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A Multiband PIFA Design for GSM/UMTS/LTE/IRNSS/Wi-Fi/Bluetooth Operations in Mobile Phone

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Abstract

A multi-resonance PIFA antenna is designed to support the proliferation of wireless standards in this current era. The proposed antenna can support Global System for Mobile Communication (GSM), Indian Regional Navigational Satellite System (IRNSS) standard positioning service, Universal Mobile Communication System (UMTS), Long Term evolution (LTE), ISM bands of Bluetooth/ Wi-Fi. It is designed using the FR4 epoxy dielectric substrate with the relative permittivity of 4.4, a dielectric loss tangent of 0.02 and the height of 1.6 mm. Radiation Pattern, Axial Ratio and Return loss are the factors used to analyze and optimize the antenna performance. The proposed multiband PIFA is designed and simulated using the High-Frequency Structure Simulator Tool.

Keywords - PIFA, IRNSS, Multiband, FR4

I. INTRODUCTION

A multiband PIFA was designed using 3D Electro Magnetic Simulation tool. Two structures namely meandered strip and folded loop structure was combined in that PIFA to enhance the multi-resonance characteristics. At 6 dB return loss, the PIFA covered the low and high-frequency bands of LTE, UMTS, and GSM bands. Coaxial

feed is used to provide input as well as 50 Ω impedance to the radiating device[1].An internal multiband PIFA was designed using meandered slot technique over the conventional PIFA to overcome the narrow bandwidth limitation. The PIFA covered the DCS, GPS, UMTS, WLAN, Zigbee, RFID and WiMAX frequency bands with the peak gain and peak radiation efficiency of 84.35 dB and 82.14 % [2-3]. The regional based and autonomous navigational system of our Indian region was discussed based on the services, positioning of satellites, and 3 segmental operations(space, ground, and user). The space segment of IRNSS is based on the 7 Satellite constellations to provide standard positioning service at 1.176 GHz for civilian purpose and precision service at 2.492 GHz for military purpose. Among 7 satellites 3 were positioned in the East region of Geo-Stationary orbit and 4 placed in the Geo-Synchronous orbit to cover Indian landscape as well as 1500 Km around the Indian region. The ground segment includes the various functionality of IRNSS center such as navigational, space-craft, ranging and monitoring. The IRNSS is suitable for aerial, navigation, mapping, positioning, terrestrial, timing and mobile phone applications[4-5].

An antenna was designed to operate at the ISM band of 915MHz for a specific medical application which achieved circular polarization. The size reduction technique was utilized to deduce the size of the antenna up to 65% when comparing with the conventional loop antenna. At 14 MHz resonant frequency, the axial ratio was obtained at 3 dB which essential for Omni-directional radiating device[6].A hexagonal shape antenna which supports circular polarization was designed in the FR4 dielectric substrate. At 2.45 GHz resonant frequency, the antenna attained the axial ratio of 0.5 dB i.e., less than 3 dB. The radiation pattern was obtained in XZ and YZ plane[7]. Various circularly polarized planar Inverted-F Antenna was analyzed based on the condition for circular polarization with respect to the axial ratio(AR). The technique of slotted double circle was used to design the PIFA. The Axial Ratio of 1.75 dB was achieved at 2.4 GHz. In truncated asymmetric edge technique, 0.351 dB of axial ratio was achieved at 2.6 GHz.

In combination method, 4 PIFA were placed to form a circle with 90^0 phase difference in order to achieve the axial ratio of 1.21 dB at 2.35 GHz[8]. A compact PIFA with the combination of meandered strip and two monopole strips was designed to operate in GSM, UMTS and LTE frequency bands in the electromagnetic spectrum. The single monopole strip had S and inverted-F-shaped strips to widen the bandwidth coverage with the VSWR of 2.5:1[9].The size reduction techniques such as insertion of shorting plate, shorting pin and parasitic element were utilized in PIFA to achieve the wide bandwidth coverage. It covered 1900 MHz of PCS and the WiMAX bands of 5.5 & 3.5 GHz with the peak radiation efficiency of 62%, 93% and 61%[10]. Dual

band PIFA was designed using U-shape slotted technique to cover the low-frequency of GSM 900 and high-frequency of 1900 MHz. High-Frequency Structure Simulator tool was used to optimize the change in results by varying the dielectric substrate, the height of the substrate, and the width of shorting pin[11]. A T-slot was placed on the top of the radiating patch and the rectangular slot was etched with a ground plane. It covered the UMTS, LTE, WiBro, Wi-Fi and WiMAX bands with multi-resonance characteristics[12].

