference on Technological Trends (NCTT09) 6-7 Nov 2009

[11] Arnau Cabedo, Jaume Anguera, Cristina Picher, Miquel Ribo, and Carles Puente," Multiband Handset Antenna Combining a PIFA, Slots, and Ground Plane Modes"- SEPTEMBER 2009.

[12] Sinhyung Jeon, Hyengcheul Choi, and Hyeongdong Kim, "Hybrid Planar Inverted-F Antenna with a T-Shaped Slot on the Ground Plane - June 15, 2009.

[13] Xingyu Zhang and Anping Zhao, "Enhanced-bandwidth PIFA Antenna with a Slot on Ground 111Plane" March 23-27, 2009.

[14] Xingyu Zhang and Antti Salo," Design of a Novel Wideband Planar Inverted-F Antenna for Mobile Applications"- Progress In Electromagnetics Research Symposium, Beijing, China, March 23-27, 2009

[15] Kin-Lu Wong, and Li-Chun Lee, "Multiband Printed Monopole Slot Antenna for WWAN Operation in the Laptop Computer," IEEE Transactions on Antennas and propagation, vol. 57, No. 2, Feb. 2009.

[16] Rashid A. Bhatti, Yun-Taek Im, Jung-Hwan Choi, Tuan D. Manh, and Seong-Ook Park "Ultrathin PIFA for multistandard handsets", Microwave and Optical Technology letters / vol. 50, No. 11, November 2008.

[17] Dong-yeon Kim, Jae W. Lee, Choon Sik Cho, and Taek K. Lee," Design of a Compact Tri-Band PIFA Based on Independent Control of the Resonant Frequencies"- IEEE Transactions on Antennas and Propagation, Vol. 56, no. 5, May 2008