Tri-Band Printed Monopole Antenna for WLAN and WiMAX MIMO Systems

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Abstract— **Anovel Tri-band printed monopole antenna for multi input- multi output (MIMO) application is presented. A c-shaped printed monopole antenna resonates in two frequency bands, due to its two resonance paths. The tri-band antenna is obtained with etching a c-shaped slot on it, which has been used in a two elements MIMO structure. The proposed antenna provides three frequency bands for WLAN and WiMAX application, covering 2.4, 3.8 and 5.2 GHz. This structure provides low mutual coupling and envelope correlation. The antenna parameters and simulation results are presented.**

I. Introduction

Recently, there is a great interest in using multi-input multi-output (MIMO) systems in the wireless communication, because of their ability to increase the capacity of channel and reduction of multipath fading. So it seems to be very essential to design adequate antenna due to use in MIMO systems.

There is extensive literature on non-printed MIMO antennas such as planar inverted F antennas (PIFA) [1].However, among the antennas which are used for MIMO application, printed antennas are more appropriate due to their low cost, straightforward manufacture, and their capability of easily being integrated to small terminal devices. The design of a four-element U-shaped printed MIMO antenna operating at 5.8 GHz is reported in [2].

The omnidirectional pattern enhances and increases the channel capacity [3]. Thus, because of the omnidirectional pattern of printed monopole antennas, they are more attractive for MIMO application. The design of a single-band four-element printed monopole antenna for UMTS mobile phone application is given in [4].

Rapid developments in the wireless communication industry demand novel antenna designs that can be used in more than one frequency band. The design of a dual-band back-to-back printed monopole antenna operating at UMTS and 2.4 GHz WLAN is reported in [5]. A tri-band E-shaped printed monopole antenna loaded with two U-shaped resonance paths suitable for MIMO systems for WLAN application, covering 2.4, 5.4, and 5.8 GHz is reported in [6]. This antenna cannot provide WiMAX application.

In this paper a novel triband c-shaped printed monopole antenna for MIMO application is presented.It can provide three frequency bands for WLAN and WiMAX applications, covering 2.4, 3.8, and 5.2 GHz.These three resonances are obtained by etching slot in the c-shape antenna. Two elements of such antennas are used for MIMO applications. The proposed structure obtains low mutual coupling and envelope correlation.The full wave package Ansoft HFSS is used simulating the proposed antenna.

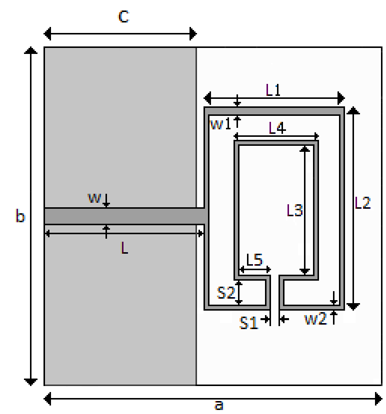

Fig.1: A c-shaped slotted arms printed monopole antenna.

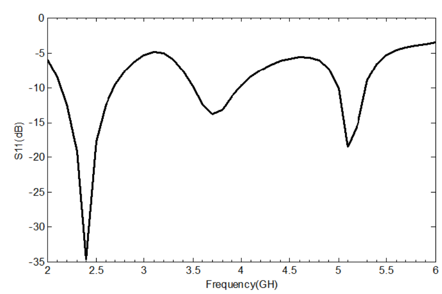

Fig2: The return loss of the slotted C-shaped antenna

II. Antenna Design

A c-shaped tri-band printed monopole antenna is proposed, as shown in Fig. 1. As it seen this structure consists of a c-shaped path, with a c-shaped slot in its arms. The c-shaped

