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Design of a Compact MIMO Antenna with Polarization Diversity for WiMAX Application

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ABSTRACT: In this paper, we present a compact multiple-input multiple-output antenna using polarization diversity is presented for WiMAX application. The proposed design combines horizontally and vertically S-shaped polarized radiating elements. The effect of mutual coupling between radiating element is reduced by orthogonal placement of antenna elements. The whole configuration is designed over a FR4 substrate of size 50 × 50 mm^2. The proposed MIMO antenna has an isolation greater than 24 dB at 3.5 GHz and the envelope correlation of the antenna is always less than 0.087. Detail of the whole design consideration and the experimental results of the MIMO antenna using polarization diversity are presented and discussed.

KEYWORDS: Multiple Input Multiple Output (MIMO), isolation, Flame Retardant 4 (FR4),polarization diversity, Worldwide Interoperability for Microwave Access (WiMAX)

I.INTRODUCTION

Nowadays, wireless communication technologies have been rapidly developing.The huge demand for high speed data transmission and high quality data transmission in wireless communications has increased greatly,which makes multiple-input multiple-output (MIMO) technology attractive for its excellent performance in terms of channel capacity without occupying extra spectrum and radiating power[1]. The multiple-input multiple-output (MIMO) technology made a better quality mobile communication services by mitigating the multipath fading which is required in various wireless applications like WiFi, WiMAX, LTE and WLAN to provide multimedia services[2,3]. In MIMO systems, the uncorrelated signals between the channels must be improve the channel capacities. To achieve this improvement, space,pattern and polarization diversities are being used[1-10]. Due to the compact size of handheld devices, using all diversity techniques together is not possible. To reduce the mutual coupling between the elements, a crossbar or connecting a line on the proper place between them have been reported[4-7]. Two orthogonally polarized antenna elements are used to utilizing the polarization diversity between them and achieves the high isolation [8-16]. square ringpatch and a planar inverted F antenna (PIFA) was designedforimpedance matching and coverage of signals in both thevertical and horizontal directions [10].Acompact MIMO antenna with two monopoles andconnecting lines was designed using pattern andpolarizationdiversities to improve isolation between ports [11].

In this paper, we propose a MIMO antenna using polarization diversity for WiMAX applications. The proposed MIMO antenna consists of two S shaped meander with modified ground plane. Input port 1 of the first antenna element is orthogonally disposed with respect to Input port 2 of the second antenna element. The orthogonal placement of the two feed of the antenna element ensure the dominant polarization of each of the patch is opposite to each other, resulting in a good isolation performance. The proposeddesign covers frequency range at 3.5GHz for WiMAX applications. Thesection II describes the proposed design. The section III describes simulatedresults, and the section IV shows the conclusion.

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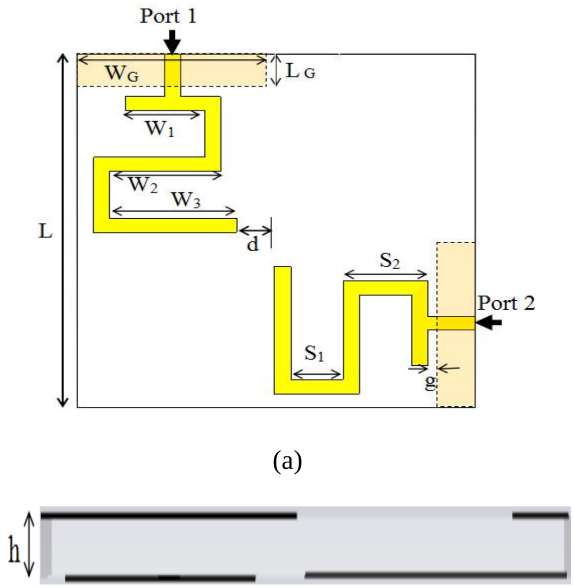
II. MIMO ANTENNA DESIGN

The proposed polarization diversity dual element MIMO antennahas overall dimension of 50 x 50mm^{2}on FR4dielectric substrate. The thickness of copper layer on the dualside of FR4 dielectric substrate is 0.0354. The FR4 dielectricsubstrate has permittivity of 4.3, thickness of 1mm, andloss tangent of 0.025. The optimizedMIMO antennaelements are S shaped and the modified ground structure. Each single antenna is fed by a 50 Ω microstrip feed line, where the signal strip is1.875, and the gap between the radiating patch and grounded conductoris g=0.5mm. Theradiating patch consists anS-shape meander line with overall width of 18 mm andoverall lengthof21.2 mm, connected to themicrostrip feed line with length of L_G= 5 mm.



(a)

(b)

Fig. 1: Schematic view of proposed polarization diversity antenna a)rear view, b) bottom view.

TABLE 1: Parameters of the proposed antenna (unit: mm)

parameter	L	W_G	L_G	W1	W2	W3
value	50	24	5	16	14	10
parameter	S1	S2	d	g	h	
value	6	6	4.7	0.5	1	

III. SIMULATION AND EXPERIMENTAL RESULTS

A. Returnloss and Isolation

The design of the proposed MIMO antenna is performedusing computer simulation tool(CST),The returnlossand isolation of the proposed design are maintained using theorthogonal placementof modified ground structure and antenna elements. Due to the *S*12=*S*21condition obtained in results from CST, weconsidered only *S*11, *S*22, and *S*12 parameters. Aplot of simulated *S* parameters has beenshown in Fig. 2. The simulatedreturnloss of port 1 is 46 dB at 3.49 GHz and port 2 is 43 dB at 3.51 GHz.The high isolation in frequency bands comes dueto the modified ground structure and orthogonalplacement of ground and antenna elements.The simulatedisolation in 3.5GHz frequency band is less than 24 dB.