II. CONFIGURATION OF PROPOSED PIFA

The proposed multiband PIFA consist of UV-slotted structure and folded loop structure on a single substrate. The FR4 epoxy dielectric substrate (ξ_r= 4.4, tangent= 0.02 & height=1.6 mm) is used to design the PIFA in HFSS tool. The total size of the PIFA antenna is 140 X 50mm X 1.6mm in which the size of the UV-slotted structure and folded loop structure are (38 X 28 X 1.6) mm and (30 X 40 X 1.6) mm. The diagrammatical description of the designed PIFA is given in Figure 1.

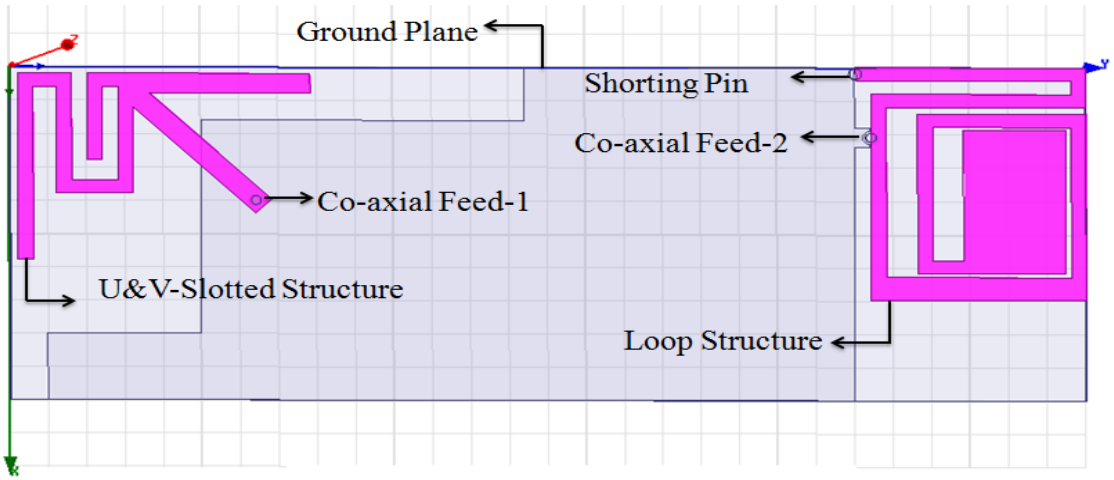

Fig.1. Structure of Proposed Multiband PIFA

Figure 2a and 2b gives the detailed dimension of proposed PIFA in mm units In this design, two feeds are used to give input power of 1 watts to the UV- slotted structure which is circularly polarized and folded loop structure which is linearly polarized. . The outer conductor of coaxial cable is etched with ground plane and the inner conductor is used to feed the antenna. Table 1 lists the primary dimension details of proposed PIFA.

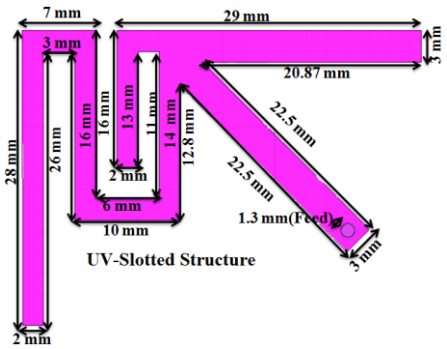

Fig. 2a. Geometry of UV-Slotted Structure

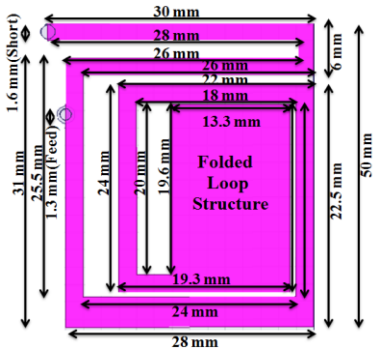

Fig. 2b. Geometry of Folded Loop Structure

Table 1. Dimensions of Proposed Planar Inverted-F Antenna

Parameters	**Dimensions (mm)**
Total Length of PIFA	140
Total Width of PIFA	50
Length of UV- Slotted Structure	38
Width of UV- Slotted Structure	28
Length of Folded Loop Structure	30
Width of Folded Loop Structure	40
Width of Shorting Pin	1.6
Width of Coaxial Feed-1	1.3
Width of Coaxial Feed-2	1.3
Height of PIFA	1.6

