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A Survey on Design and Development of Planar Antennas for Wireless Applications

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ABSTRACT: In this paper we are exploring the various planar antennas and their performance improvement techniques to overcome their limitations and enable them for wireless applications. Planar antennas have many advantages compared to conventional antennas. The various attractive features of these antennas are low profile, light weight, low cost, low volume, ease of fabrication, compactness, integration into microwave integrated circuits etc., which make them more suitable for wireless applications. The major limitations of planar microstrip antennas are narrow bandwidth, low gain and low efficiency and these can be overcome by using performance improvement techniques.

Keywords: Planar Microstrip Antenna, Performance improvement techniques, Wireless applications.

I. INTRODUCTION

Planar antennas such as Microstrip and printed antennas have the smart features of low profile, small size, and conformability to mounting hosts and are very promising candidates for satisfying design consideration of wireless applications. The major limitation of many low-profile antennas is their narrow bandwidth.

A planar array is an antenna in which all the elements, both active and parasitic are in one plane. A planar array provides large aperture and may be used for directional beam control by varying relative phase of each element. Planar array configurations are extensively used in both communication and radar systems where a narrow pencil beam is required. Planar arrays of printed radiating elements are potentially good candidates for low cost scanning array applications. Microstrip patch arrays are versatile as they can be used to synthesize a required pattern that cannot be achieved with a single element. In addition, they are used to increase the directivity and perform various other functions, which would be difficult with any one single element.

II. PERFORMANCE IMPROVEMENT TECHNIQUES.

1. Low-Profile Enhanced-Bandwidth PIFA Antennas for Wireless Communications packaging.

In this paper [Kathleen L. Virga, 1997], authors have proposed the development and characterization of several low-profile and integrated antennas with enhanced bandwidth for wireless communication systems.

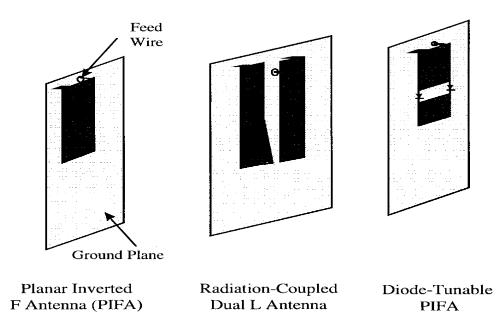


Fig. 1. Low-profile integrated antenna configurations for wireless communication applications.

Fig. 1 shows the configurations of several low-profile antennas with enhanced bandwidth performance. These antennas include the radiation-coupled Dual L antenna and the diode-tunable planar inverted F (diode PIFA) antennas. These antenna structures have specific advantages over other candidate elements because the bandwidth is increased while maintaining a low-profile geometry and without additional internal matching networks.

The new radiators are developed by adding parasitic elements or tuning devices to a familiar integrated antenna—the planar inverted F antenna (PIFA). Simulations based upon the finite-difference time-domain (FDTD) method and methods of moments (MoM) are used to model the performance of the antennas.

The PIFA is modified in ways that extend the maximum bandwidth obtainable from this element. In the case of the Dual L, an additional coupled element is added to the PIFA structure. In the case of the diode PIFA, tuning diodes are added to effectively tune the length of the PIFA element. The addition of diodes to the PIFA structure overcomes some of fundamental limitations that exist in the general problem of matching arbitrary load impedance to a pure resistance.

This paper has focused on the development of low-profile integrated antennas with enhanced bandwidth performance. The featured radiators have several advantages over other candidate antenna elements. The results for the PIFA, radiation-coupled Dual L, and the diode-tunable PIFA show that these antennas are potential low-profile candidates for wireless communications systems. The PIFA can be designed for up to about 9.6% bandwidth. A Dual L antenna with a predicted bandwidth of 16% bandwidth and a diode PIFA antenna with 50% predicted bandwidths were designed. The design methodology to develop Dual L antennas for different frequencies of operation was described. Measured results on fabricated antennas were used to confirm the simulation results used FDTD and MoM.

