Design of Novel Structured Triband PIFA for Mobile Application

Hemal H.Thakor, Raj Hakani
Electronics and Communication Engineering Department
Silver Oak College of Engineering and Technology, Ahmadabad

***Abstract*–|A planar inverted-F antenna with a huge bandwidth starting from 817MHz to 11.5 GHz proposed as an substitute for high concert mobile phones proposed to cover the major part of the mobile phone frequencies global as well as the multi wideband frequency range. A prototype of the antenna was construct and the reflection coefficient and radiation patterns were measured to display an adequate radiation performance. Besides, the easy creation without a matching network or a difficult geometry is an supplementary attribute that can be reflected in low invention cost**

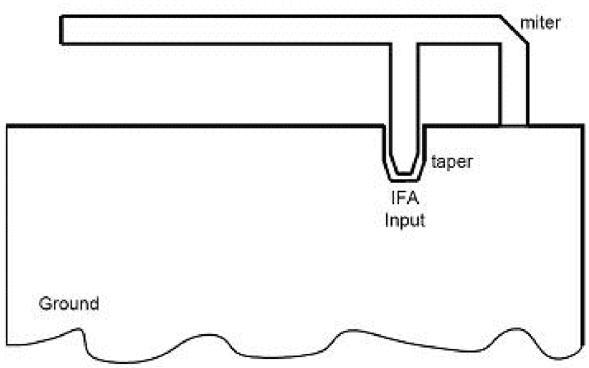
Index Term- PIFA, Multiband, VSWR, Return Loss, Mobile Applications

I. INTRODUCTION

The planar inverted-F antenna (PIFA) remains as one of the most accepted antennas used in mobile phones today. It is widely working due to its small size, low profile, excellent performance, simple fabrication and fairly low specific absorption rate (SAR). However, a square PIFA has an inbuilt narrowband that has to be enhanced in order to fulfill the more and more bandwidth rations imposed by the new handsets. If a mobile terminal is designed for global coverage and international roaming, the antenna should be able to operate in dozens of frequency bands to cover the many 2G, 3G, and 4G network around the world. Achieving this is not an easy task considering that the new smart phones command more space for the electronics associated to multiple functionalities that these terminals order, leaving small room to accommodate the antenna system. In the past, several techniques have been used to improve the bandwidth of PIFA antennas. The introduction of various resonant basics in order to create a multiband PIFA is a very common approach. Another method calls for the addition of parasitic patches with resonant lengths close to the occurrence band where the bandwidth development is required. The inclusion of slots in the ground plane has also been used to enhance the bandwidth mainly in the lower frequencies of the spectrum allocated to mobile phone services . The same type of slots can be employed in the main radiating structure to increase the bandwidth of some of the bands of interest. Other PIFA structures can use multilayer of resonators in order to increase the number of bands where the PIFA can operate . Finally, a combination of the previous techniques is frequently utilized to add the effects of each method and increase the PIFA bandwidth. The foregoing techniques have the ability to increase the number of bands in which a PIFA can operate or to enhance the bandwidth of some of the bands of interest. However, the total bandwidth enhancement is not enough to cover the great diversity of bands at which a mobile terminal should operate in many countries with different RF interface principles at different frequency allocations. An interesting new approach that is an alternative to the well-known techniques is to design a PIFA with a single but very large bandwidth that is capable of covering all the mobile phone bands within that single wideband.. Both antennas are easy to construct and have dimensions that fall within the limits of many antennas for mobile devices. However, the height of the main radiator element above the ground plane in both antennas is 10 mm. That is a construction restriction that is not allowed in many new smart phones where the very low profile of the antenna system is imperative. Besides, these antennas cannot work on the very important bands of 800 and 900MHz where numerous mobile phone networks operate around the world. To overcome the above restrictions a new antenna with a very large bandwidth between 817MHz and 11.5 GHz has been developed. The new antenna has a lower profile of 5mm that is entirely compatible with the size restrictions imposed by smart phones. On the other hand, it can cover the cellular bands of 800 and 900MHz as well as any band below 11.5 GHz. However, the last figure has become from some years ago in the most common criterion for mobile phone antennas where a part of radiation performance is sacrificed in sake of a lower volume.

