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Planar Internal Antenna Design for Cellular Applications & SAR Analysis

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Abstract:- This paper presents a new design of direct-fed Multi band printed Planar Internal Antenna (PIA), for cellular applications. The PIA antenna is composed of ground plane, meander radiating strip and two other parasitic strips are printed on a common substrate. The designed antenna has been simulated in CST environment. The simulated results for the resonant frequency, return loss, radiation pattern and gain are presented and discussed. The bandwidths for three resonance achieved on the basis of -6 dB return loss.These Bandwidths can be utilized for GSM 900, GSM 1800, GSM 1900, LTE 2300 and Bluetooth/WLAN as an acceptable reference in mobile phones applications. Further the antenna was placed in proximity to the SAR head on CST environment. The simulated results of SAR analysis are presented in this paper with acceptable range.

Keywords:- PIA, GSM, LTE, Bluetooth/WLAN, SAR.

I. INTRODUCTION

WITH the development of modern wireless communications, the features of compactness, multifunctional, and multiband operations are not only important, but also in large demand. In order to achieve a multiband operation in a limited circuit space, many novel multiband antenna designs have been proposed in the past. For a hand-held cellular phone, the antenna should be miniaturized to reduce the size, weight and cost besides Omni-directional radiation pattern, higher gain, and wide impedance bandwidth in order to have multi band behavior [1]. An internal to have a built in antenna which becomes very promising candidates for applications in mobile handsets [2].

To design mobile antenna with slim and small size, multiresonance and light weight to support these requirements is becoming more and more challenging task for the researchers now a days.

New technology in wireless communication has brought a lot of portable devices in the future, such as a mobile phone that will possess Long Term Evolution (LTE) function for the voices and data transmissions [3]. PIFA is formed from a linear Inverted F antenna (IFA) where the wire radiator element of IFA is replaced by a plate to enhance the bandwidth performances. The PIFA have some unique characteristic that makes it suitable for use in portable wireless device especially on mobile handsets. It has several advantages compared than other micro strip antennas. It has

A low profile, small size and can locate in structure such as at the back cover of the mobile phone [4]. The other major compensation is it is easy to fabricate, low manufacturing cost, and simple structure [6], [8].

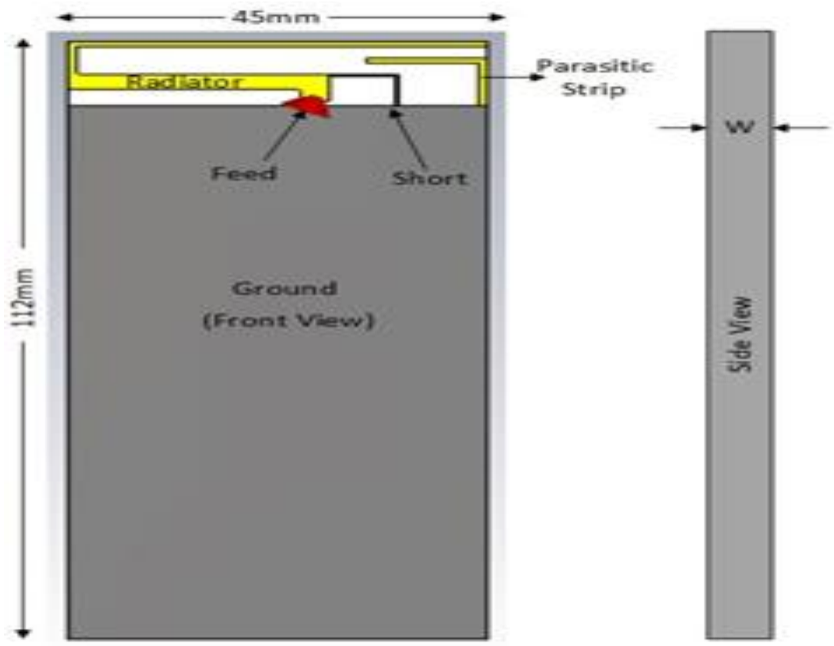
But, conventional PIFA has some disadvantages which are it has narrow bandwidth, cannot support multi frequencies simultaneously and low antenna efficiency [7]. The PIFA consists of three main elements which is rectangular planar located above a ground plane (top radiating patch), a short circuiting wall or plate and a feeding technique for the planar element. Therefore, these antenna required more volume and were not suitable for slim handsets.