III. RESULTS AND DISCUSSION

A. Return Loss

Figure 4 shows the simulated return loss of both the structures of UV- slotted and folded loop is acquired at the single rectangular plot of far field region. Both

structures cover the low and high-frequency bands of GSM, UMTS, LTE, IRNSS standard positioning service, Bluetooth/ Wi-Fi. The UV- Slotted structure covers the two bandwidths i.e., 934 MHz - 1.21 GHz and 1.604 - 2.3 GHz. The folded loop structure covers three bandwidths i.e., 824-949 MHz,1.488-1.782 GHz, and 2.02-2.519 GHz.

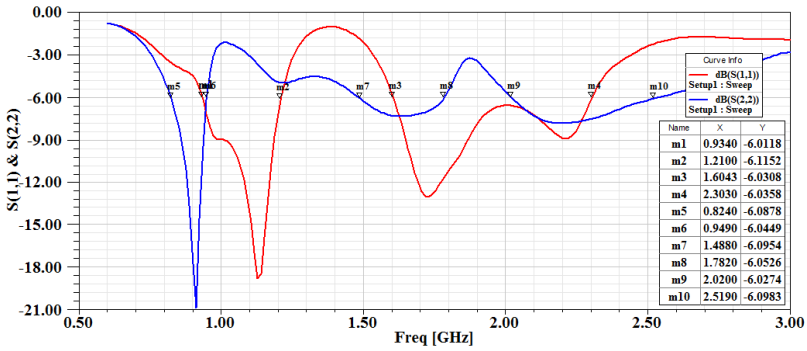

Fig.3. Return Loss Vs Frequency Plot obtained at Far Field Region

C. Axial Ratio

The axial ratio (AR) of 2.5 dB is obtained for IRNSS standard positioning service at 1.176 GHz. Figure 4 shows the plot at which the condition for circular polarization (< 3 dB) is achieved. This enables the proposed PIFA antenna to provide the positioning and timing service at 1.176 GHz by incorporating it into the mobile phone.