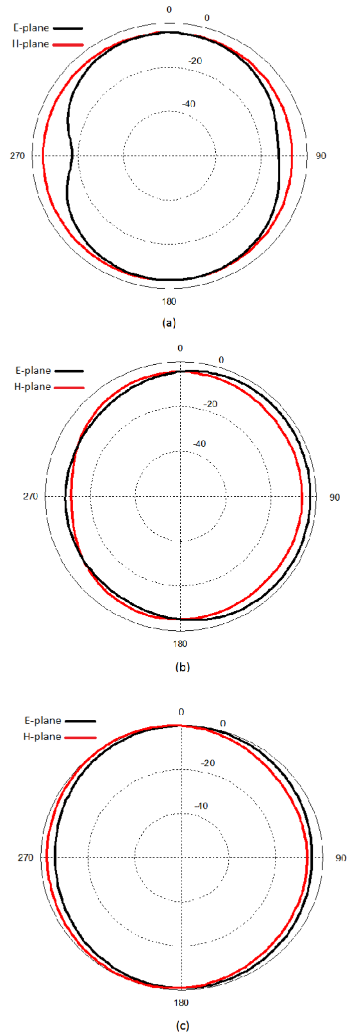

Fig. 3:TheE- and H-plane radiation pattern of the slotted C-shaped antenna at (a) 2.4, (b) 3.8, and (c) 5.2 GHz

printed monopole antenna without the slot provides two frequency bands due to its two resonance paths. When this antenna is been loaded with the c-shaped slot, new resonance paths is created, which provide three frequency bands. The return loss of the slotted C-shaped antenna is shown in Fig. 2.

As can be seen the proposed antenna resonates at 2.4, 3.8 and 5.2 GHz.

The E- and H-plane radiation patterns of the slotted C-shaped antenna at 2.4, 3.8, and 5.2 GHz are shown in Fig. 3. It is noticed that the E- and H-plane components are omnidirectional.

The permittivity of the substrate that used in the proposed structure, is ε_r= 6.15 and its thickness is h = 0.64 mm. The dimensions of this antenna are as follows: a=40, b=40, c=18, w=2, L=19, w1=1, w2=0.5, L1=16.5, L2=24, L3=15.5, L4=10, L5=3.75, s1=1 and s2=3 mm.

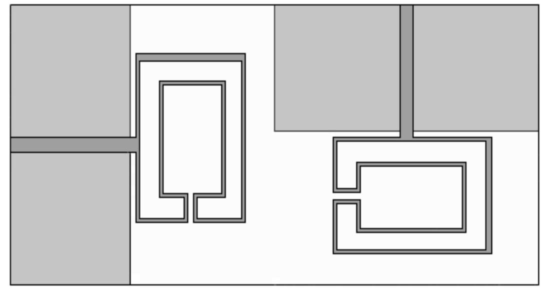

Fig.4: Tri-band MIMO printed monopole antenna. (Space of antenna $\cong \frac{\lambda_g}{5}$).

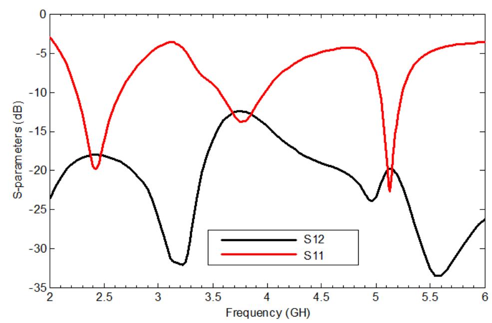

Fig.5: Reflection coefficient and mutual coupling of the designed antenna.

Due to design a MIMO structure of this antenna, two elements have been used. In a MIMO antenna high radiation efficiency, high peak gain, low envelope correlation, and high isolation between the signal ports is required. The various configurations of suchantennas in relation to eachother are investigated and basedon the least correlation and mutual coupling,the mostsuitable configuration for MIMO application is presented. The proposed configuration consists oftwo orthogonal elements as shown in Fig. 4.

These two elements are placed in orthogonal configuration with $0.2\lambda_g$distance of each other, and due to the polarization diversity comes from this configuration, the correlation and coupling is decreased.

III. RESULTS

Fig. 5 shows the reflection coefficient and mutual coupling of the designed antenna. As it seen S11 is lower than -15dB at resonance frequencies and the proposed MIMO antenna operates at frequencies 2.4, 3.8 and 5.2 GHz. Also S12 is less than -12dB, thus the mutual coupling of this structure is low and these two antennas are approximately independent.

The E- and H-plane radiation patterns of the proposed MIMO antenna at 2.4, 3.8, and 5.2 GHz are shown in Fig. 6.