2. Small Planar Monopole Antenna with a Shorted Parasitic Inverted-L Wire for Wireless Communications in the 2.4-, 5.2-, and 5.8-GHz Bands.

In this paper [Jen-Yea Jan, 2004], a small low profile planar monopole antenna with a shorted parasitic inverted L-wire for wireless communication is studied. The driven monopole element and shorted parasitic wire can separately control the operating frequencies of two excited resonant modes, which can cover the 2.4-, 5.2-, and 5.8-GHz WLAN bands.

The proposed antenna design is suitable as a monopole antenna as well as a diversity antenna. The proposed antenna has good impedance matching triple band operation but it also performs as a diversity triple-band antenna. For the proposed antenna, by placing the parasitic wire in close proximity to the driven monopole element, an additional resonant mode contributed from the parasitic wire can be excited. The parasitic wire is electromagnetically coupled and excited by the driven element, and the operating frequencies can be controlled by the driven element and parasitic wire. In this design, because the parasitic wire used is a bent shorted inverted-L wire surrounding one of the corners of the driven element closely, it is found that a smaller antenna design in volume can be obtained. A 50Ω microstrip feed line is used in this antenna design, which can provide the triple-band operation with good impedance matching.

The proposed antenna is small and easy to construct. Also, it is capable of integration with the associated circuit on the same dielectric substrate, which can reduce the fabrication cost and the required volume of the whole system. The proposed antenna has two operating bandwidths with a tunable frequency ratio. Hence it can be a good antenna design for WLAN operations in the 2.4-, 5.2-, 5.8-GHz bands.

3. Design of Planar Inverted–F Antenna for Wireless Applications.

In this paper [Dr. S. Raghavan, 2009] a compact dual band PIFA was presented. This antenna has a bandwidth of 530 and 303 MHz for 2.25 GHz and 3.546 GHz bands respectively, has an Omni directional radiation pattern and is very efficient. This antenna is suitable for ISM, Bluetooth, IEEE 802.11b, 802.11g, 802.11n, 802.16e, Wi-Fi, Wi-Max applications and this antenna design is mainly focusing on mobile terminal antennas. New applications are arising that will be included in mobile phones.

Size reduction is needed for antennas incorporated in wireless applications. The method of moments is then used to model the PIFA mounted on a finite ground plane. Extensive Simulations using IE3D and measurements were performed to investigate the characteristics of these antennas.

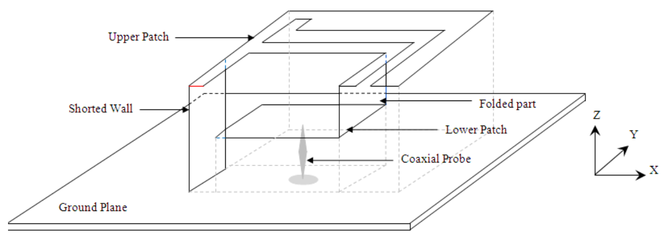
Antenna I and II has a bandwidth of 510 and 577 MHz respectively. This Omni directional radiation pattern of this type of antenna is very much useful for mobile devices, because the position of the user relative to the base station is not known. The antenna with different Substrates discussed in this paper is suitable for ISM, Bluetooth and Wi-Max applications.