II. PIFA

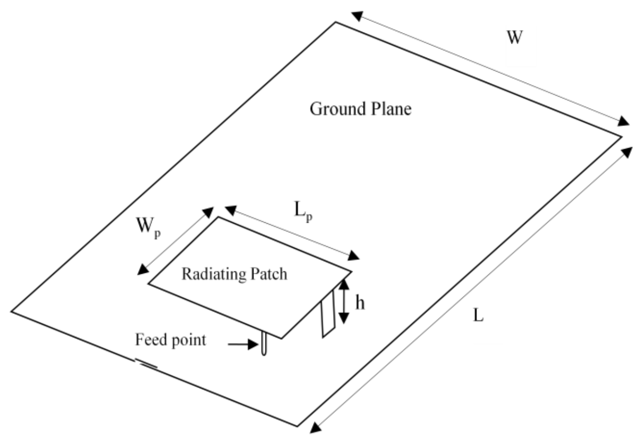
The Inverted F Antenna (IFA) typically consists of a rectangular planar element located above a ground plane, a short circuiting plate or pin, and a feeding mechanism for the planar element. The Inverted F antenna is a variant of the monopole where the top section has been folded down so as to be parallel with the ground plane. This is done to reduce the height of the antenna, while maintaining a resonant trace length. This parallel section introduces capacitance to the input impedance of the antenna, which is compensated by implementing a short-circuit stub. The stub's end is connected to the ground plane through a via. The ground plane of the antenna plays a significant role in its operation. Excitation of currents in the printed IFA causes excitation of currents in the ground plane. The resulting electromagnetic field is formed by the interaction of the IFA and an image of itself below the ground plane. Its behavior as a perfect energy reflector is consistent only when the ground plane is infinite or very much larger in its dimensions than the monopole itself. In practice the metallic layers are of comparable dimensions to the monopole and act as the other part of the dipole.



The F Inverted Antenna

· The antenna/ground combination will behave as an asymmetric dipole, the differences in current
distribution on the two-dipole arms being responsible for some distortion of the radiation pattern.
· In general, the required PCB ground plane length is roughly one quarter (λ/4) of the operating
wavelength.
· If the ground plane is much longer than λ/4, the radiation patterns will become increasingly multiplied.
· On the other hand, if the ground plane is significantly smaller than λ/4, then tuning becomes increasingly difficult and the overall performance degrades.
· The optimum location of the IFA in order to achieve an omni-directional far-field pattern and 50Ω
impedance matching was found to be close to the edge of the Printed Circuit Board.
· The miter is used to avoid a right angle micro strip bend, which results in a poor current flow on the
Stub.
· The taper is needed in order to compensate the abrupt step transition encountered between the
micro strip line feed and the antenna.

III. DESIGN ON PIFA



Typical PIFA Structure

PIFA is also referred to as short-circuited micro strip antenna due to the fact that its structure resembles to short-circuit MSA. The shorting post near the feed point of PIFA structure is a good method for reducing the antenna size, but this result into the narrow impedance bandwidth which is one of the limitations. By varying the size of the ground plane, the bandwidth of a PIFA can be adjusted and optimized. The location and spacing between two shorting posts can be adjusted accordingly.

Parameters	Effects
Length	Determines resonance frequency
Width	Control impedance matching
Height	Control Bandwidth
Width of shorting plate	Effect on the anti-resonance and increase bandwidth
Feed position from shorting plate	Effect on resonance frequency and bandwidth

$L_p + W_p = \lambda/4$ (1)

Where L_p is Top patch length

W_p is Top patch Width

λ is wavelength corresponding to resonant frequency When $W/L_p=1$ then

$L_p + h = \lambda/4$ (2)

When W=0 then

$L_p + W_p + h = \lambda/$

IV. CHALLENGES

Single-band antenna supports only one or two frequencies of wireless service. And these days more & more wireless standards are being supported by the devices. So they employ several antennas for each standard. This leads to large space requirement in handheld devices. One foreseen associated problem with the antenna design for such devices is to cover 4G LTE bands while still covering DCS 1800, PCS 1900, UMTS 2100, wImax and WLAN/Bluetooth bands. Thus, due to space constraints in mobile devices, covering multiple bands with a single antenna structure is the need of the hour. Therefore, the thesis work is directed to make a multiband antenna and it can be achieved by using low profile antenna structures like PIFA with additional features to enhance the bandwidth coverage and other important performance parameters