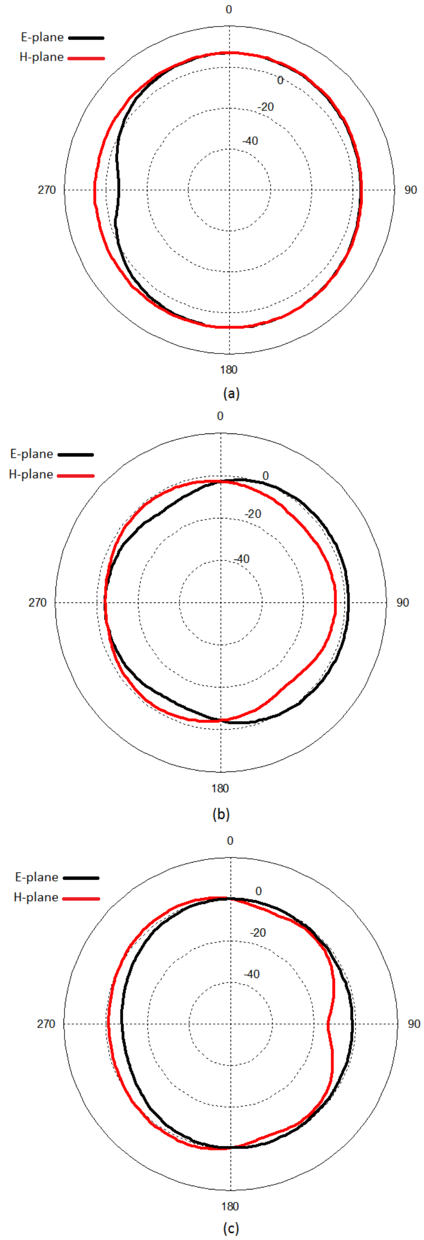

Fig. 6:TheE- and H-plane radiation pattern of the proposed MIMO antenna at (a) 2.4, (b) 3.8, and (c) 5.2 GHz

The envelope correlation can be computed froms-parameters using the following formula [6]:

$$\rho_e = \frac{|\quad {}^{*} \quad\quad {}^{*} \quad |}{|(\quad |\ |\ \ |\ \ |)(\quad |\ |\ \ |\ \ |)|}. \qquad (1)$$

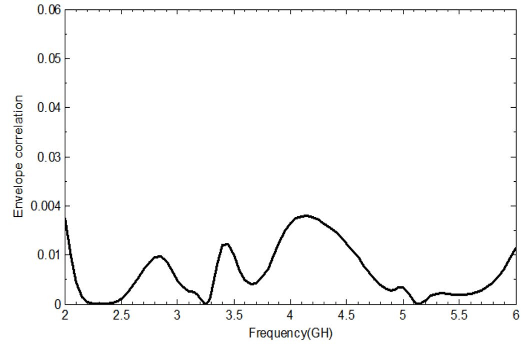

Fig.7:Envelope correlation of the proposed MIMO antenna.

TABLE I
GAIN AND RADIATION EFFICIENCY RESULTS

Frequency (GHz)	2.4	3.8	5.2
Peak Gain (dBi)	-2.7	1.9	2
η (%)	96	82	95

The maximum acceptable amount for this parameter is about 0.3. Fig. 7 shows envelope correlation of the proposed MIMO antenna. As can be seen, the envelope correlation of thisstructure is less than 0.0073. So the proposed antenna is appropriate for the MIMO applications.

The peak gain and radiation efficiency of the antenna in the resonance frequencies are listed in Table I. The radiation efficiency, which is obtained by calculating the ratio of the total radiated power of the array antenna to the total input power, in all of the resonance frequencies is higher than 82%.

IV. CONCLUSIONS

A novel triband C-shaped printed monopole antenna for MIMO application has been presented. The antenna for WLAN and WiMAX applications, covering 2.4, 3.8 and 5.2 GHz, are given. The proposed MIMO array configuration with element spacing of $\lambda_g/5$ provides less than -12 dB mutual coupling, envelope correlation of lower than 0.0073 and efficiency of higher than 82%.

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