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Planer Ultra Wide Band Antennas and Band Rejection Characteristics

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COMPACT PLANNER MOBILE PHONE MIMO ANTENNA WITH ENHANCED GAIN

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***ABSTRACT**— The presented paper exhibits a compact two element multiple input multiple output (MIMO) antenna which is covering wide bandwidth and enhanced gain is presented. The proposed MIMO antenna consists of two monopoles; each is fed by L shaped microstrip line. Monopole is used to feed an inverted L shaped structure which extends from ground. Isolation between two monopoles is achieved by placing a slot on ground plane. The proposed antenna has dimensions of 100mm x 97mm. In addition, an impedance bandwidth (S11<-6dB) from 0.8GHz to 3.5GHz which covers the 2G frequency bands (GSM900/GSM1800/GSM1900), 3G frequency band (CDMA2000) and of the 4G frequency band having isolation greater than -13.5dB is achieved. The performance of diversity is also calculated in terms of envelope correlation coefficient and diversity gain. Simulated and measured results of the proposed antenna are in good agreement.*

I. INTRODUCTION

Modern wireless technology has an increasing demand of increase data rate and high performance. Traditional wireless technologies can barely satisfy these demands. Recently, MIMO (Multiple Input Multiple Output) technology has gained importance due to reduced multi path fading, high data capacity and high reliability [1]. Multi path fading is a big challenge in many practical applications because transmitted signals can travel from different paths to the receiver having different phase angles and amplitudes, and most probably they add up destructively at receiver. MIMO technology in antennas is the best solution to this challenge. [2]-[9] present various MIMO antennas designed specifically for certain type of communication applications.

Eye catching advantages of MIMO technology have made it an important technology for 4G (LTE) and as well as for 5G which is a future wireless communication technology. While 2G/3G technology is still in use, 4G communication is quickly popularizing all over the world. MIMO antennas are a perfect choice for mobile phone purposes as they offer wide bandwidth and coverage of 2G/3G/4G bands. [2]-[9] presents with a few MIMO designs for 4G applications. Out of stated 4G MIMO antennas, designs presented in [4]-[5] are not suitable for use in mobile phones due to their large size as compared to the standard sizes of current generation mobile phones. Ceramic based mobile phone antenna is presented in [6] and a multi-band MIMO antenna with PIFA structure is proposed in [7]. Both of them have significant heights and non-planner structure which makes them unsuitable for mobile phones as they are getting thinner with advancement in technology. MIMO antennas of [8] and [9] have simpler structure and suitable size but they do not have adequate bandwidth to cover all 2G, 3G and 4G bands. Bandwidth enhancement techniques are presented in [14-17]. The following discussion presents a planer wideband two-port MIMO antenna for smart phone application. The exhibited MIMO antenna has single element working at center frequency and an inverted L shape structure is made from ground plane to create low resonance frequencies. A two port antenna is formed by placing elements in symmetry. A slot is etched from ground plane in order to increase isolation between the individual elements. The bandwidth of the MIMO antenna under discussion ranges from 0.8GHz to 3.5GHz, which covers operating bands of 2G, 3G, 4G and Wi-Fi (2.45GHz). The measured and simulated isolation, peak realized gain and envelope correlation coefficient are also presented in this paper.

II. GEOMETRY & DESIGN

The geometry of MIMO antenna constitutes an element located on the ground plane having dimensions of 60x58mm^2, which is small in size as compared to the mobile phones. The substrate material used for planner MIMO antenna is FR4 with relative permittivity of 4.4, thickness 1 mm and dielectric loss tangent of 0.02. The Objective of our design is to cover a wide band which should cover 2G/3G/4G bands and Wi-Fi (2.45 GHz).