V. CONCLUSION AND FUTURE WORK

The designed multi-band antenna, built on PIFA structure, is very sensitive to any changes to the dimensions of the structure including the ground plane. Ground plane of the antenna is used as a radiator resulting in overall size reduction and improvement in the operating bandwidth. Also there is significant improvement in gain and radiation efficiencies at obtained resonant frequencies. The development of wireless technologies and mobile communications has included considerable research on the production of small, easily adaptable, low cost antennas. One such device, the PIFA (Planar Inverted F Antenna), is widely used in mobile, automotive and wireless communications. The advantage of using this type of antenna in wireless communications is its small size, low profile, and avoidance of additional matching networks .The antenna prototype can be developed which can be used to study the performance of the antenna with human interaction and investigate the Specific Absorption Rate (SAR) value by employing human model testing. The antenna structure can be placed inside a handheld device casing and it can be analyzed using an Anechoic chamber. The design proposed in this thesis work can be extended for supporting MIMO applications for the devices which supports LTE and WiMAX technologies.

REFERENCES

[1] Kin-Lu Wong, "Planar Antennas for Wireless Communication", Published by John Wiley & Sons, Inc., Chapter: 2, Pages: 26-65, 2003.

[2] C. Rowell, E.Y. Lam, "Mobile-phone antenna design", IEEE Antennas and Propagation Magazine, Vol. 54, No. 4, Page(s): 14 – 34, 2012.

[3] W. Geyi, Q. Rao, S. Ali, and D. Wang, "Handset Antenna Design: Practice and Theory", Progress in Electromagnetic Research Journal (PIER), Vol. 80, Pages: 123–160, 2008.

[4] Hang Wong, Kwai-Man Luk, Chi Hou Chan, Quan Xue, Kwok Kan So, Hau Wah Lai, "Small antennas in Wireless Communications", Proceedings of the IEEE Journal, Vol. 100, No. 7, Page(s): 2109 – 2121, 2012.

[5] R. Vaughan, "Model and results for single mode PIFA antenna", IEEE Antennas and Propagation Society International Symposium, Vol. 4, Page(s): 4028 – 4031, 2004.

[6] Taeho Son, "Feeding point determination for PIFA type mobile phone handset internal antenna", IEEE Antennas and Propagation Society International Symposium, Vol. 1A, Page(s): 475 – 478, 2005.

[7] J.A. Ray, S.R.B. Chaudhuri, "A review of PIFA technology", IEEE Indian Antenna week (IAW), Page(s): 1 – 4, 2011.

[8] Y. Belhadef, N. Boukli Hacene, "PIFAs antennas design for mobile communications", 7th IEEE International Workshop on Systems, Signal Processing and their Applications, Page(s): 119 – 122, 2011.

[9] Hassan Tariq Chattha, Yi Huang, Xu Zhu, and Yang Lu, "An empirical equation for predicting the resonant frequency of planar inverted-F antennas", IEEE Antennas and Wireless Propagation Letters, Vol.8, Page(s): 856 – 860, 2009.

[10] Rashid Ahmad Bhatti, Ngoc-Anh Nguyen, Viet-Anh Nguyen and Seong ook Park, "Design of a Compact Internal Antenna for Multi-Band Personal Communication Handsets", IEEE Proceedings of Asia-Pacific Microwave Conference, Page(s):1-4, 2007.

[11] Viet-Anh Nguyen, Manh-Tuan Dao, Yun Tack Lim, and Seong-Ook Park, "A Compact Tunable Internal Antenna for Personal Communication Handsets", IEEE Antennas And Wireless Propagation Letters, Vol. 7, Page(s): 569 – 572, 2008.

[12] Ya-Chung Yu and Jenn-Hwan Tarng, "A Novel Modified Multiband Planar Inverted-F Antenna", IEEE Antennas and Wireless Propagation Letters, Vol. 8, Page(s): 189 – 192, 2009.

[13] J. Cho, C.W. Jung and K. Kim , "Frequency-reconfigurable two-port antenna for mobile phone operating over multiple service bands", IEEE Electronics Letters, Vol. 45 No. 20, Page(s): 1009 – 1011, 2009.