The above reported antenna in [8], [9], [10], [11], [12] are having larger size compare with the size of slim mobile phone. The size of an antenna is main constraint for mobile handheld devices while maintaining the multi band and wideband performances.

The printed antenna with planar and compact structure is very attractive for slim mobile phone mainly due to they can be printed directly on the system circuit board of the mobile phone at low cost and the height of the antenna can be ignored easily [13].

This paper presents a novel and simple PIFA design for mobile phone application. The PIFA designs exhibits a Tri band frequencies and resonate at 900MHz, 1800 MHz and 2.45 GHz and the bandwidth is 120 MHz. The designed antenna, which is attained using a FR-4 substrate double sided PCB. Dimensions of the proposed design are 45 mm × 112 mm × 1.6 mm.

The numerical simulation of the antenna design is conducted by using HFSS [14], [15]. The specifications of key elements for the design of the rectangular planar inverted -F antenna are listed in Table I. This paper is divided into four sections as follows: Section I discuss the introduction and basic theory of PIFA. Section II presents the antenna design and structure, section III presents about the simulation results and section IV will summarize the conclusion of this paper.



In this paper, the proposed PIFA design consists of five basic elements which are a metallic ground, main radiating strip, one inverted-L strip for impedance matching, one parasitic strip and one common substrate. The feeding mechanism used in this proposed antenna is a probe feed method where the 50 Ω SMA connector is used to feed the rectangular patch antenna.

PIFA also has Low SAR value where it has a small backward radiation toward the users head and reducing the electromagnetic wave power absorption and increase the antenna performance. Recently, the specific absorption rate (SAR) measured in W/Kg becomes important environmental issue. The lower electromagnetic radiation generated by a portable unit into a

Fig. 1.Antenna Geometry

Table I. Design parameters of antenna

Shape	Rectangular
Operation Frequency	900MHz, 1.8 GHz, 2.45 GHz
Dielectric Constant of Substrate	4.4
Thickness of Substrate (W)	0.8 mm
VSWR	1.2:1
Gain	0 dB-5dB

Phantom and a body the better the unit [17]. This paper also presents the SAR analysis for the proposed antenna structure.

II. ANTENNA DESIGN

The geometry of proposed planner antenna is shown in fig.1 which is fabricated using a 112 mm × 45 mm × 0.8 mm FR4 substrate with dielectric constant 4.4. On the lower portion of FR-4 substrate is a 45 mm × 100 mm is a ground plane, above which an area of 45mm × 12 mm is considered as an antenna space [20]. This proposed antenna structure comprises of: a main radiator, parasitic structure and a structure for impedance adjustment as shown in Fig.2. The antenna structure is co planar with the ground plane which is printed on common substrate. The main radiator is a meandered strip which is excited using SMA connector as lumped port. This strip is optimized and designed to resonate at 900 MHz. A shorting strip of inverted-L shaped is provided for better impedance matching. A parasitic strip (1 mm wide) is placed on the lower right corner of the antenna area, traverse parallel to shorting strip. The parasitic strip is grounded inverted-L metal strip. The geometrical shape specification of the proposed Planar internal antenna has been enlisted in Table II.

Fig. 2. Antenna Geometry (Radiator Part)

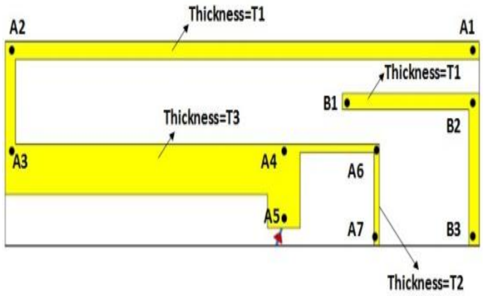


Table II. Geometrical specifications of antenna

Parameter	***A1A2***	***A2A3***	***A3A4***	***A4A5***	***A4A6***	***A6A7***
Value(mm)	42.5	5	28	2	13.5	6
Parameter	*B1B2*	*B2B3*	T1	T2	T3	T3
Value(mm)	12	9	1	0.5	3	...

