A Dual Band MIMO PIFA for WLAN Application

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***Abstract*— A printed dual-band MIMO-PIFA has been presented in this paper. One of the arms of the PIFA has been loaded with a spiral inductor to realize miniaturization as well as dual-band operation. High isolation between the elements has been achieved by placing floated parasitic elements on the ground plane. 10 dB return loss bandwidth of the antenna covers the two WLAN bands (2.3–2.5 GHz and 4.8–5.4 GHz) with a peak gain of 2.67dB and 3.8dB respectively. A good diversity performance has been realized by analyzing its essential matrices.**

Keywords—Diversity; Isolation; MIMO; PIFA; WLAN

I. Introduction

Ever increasing demands of WLAN systems in day to day life have prompted antenna researchers to develop advanced antennas for such systems. Present days WLAN systems require high level of throughput, enhanced channel capacity and better reliability. MIMO technology satisfies these demands without exploiting any additional techniques [1]. Due to the compactness of present day WLAN systems, isolation improvement is a challenging task as it strongly affects the radiation efficiency and channel capacity of MIMO system. In literatures, numerous approaches have been presented for improving the isolation performance [2], such as use of decoupling networks, parasitic elements, floated parasitic element, slit /stub on the ground plane, neutralization line, use of Metamaterials and proper alignment of antennas.

In this work a dual band MIMO PIFA has been proposed for applications in the 2.45 and 5 GHz WLAN bands, based on the structure presented in [3]. Antenna miniaturization has been achieved by loading one of the arms with spiral inductor. The loading is also responsible for dual band operation. An equivalent transmission line model has been presented to relate the loading of spiral inductor with the dual band operation. Two floated parasitic elements have been used on the bottom of the substrate to improve isolation. In order to analyze the diversity performance, total active reflection coefficient (TARC), envelope correlation coefficient (ECC), diversity gain (DG) and channel capacity loss (CCL) are studied.

II. Antenna Design

The geometry of the proposed MIMO antenna is shown in Fig.1. It is printed on a 29×29 mm^2 FR4 substrate (ε_r=4.4, tanδ= 0.02, thickness = 0.8 mm). Simulation and optimization of the design has been carried out using ANSYS HFSS (Ver. 15). The dimensions are L=29, l=14.5, l1=4, l2=4.88, l3=2.4, l4=2.5,l5=1.7,lp=10,lp2=2.8,lg=8.5,Wg=10.8,Ws=1.6,Wf=1.4, w1=1, w2=0.5. The dual band characteristic has been achieved as a result of the loading of one of the PIFA arms with a spiral inductor. To establish this, a lumped element equivalent circuit model of the proposed antenna is presented in fig. 1.In the figure $\theta_1 + \theta_2 = \beta l$ (β is the phase constant), Z_0 , Z_{01} are the characteristic impedances of the lines of length *l* and *ls,* respectively, Rrad is the radiation resistance, Ls is the inductance of the spiral inductor, and Cs is the fringing capacitance. The equivalent circuit is simulated for different values of L_s and plotted in Fig. 1, which reveals that for L_s=0nH the antenna has single band characteristics. However, as the inductance value increases, the second band is introduced. It also reveals that L_s has minor effect on the lower band. In the proposed MIMO structure the PIFA elements have been oriented perpendicularly (Fig.1) to achieve high isolation. However, the antenna placement is not much effective at the 2.45 GHz band as shown in Fig. 2. Therefore, to improve the isolation at 2.45 GHz band, two floated quarter wavelength parasitic elements (PE) have been introduced on the bottom of the substrate [4].Fig. 2 reveals that the introduction of the PE has significantly reduced coupling at both the bands. The in-band surface current distributions on the antenna are also shown in Fig. 2, which reveal that due the introduction of the PE, the induced surface current density on the second antenna has been reduced significantly.

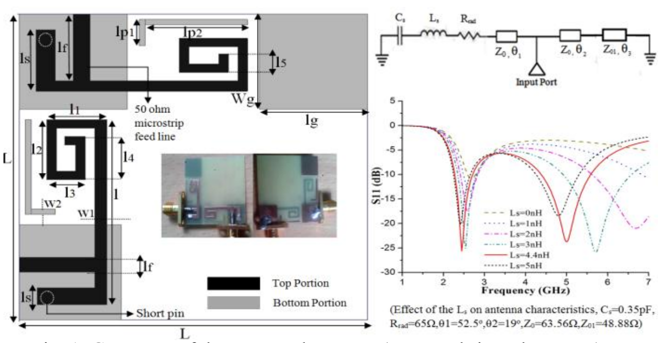

Fig. 1. Geometry of the proposed antenna (Inset: Fabricated antenna) and Equivalent circuit model