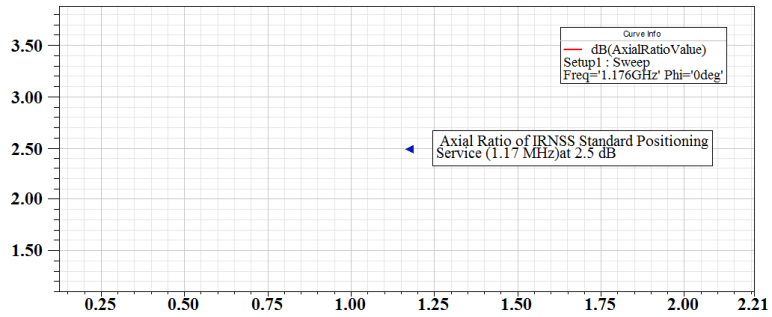

Fig.4. Axial Ratio of 2.5 dB obtained at 1.176 GHz

D. Radiation Pattern

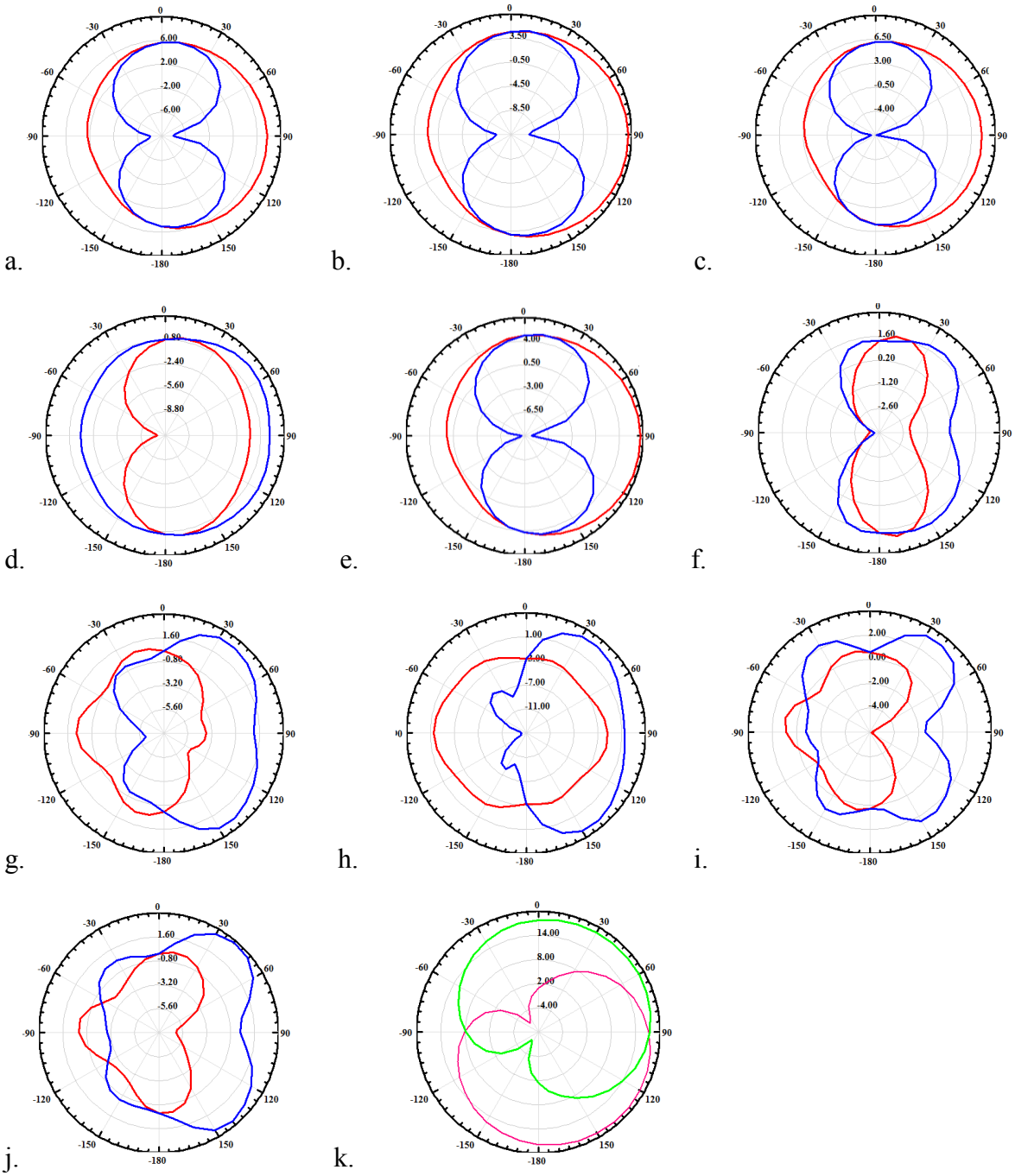

Fig.6. 2D Radiation Pattern Obtained at Far Field Region.a) GSM-0.85 GHz, b) GSM-0.9 GHz, c) UMTS-0.824 GHz, d) UMTS-0.89 GHz, e) DCS-1.71 GHz, f) PCS-1.85 GHz, g) UMTS-2.17 GHz, h) LTE-2.3 GHz, i) LTE-2.5 GHz, j)Bluetooth/Wi-Fi-2.4 GHz and K) IRNSS Standard Positioning Service-1.176 GHz (RHCP & LHCP)

The attained 2D-radiation patterns of all possible operating frequencies are given in Figure 6.This Omni-directional radiation pattern is obtained at XZ plane ($\phi = 0^0$) and YZ plane ($\phi = 90^0$). At 2.5 GHz, the proposed PIFA obtained the maximum radiation efficiency of 98% with 2.88 dB peak gain. At 824 MHz, the PIFA has achieved the maximum gain of 7.24 dB.

