A Review of Antennas for Wireless Communication Devices

Sunakshi Puri[1], Kiranpreet Kaur[1], and Naveen Kumar[2]
[1]Electronics & Communication Department, Baba Banda Singh Bahadur Engineering College, Punjab, India
[2]Electronics & Communication Department, Universal Inst. of Engineering & Technology, Punjab, India
Email: sunakshi_86@yahoo.co.in, kiranpreet.kaur@bbsbec.edu.in, chd.naveen@gmail.com

***Abstract*—The extensive demand for mobile communication and information exchange through wireless devices has lead to major achievements in antenna designing. The purpose of the paper is to give a frame of reference, understanding, and overview of antennas used in wireless communication devices. In this paper we will be discussing various antennas, their advantages and drawbacks. Also a brief framework of comparisons between various antennas is presented on the basis of various parameters. This paper also summarizes the benefits and use of PIFA for USB dongle to cover the WiMAX bands.**

***Index Terms*—PIFA, USB dongle, WiMAX, antennas**

I. Introduction

Wireless communication have progressed so fast in recent years, it requires small equipments supporting multiband communication. As an essential part of the communication system, antenna is one of the most significant design issues. As we concern about small equipments we require antennas which are small in size and light in weight [1]. Due to its compact size Planner inverted-F antennas (PIFAs) are most suitable to be employed in wireless equipments. The major advantages of PIFA are its simple structure, easy fabrication and less manufacturing cost. PIFA is a promising antenna for the future technology due to adjustability of its structure [2]. PIFA structure is widely used for internal mobile handset antenna. But its narrow bandwidth makes it difficult for it to be used as multiband antenna. So researchers have analyzed, designed and tested several techniques through which multiband operation can be achieved from PIFA structure.

A multiband antenna utilized in a mobile communication system can operate at distinct frequency band. Presently, the mobile communication system uses frequency bands such as GSM 850 (824-894MHz), GSM 900 (890-960MHz), GSM 1900 (1850-1990MHz), UMTS (1920-2170MHz), Bluetooth (2.4-2.48GHz) and WLAN (5.16-5.5GHz) [3]. WiMAX is designed in such a manner that it supports 30 to 40Mbps data rates. WiMAX has three licensed spectrum profiles i.e. low band, middle band and high band. Low band has frequency ranging from 2.5 to 2.8GHz, the middle band has frequency ranging from 3.2 to 3.8GHz and high band has 5.2 to 5.8GHz.

USB can provide connection to WiMAX via a device called dongle. Universal Serial Bus (USB) dongles are used for providing plug-and-play functionality in devices such as laptops. Future wireless USB dongles should have capability of accommodating high data rates to provide various multimedia services. By using two printed Dual-band PIFAs, a Dual-band Multi Input Multi Output (MIMO) antenna can be made in order to implement 4G USB Dongle application [4]-[6]. A vast range of application uses PIFA as their antenna element including wearable devices, wireless sensors, RFID and UWB systems with adaptive antennas covering an available wide frequency band of GSM 850 (824-890MHz), GSM 900 (890-960MHz), DCS/GSM 1800 (1710-1880MHz), WiBro (2.300-2.4GHz), Bluetooth (2.4-2.48GHz), and UMTS.

II. Wideband Antennas

Wideband antenna has remarkable ability to be designed for wireless and radio frequency electronics. Wideband antennas are different from broadband antennas, as in wideband antennas pass band is large, but radiation pattern and antenna gain may not be the same over the pass band. Wideband antennas need larger space to be installed as compared to multiband antennas. Microstrip patch antenna comes under the category of wideband antennas and they are also known as printed antennas. Fig. 1 shows a basic microstrip antenna. The advantages like light in weight, low cost and providing both linear and circular polarization makes them popular [2]. Using it with its original configuration, this type of antenna has a narrow bandwidth and low gain. But by using a suitable technique such as stacked patch i.e. making the substrate thick or using a low permittivity substrate its bandwidth can be widened.