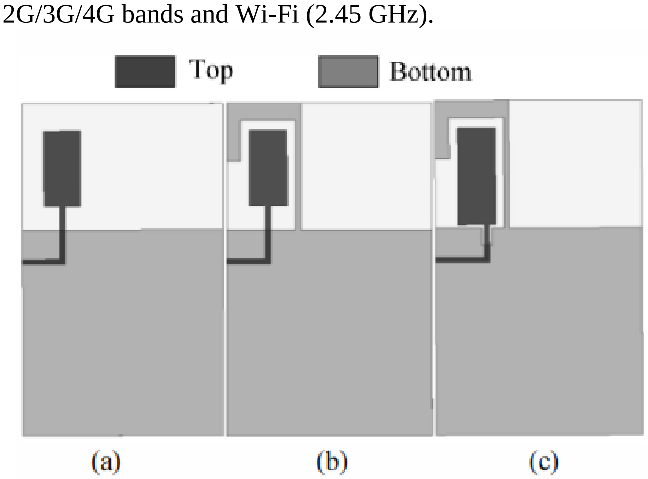

Fig. 1. Three design steps (a) Single antenna element (b) Single element with inverted L structure (c) Optimized antenna element design

A. Wide Band Technique

Fig. 1 shows the steps for designing the planner wide band MIMO antenna. First of all, a monopole was designed with proper dimensions, which was designed to operate at center frequency of 1.8GHz. A feeding strip of 50 ohms feeds the monopole. Then the design was simulated on HFSS and the simulated S parameters of monopole show that the monopole was covers the wide range of bandwidth from 1.1 GHz to 2.7 GHz at -6 dB reference line. Then an inverted L shape structure known as SIR stub technique is used to enhance the bandwidth. The inverted L shape structure which is extended from the ground plane is placed around the monopole which generates the low resonant frequencies and also broadens the bandwidth. Bandwidth is broadened to 0.8 GHz to 3.5 GHz. For the purpose of more impedance matching, a small patch is etched from the ground plane opposite to the feeding and all the parameters are optimized accordingly as shown in Fig1 (b).

Fig. 2 presents the S parameters of the optimized design of antenna element, simulated using HFSS. It can be seen that the final design is achieving 0.8GHz to 3.5GHz bandwidth with a very good impedance matching.

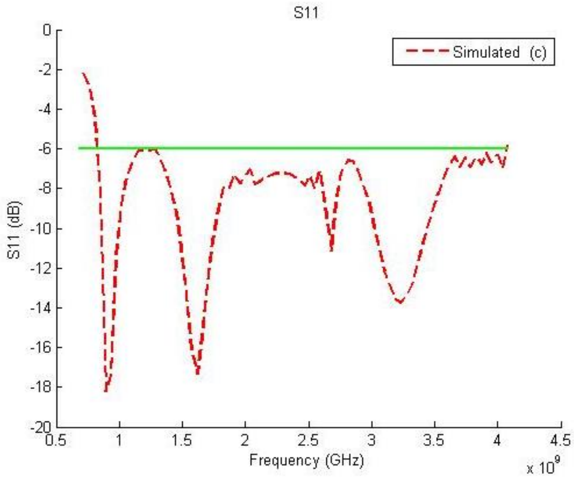

Fig. 2. Simulated S parameter of antenna final antenna element of 1(c)

B. TWO ELEMENTS MIMO ANTENNA

Basing on the above mentioned final design, second antenna element is introduced in the antenna design on the substrate which is totally symmetrical to form a compact wide band planar MIMO antenna as presented in Fig. 3. The compressed size of the compact wide band planar MIMO antenna is 97 mm x 60 mm x 1 mm, while the size used in [9] is 125 mm 85 mm x 0.8-mm using FR4. The software used for the simulation is High Frequency Simulation (HFSS) Version-13. The optimized parameters and dimensions of the compact wide band planar MIMO antenna are listed in Table.1.