4. **Small Planar Antenna for WLAN Applications.**

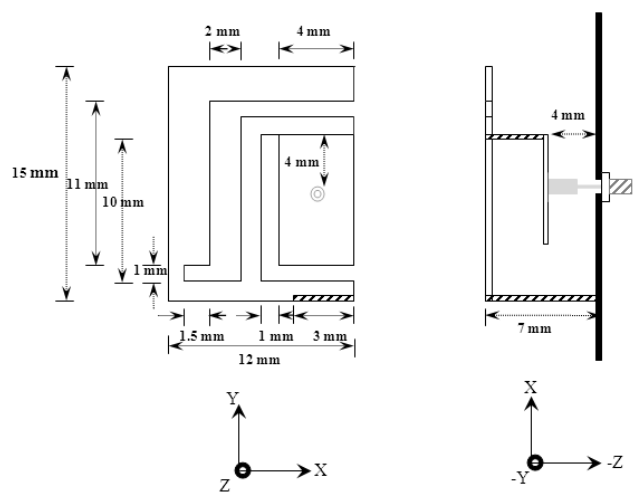
In this paper [M. Yunus, 2010], a miniature dual-band folded patch antenna for WLAN and cellular applications is presented. The proposed antenna provides 3.3% and 25% bandwidth at $S_{11} < -10$ dB for 2.5 GHz and 5.2 GHz WLAN bands that completely encompasses the desired ISM2400 and IEEE802.11a/b/g standards.

A novel dual-band planar antenna is presented that consists of a double-L slot facing each other when viewed from the top configured together with folded-patch feed and shorting wall is presented. All these modification will strongly contribute to reduce antenna size and broaden the bandwidth, compared with a simple patch.

A prototype of the proposed antenna has been developed by using 0.2 mm copper sheet which has been cut and properly bent in order to obtain tridimensional element. The idea of using copper material is to have an antenna that can be easily integrated on top of the circuit board of the mobile devices to reduce packaging cost. The radiation element is physically supported by a coaxial cable and shorting wall. They are electronically consisting of a feeding structure. The 50 Ω coaxial cable directly feeds to a radiation patch.



(a) 3D-view



(b) Top view (c) Side view.

Fig. 2. Geometry of the proposed antenna

The total size of the proposed antenna has the volume of 15 × 12 × 7 mm, and on top of the ground plane with dimension of 57 × 54 mm. The simulated antenna performance is analyzed using CST Microwave Studio Suite and measured using Agilent Network Analyzer E8362C.

Figure 3 depicts the comparison results between the simulated and measured return losses of the proposed antenna. The solid and the dashed line denote the simulated and measured return losses respectively. The obtained bandwidths can sufficiently cover the bandwidth requirement for WLAN standards IEEE 802.11a, IEEE 802.11b/g and IEEE 802.11n. The maximum return loss of -22.9 dB and -17.89 dB are obtained at the resonant frequencies of 2.4 GHz and 5.5 GHz respectively.

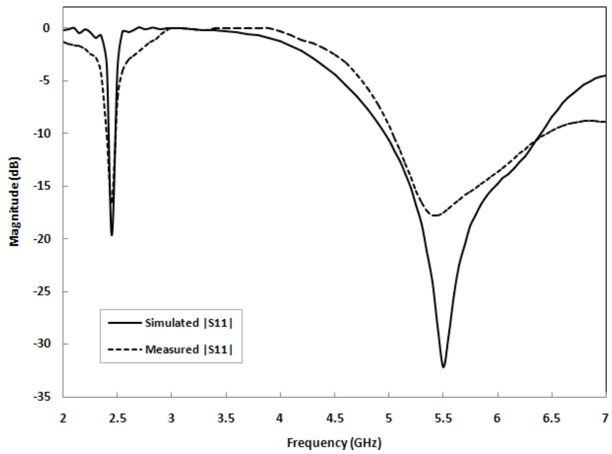


Fig. 3. Comparison between simulated and measured return losses of the proposed antenna.

When tested the antenna prototype exhibits maximum gain of more than 7dBi with a good radiation pattern in the lower and higher frequency bands, respectively. Moreover, the proposed antenna is compact in size, low cost and easy to manufacture. These features are very useful for worldwide portability of wireless communication applications.

CONCLUSION

Planar antennas have the attractive features such as low profile, small size, light weight and conformability. The major limitations of planar antennas are narrow bandwidth and low gain. In this paper we have made the survey of design and development of planar antennas and some performance improvement techniques to overcome their limitations.

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