But increase in substrate thickness over a limit may lead to decrease in efficiency of microstrip antennas. The increase in substrate thickness also results in increase in probe length. Increase in probe length also increases probe inductance which may lead to impedance matching problems.

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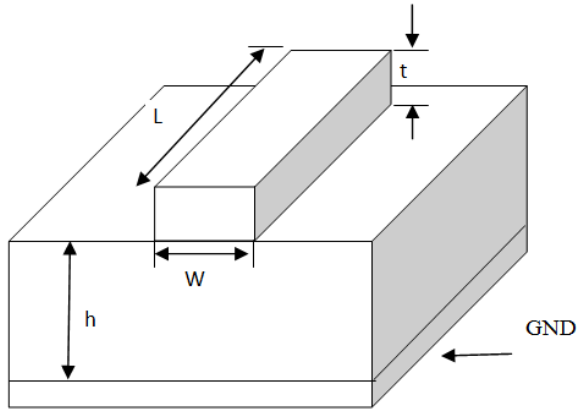

Figure 1. Basic microstrip patch antenna

A vast research has been targeted on the development of monopole antennas that provide wide impedance bandwidth to cover number of operating frequency bands. The Planar monopole antennas are found to be having most affective design because of their Omni-direction radiation pattern, compact size and high radiation efficiency [1]. In the category of monopole antennas, the circular monopole and the elliptical monopole are found to provide maximum bandwidth. Wideband monopole planar antennas are proven to be the best radiators over large bandwidths. But the planar monopole configurations are not so preferred as for most of the applications they are installed on large ground plane which is actually perpendicular to plane of monopole forming it a 3-dimensional structure. Also, due to large size of ground plane, the radiation pattern is bounded to half hemisphere. The Table I shows the comparison between different antenna structures.

TABLE I. COMPARISON BETWEEN DIFFERENT ANTENNA STRUCTURES

PARAMETERS	MICROSTRIP PATCH	MONOPOLE	PIFA
Radiation pattern	Directional	Omni-directional	Omni-directional
Fabrication and modeling	Easier to fabricate	Modeling is difficult	Easier fabrication using PCB
Application	Satellite communication	Radio broadcasting	Internal antennas of mobile phones
Merits	Low cost and low weight	Small size, low cost & supports large bandwidth	Small size, low cost, reduced backward radiation i.e. Low SAR

III. MULTIBAND ANTENNAS

A multiband antenna is basically designed to operate on several bands. This type of antenna is designed in such a way that one part of antenna can be made active for one band. The main confrontation in designing of multiband antenna is to design a multiband antenna to create multi resonating paths [7]. To meet the need of wireless communication revolution, classical monopole antennas with length λ/2 were the first one to meet the demand. But soon Planar inverted-F antenna (PIFA) took over monopoles because of its advantages like low SAR, compact size and desired cross polarization [8]. We can also say that PIFA is the reformed version of monopole antennas. Fig. 2 shows the variations made in monopole to form an inverted-F or inverted-L antenna. This additional inverted-L segment makes it possible to tune the antenna easily. Both ILA and IFA have inherently narrow bandwidths. The evolution of the handset antenna structures from a monopole to the PIFA indicates that the essential component of a handset antenna is the "wire" [9]-[10]. The patch(s) slot(s), and stub(s) are only used to compensate for the mismatch and improve the radiation characteristics.

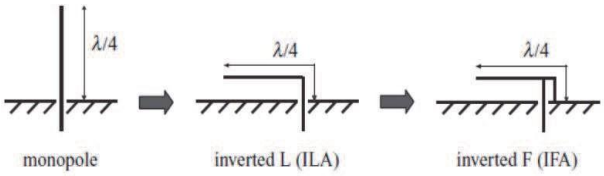

Figure 2. Inverted-F and Inverted-L antenna the reformed version of monopole

A PIFA can be easily fabricated in a USB dongle because of its small size and simple structure. A PIFA is actualized by short circuiting radiating patch to the antenna's ground plane with the help of shorting plate. PIFA can also be considered similar to the inverted-F antenna, where the wire element is replaced by plate to increase the bandwidth [3]-[5]. A basic PIFA has a grounded patch antenna of length λ/4 instead of conventional λ/2. Also, PIFA's inherent bandwidth is higher than the bandwidth of the conventional patch antenna.