Frequency	**SAR(mW/g) for Reference (Top Position)Design**	**SAR(W/Kg) for proposed Design**
900 MHz(for 1g Tissue)	**2.42**	**0.6531**
900 MHz(for 10g Tissue)	**1.61**	**0.9067**
1800 MHz(for 1g Tissue)	**2.14**	**2.278**
1800 MHz(for 10g Tissue)	**1.03**	**1.416**
1900 GHz(for 1g Tissue)	**3.28**	**1.902**
1900 GHz(for 10g Tissue)	**1.5**	**1.193**
2.45 GHz(for 1g Tissue)	**None**	**1.083**
2.45 GHz(for 10g Tissue)	**None**	**0.6052**

Fig. 3. (a)VSWR Plot, (b) Return loss Curve

III. SIMULATION & RESULTS

As shown in Fig.3 the antenna operates as multi band, although for this bandwidth VSWR is less than 1.5. First resonance is occurring at 926.50 MHz for GSM900 (880960 MHz). The second resonance is occurring at 1970 MHz for GSM1800 (1710-1880 MHz) and GSM1900 (1850-1990 MHz). The third resonance is occurring at 2364 MHz so it can cover LTE2300 (2305-2400 MHz) and Bluetooth/WLAN (2400-2480 MHz) with VSWR less than 2.0. The invertedL shaped shorting strip is optimized to obtain good VSWR matching at 0.926, 1.97 and 2.436 GHz. In Fig.4 & Fig.5 show the antenna directivity and gain at frequencie of 900 MHz, 1800 MHz, 1900 MHz and 2.45 GHz respectively while the surface current on antenna is depicted in Fig.6. The final antenna has Omni directional pattern with sufficient gain for this application. The antenna was simulated on CST environment [16].

A. Simulated SAR Results using SAR Phantom

CST Microwave studio [16] is used for SAR calculation, the proposed antenna SAR is shown in Fig. 7.

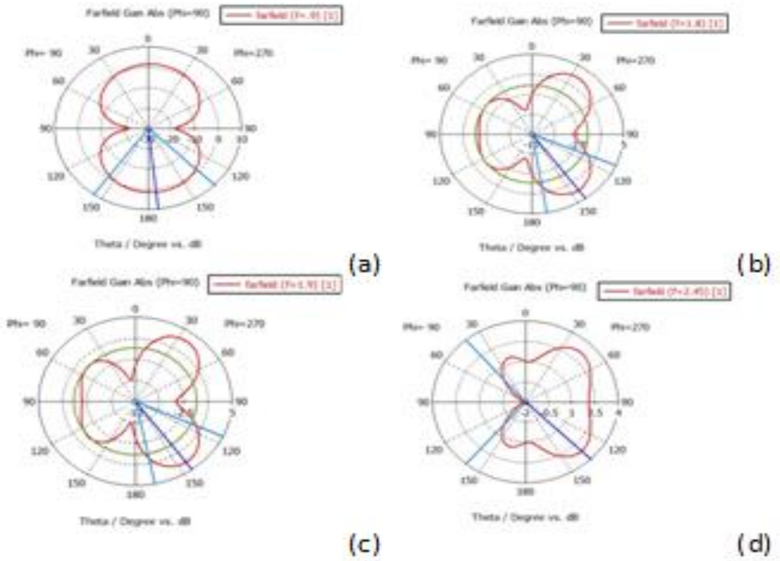
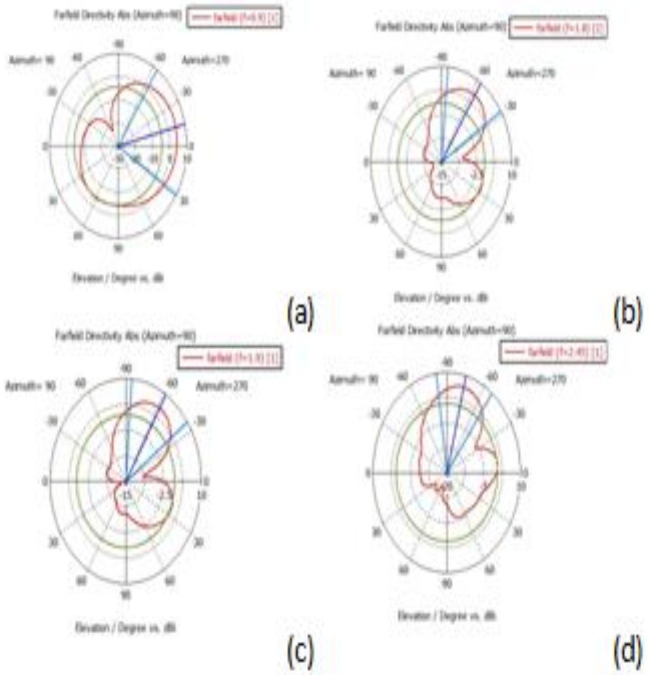