IV. CONCLUSION

The proposed antenna has UV-slotted structure and folded loop structure to provide wide bandwidth coverage with two different polarization techniques. This PIFA can function in GSM(0.85 GHz), GSM(0.90 GHz), UMTS(0.824 GHz), UMTS(0.89 GHz), IRNSS standard positioning service (1.176 GHz), DCS(1.71 GHz), PCS(1.85 GHz), UMTS 2.17 GHz, LTE 2.3 GHz, LTE 2.5 GHz and Wi-Fi/Bluetooth (2.4 GHz) in the electromagnetic spectrum. The wider bandwidth is obtained at -6 dB return loss with a voltage standing wave ratio of 3:1.At 1.176 GHz, the axial ratio of 2.5 dB is obtained for IRNSS standard positioning service which meets the stipulation of circular polarization (less than 3 dB). This PIFA antenna is applicable for smartphone applications.

REFERENCES

[1] Akilesh Verma, Anamika Chauhan, 2016, "Compact Slotted Meandered PIFA versus Conventional PIFA Antenna for DCS, GPS, Bluetooth/WLAN, 4 G LTE, WiMAX, UMTS, GLONASS Applications," 3rd International Conference on Computing for Sustainable Global Development, IEEE Publications, Pages:951 - 954.

[2] Ting Zhang, Rong Lin Li, GuiPing Jin, Gang Wei and Manos M. Tentzeris, 2015, "A Novel Multiband Planar Antenna for GSM/ UMTS/ LTE/ Zigbee/ RFID Mobile Devices," IEEE Transactions on Antennas and Propagation, Vol.59, Issue 11, pages:4209-4214.

[3] Youngtaek Hong, Jinpil Tak, Jisoo Baek, Bongsik Myeong, and Jaehoon Choi, 2014, " Design of a Multiband Antenna for LTE/GSM/UMTS Band Operation", Hindawi Publishing Corporation, IJAP, Vol.2014, 9 pages.

[4] Rahul Rai Khatri , Sarvada Chauhan, 2016," Indian Regional Navigation Satellite System," International Journal of Innovative Research in Technology, Vol.2 ,Issue 11, pages:380-384.

[5] Manisha Saini, Umesh Gupta, 2014, " Indian GPS Satellite Navigation System: An Overview, International Journal of Enhanced Research in

Management & Computer Applications", Vol. 3, Issue 6, pages: 32-37.

[6] Ke Zhang, Changrong Liu, Xueguan Liu, Huiping Guo, and Xinmi YangHindawi, 2017, "Miniaturized Circularly Polarized Implantable Antenna for ISM-Band Biomedical Devices", International Journal of Antennas and Propagation, Hindawi Publications, Article ID 9750257, 9 pages.

[7] Prakash K.C, Vinesh P.V., Jayakrishnan M.P, Dinesh R., Mohammad Ameen and Vasudevan K, 2016, "Hexagonal Circularly Polarized Patch Antenna For Rfid Applications", International Journal on Cybernetics & Informatics (IJCI) Vol. 5, No. 2, pages:173-182.

[8] Ankita Jadav, 2016, "A Review Paper on A Novel Technique for Realization of Circular Polarization in Planar Inverted F Antenna", International Journal of Scientific Research & Development, Vol.4, Issue 01, pages:208-210.

[9] R. Gokul and J. Geetha Ramani, 2016, "A Novel Tri-Band Planar Inverted-F Antenna for Wireless Communication", Middle-East Journal of Scientific Research, IDOSI Publications, ISSN 1990-9233, pages:695-700.

[10] R.P.S. Gangwar & Preeti Rani, 2015, "Multiband Planar Inverted-F Antenna (PIFA) for Mobile Phones, International Journal of Electrical & Electronics Engineering Research", Vol.5, Issue 6, Pages:71-78.

[11] K. Rama Krishna, G Sambasiva Rao, and P.R.Ratna Raju.K, 2015, " Design and Simulation of Dual-Band Planar Inverted F Antenna (PIFA) For Mobile Handset Applications", International Journal of Antennas (JANT) Vol.1, pages:37-42.

[12] Sahil Saini, Rupleen Kaur, Satbir Singh, Naveen Kumar, 2015, " A Compact T-Slot Multiband Planar Inverted-F Antenna for Handheld Devices", IEEE Publications, pages:4209-4214.