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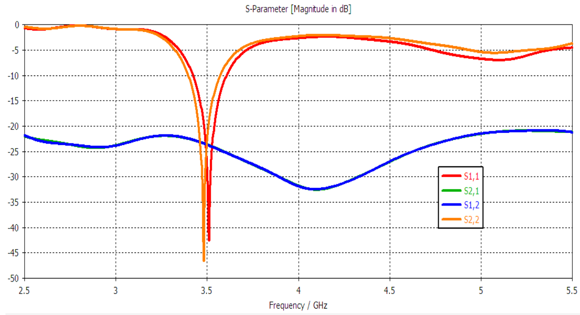

Fig.2 S parameters of proposed MIMOantenna.

B. Antenna gain, 2D gain patterns, Radiation efficiency

The diversity performance of the MIMO antenna can be derived in terms of antennagain patterns, peak gain, radiation efficiency. The obtained antenna gain is shown in Fig. 3. Thesimulated peak gains of antenna element 1 connected toport 1 are 3.2 *dB*for 3.49 GHz. Similarly, the simulatedpeak gains of antenna element 2 connectedto port 2 are 3.25*dB*at 3.51 GHz resonantfrequency.Similarly, the simulated radiation efficiencyforboth the radiators of the proposed MIMO is more than85% and the high efficiency is the effect oflow losses.

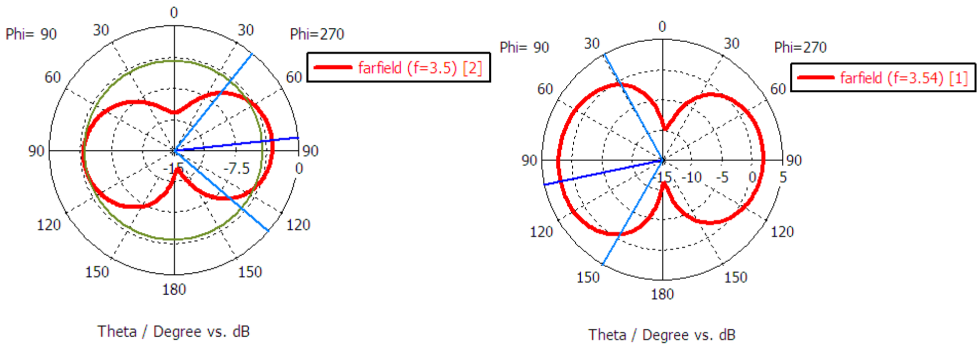

Fig.3 2D gain patterns of proposed MIMOantenna for port1 & port2.

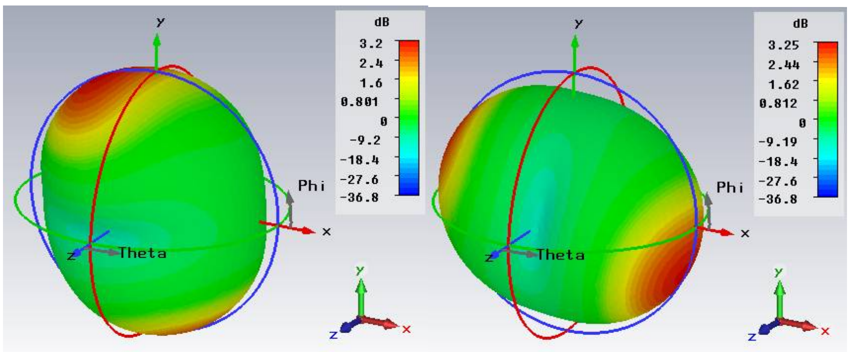

Fig.4 3D gain patterns of proposed MIMOantenna for port1 & port2.

C. Envelope correlation coefficient (ECC), Diversity Gain (D_G)

The whole effect in the all measured *S* parameters of the mutual couplingisolation is obtained in terms of ECCfor the proposedpolarization diversity MIMO antenna using equation no.(1). Thesimulated values of ECC are 0.027 at 3.5 GHz resonant frequency. Therefore, obtained diversity gain is 9.96 dBi at 3.5 GHz using equation no.(2). Such a more variation inECC value is due tothe polarization mismatches and fabrication errors of the MIMO antenna.

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$$|\rho_e| = \frac{|S_{11}^* S_{21} + S_{12}^* S_{22}|}{\sqrt{\left|\left(1-|S_{11}|^2-|S_{21}|^2\right)\left(1-|S_{22}|^2-|S_{12}|^2\right)\right|}} \quad \text{eq.(1)}$$

$$|\rho_e| = 0.087$$

$$D_G = 10 * \sqrt{1-|\rho|^2} \quad \text{eq.(2)}$$

$$D_G = 9.96 \text{ dBi}$$

IV. CONCLUSION

A S-shaped polarization diversity MIMO antenna has been designedwith perfect ground modification with orthogonal placement. Theresults are obtained and verified using S parameters and far field parameters. Theproposed polarization diversity MIMO antenna hascovers frequency range at 3.5GHz. The effect of the polarization diversity has been observed in terms of 2D gainpatterns, isolation values and by ECC. The proposed designshowed less than -24*dB* of simulated mutualcoupling, peak gains ofmore than 3.2*dB* for each antenna element, and radiation efficiencyof more than 85%, and common percentage bandwidth of 32.16%respectively.

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