Fig. 3 shows a typical PIFA structure. In order to get best matching, the position of shorting pin and feeding point is to be optimized. Bandwidth of PIFA can be improved by using various techniques like using a thick air substrate or by varying the size of ground plane.

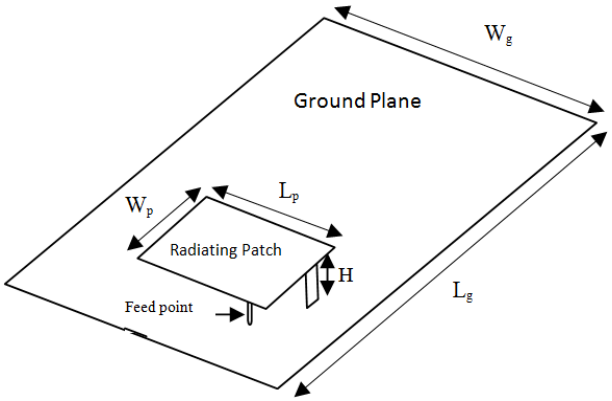

Figure 3. Structure of typical PIFA

The size of PIFA can be further reduced by using an additional shorting pin or by using a dielectric material having high permittivity as the substrate with high dielectric constant will store more energy. Resonant frequency in PIFA will decrease with the decrease in short circuit plate width. Impedance matching in PIFA can be done by varying the position of the feed and the

shorting pins and optimizing the space between them [6]-[8]. The only disadvantage of PIFA over other antennas is that, due to its quarter wavelength patch, the gain of PIFA is reduced but the size is reduced to 50%.

IV. Conclusion

In this paper, we have compared all the antennas on the basis of their design and different parameters that can be designed to work for wireless equipment. From the above discussion, we concluded that Planar Inverted-F Antenna (PIFA) stood above all other antenna designs due to its various advantages like small in size and easy fabrication. Due to these advantages PIFA can be used in small devices like a USB dongle in order to cover the desired Wireless range of frequencies.

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Sunakshi Puri was born on 28th, December 1986 in Chandigarh, India. .She received her Bachelor of Technology Degree in Electronics & Communication Engineering from Sri Sukhmani Institute of Engineering & Technology, Punjab, India (2009). She is pursuing Master of Technology Degree from Baba Banda Singh Bahadur Engineering College, Punjab, India. She has more than 3 years of academic experience. Her areas of interests are Wireless & Mobile Communication and Antenna Design.

Kiranpreet Kaur was born in Faridkot, Punjab. She received her Bachelor of Technology Degree in Electronics & Communication Engineering from T.I.E.T. Patiala, Punjab in 2000. She has completed Master of Technology Degree from PTU Jalandhar, Punjab in 2007. She is Pursuing PhD in Wireless Communication from PTU Jalandhar, Punjab. Presently, she is working as an assistant professor in Baba Banda Singh Bahadur Engineering College, Fatehgarh, Punjab. She has more than 12 years of academic experience. She has more than 19 papers published in National/International conferences. Her research area is wireless and mobile communication.

Naveen Kumar was born on 16th, October 1987 in Chandigarh, India. He received his Bachelor of Technology Degree in Electronics & Communication Engineering from Swami Vivekanand Institute of Engineering & Technology, Punjab, India (2009). He has completed Master of Engineering from National Institute of Technical Teachers' Training & Research (NITTTR), Chandigarh, India (2013). Presently, he is working as an Assistant Professor, Electronics & Communication Department, Universal Group of Institutions, Punjab, India. He has 3 years of academic experience. His research interests are Wireless & Mobile communication & Antenna Design.