Fig. 4. Directivity of Antenna at (a)900 MHz, (b)1800 MHz ,(c) 1900 MHz, (d) 2.45 GHz

Fig. 5. Gain of Antenna at (a) 900 MHz, (b) 1800 MHz,(c) 1900 MHz, (d) 2.45 GHz



Simulation Engine was run for SAR analysis after placing the proposed antenna in proximity to Phantom on CST environment [16].The results of which are obtained for both 1 g. as well as 10g. of tissue at frequencies of 900 MHz, 1800 MHz,1900 MHz & 2.45 GHz respectively.

Finally these values are compared with the reference antenna from [?] and are illustrated in Table III. It is clear from the table that the SAR values of proposed Antenna are better than reference antenna [?].

Table III reveals that the proposed antenna has better SAR values than the reference antenna. It is observed that SAR value is least at 2.45 GHz.

The SAR values for 1g. tissue at 900 MHz, 1800 MHz, 1900 MHz and 2.45 GHz are 0.6531 W/Kg, 2.278 W/Kg, 1.902 W/Kg and 1.083 W/Kg while for 10g. tissue these values are 0.9067 W/Kg, 1.416 W/Kg, 1.193 W/Kg and 0.6052 W/Kg

Fig. 6. Surface Current of Antenna at (a)900 MHz, (b)1800 MHz ,(c) 1900 MHz, (d) 2.45 GHz

Table III. Comparison of sar between proposed antenna & reference antenna respectively.

Frequency	**SAR(mW/g) for Reference**	**SAR(W/Kg) for**
	(Top Position)Design	proposed Design
900 MHz(for 1g Tissue)	2.42	0.6531
900 MHz(for 10g Tissue)	1.61	0.9067
1800 MHz(for 1g Tissue)	2.14	2.278
1800 MHz(for 10g Tissue)	1.03	1.416
1900 GHz(for 1g Tissue)	3.28	1.902
1900 GHz(for 10g Tissue)	1.5	1.193
2.45 GHz(for 1g Tissue)	None	1.083
2.45 GHz(for 10g Tissue)	None	0.6052

IV. CONCLUSION

The prototype antenna operates in Multi band mode for which the VSWR is less than 1.5. First resonance is occurring at 926.5 MHz for and GSM900. The second resonance is occurring at 1.97 GHz for GSM1800 and GSM1900. The prototype antenna has has third resonance at 2.36 GHz so it can cover LTE 2300 and Bluetooth/WLAN bands with satisfied range of SAR.

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Fig. 7. Cross Section view of SAR Phantom (a) at 900MHz for 1g. Tissue, (b) at 900MHz for 10g. Tissue,(c) at 1800MHz for 1g. Tissue,(d) at 1800MHz for 10g. Tissue,(e) at 1900MHz for 10g. Tissue,(f) at 1900MHz for 10g. Tissue,(g) at 2.45GHz for 1g. Tissue & (h) at 2.45 GHz for 10g. Tissue