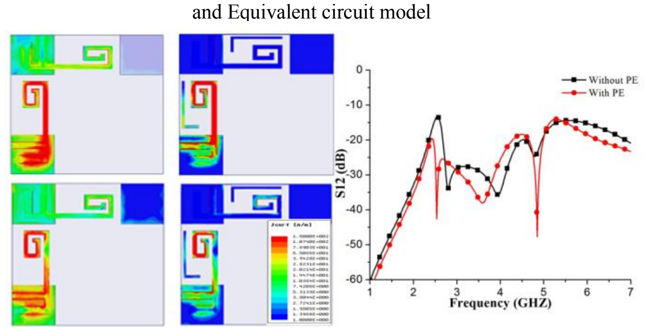

Fig. 2. Surface current distribution and Effect of PE on S12 (dB) of the antenna

III. Result and Discussion

A. Antenna Characteristics

To validate the simulation, the antenna has been fabricated and measured. The measured S parameters and gain are plotted in Fig. 3 and compared with the simulated data. The figure reveals that the proposed antenna has two 10 dB return loss bandwidths extending from 2.3 to 2.5 GHz and 4.8 to 5.5 GHz. The measured isolation at the respective bands is 24.41 dB and 24.74 dB, respectively. The slight mismatches between the simulated and measured result, in Fig. 3, are due to the losses in the SMA connectors. Simulated and measured in-band gains of the proposed antenna have been plotted and compared in Fig.4. The figure reveals a peak gain of 2.67dB at 2.45 GHz and 3.8 dB at 5 GHz. Co and cross polarization radiation patterns of the antenna on the orthogonal planes at 2.45 and 5 GHz are shown in Fig. 4. The figure reveals a relatively high cross polarization level, which may be explained as a result of orthogonal orientations of the antenna elements.

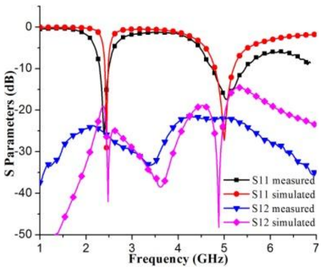

Fig. 3.S parameters (dB) of the antenna

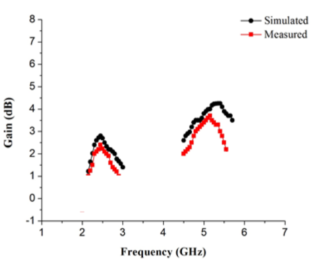

Fig. 4.Peak gain (dB) of the antenna

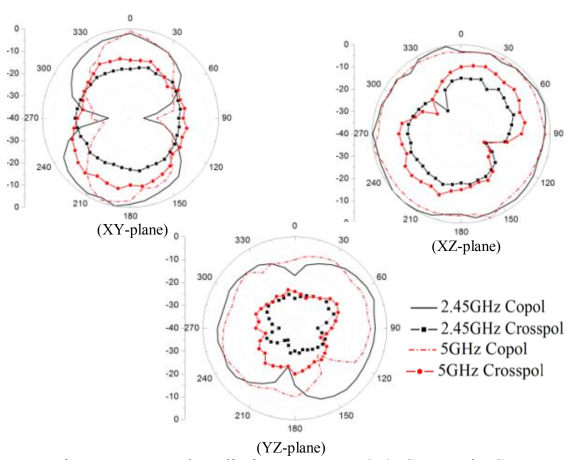

Fig. 5. Measured Radiation pattern at 2.45GHz and 5GHz

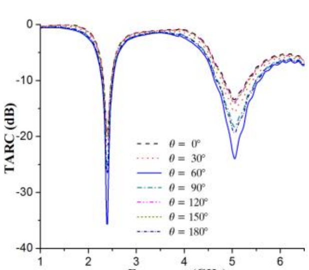

Fig. 6. Measured value of TARC (dB)

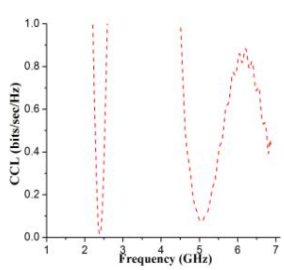

Fig.7.Measured value of CCL (bps/Hz)

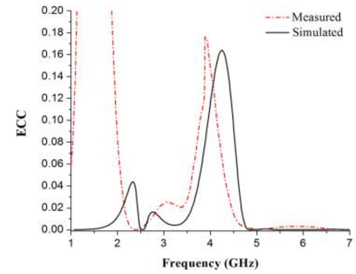

Fig. 8. Simulated and measured value of envelope correlation coefficient

B. Diversity and MIMO Characteristics

TARC is an essential attribute to compute the effective BW of a multiport antenna system. For a 2-port antenna system with a variation of feed phase 'θ' from 0° to 180°, it can be evaluated in terms of S parameter as given in [2]. Fig.6 shows the TARC response of the antenna for different phase differences between the excited ports. CCL can be realized by considering uniform multipath environment and high SNR [6].The obtained CCL values is less than 0.1 bps/Hz for both the operating bands, as shown in Fig. 7, satisfying a good diversity performance [6]. ECC can be calculated in terms of S-parameters as given in [5].Fig. 8 reveals that the measured ECCs are 0.13 at 2.45 GHz and 0.31 at 5.6 GHZ, which satisfy the criteria for good diversity performance in MIMO system [5]. DG can be evaluated in terms of ECC [2].The diversity gains of the designed antenna are 9.94 dB at 2.45 GHz and 9.96 dB at 5 GHz.

IV. Conclusion

A two port dual band MIMO PIFA is proposed for WLAN applications. Miniaturization of the antenna has been obtained by spiraling one of the arms. An enhanced isolation (higher than 20dB) has been achieved due to the orthogonal orientations of the elements and use of parasitic elements on the bottom of the substrate. A low correlation) with good diversity gain has been achieved. A CCL value of less than 0.1 bps/Hz realizes a good channel capacity of the MIMO system. It has been demonstrated that the proposed dual band PIFA exhibits a good diversity performance for MIMO system.

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