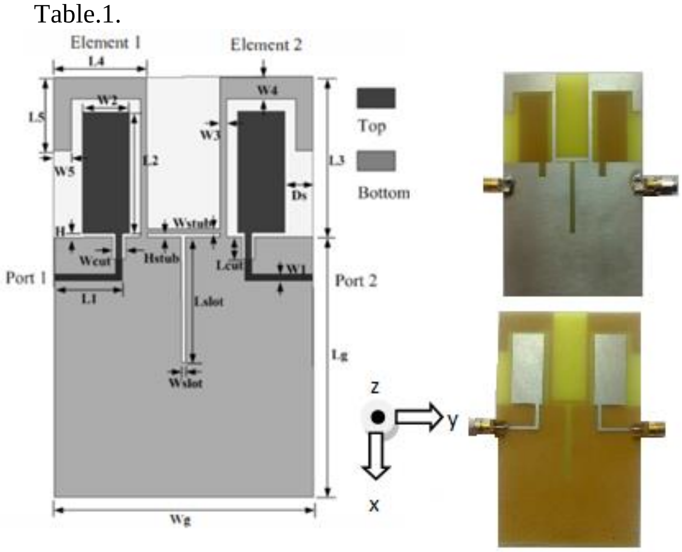

Fig. 3. Geometry of final design and prototype

Simulated and measured S parameters of the compact wide band planar MIMO antenna designs are exhibited in Figure 4. As a result of identical geometry and positioning of the two elements, antenna achieves wider bandwidth as mentioned above. The proposed design of MIMO achieves bandwidth from 0.8 GHz to 3.5 GHz which covers all the bands of frequencies currently being used by major mobile phone operators across the globe.

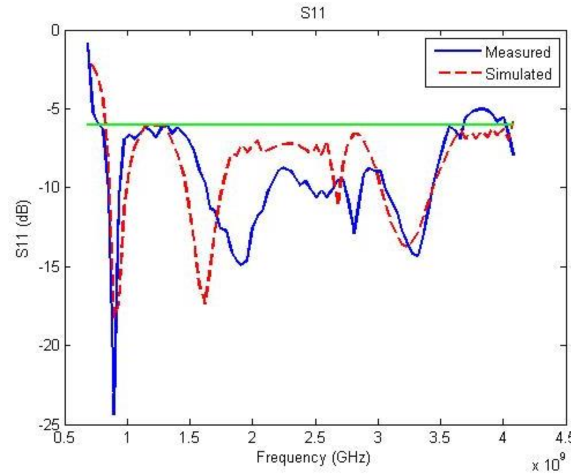

Fig. 4: Simulated and Measured S11

Table 1: Optimized Dimensions of the Antenna

Parameter	l1	l2	l3	l4	l5
Value(mm)	15	31.5	41	23	17
Parameter	**w1**	**w2**	**w3**	**w4**	**w5**
Value(mm)	1	13	1.5	9	4.1
Parameter	**Lcut**	**H**	**Hstub**	**Lslot**	**Lg**
Value(mm)	5	0.1	0.5	30	56
Parameter	**Wcut**	**Ds**	**Wstub**	**Wslot**	**Wg**
Value(mm)	3	6.5	1.5	2	60

C. ISOLATION ACHIEVEMENT

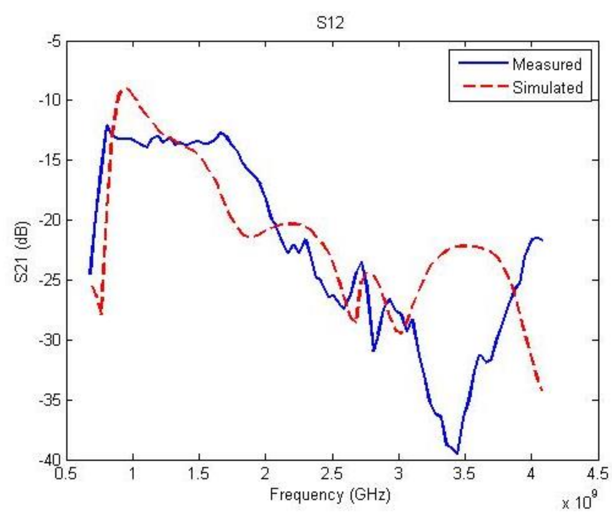

Fig. 5. Simulated and Measured S21

In compact wide band planar MIMO antenna design, higher isolation between antenna elements with less disturbing impedance match is one of the serious challenges. Various decoupling techniques are used in different applications [2]-[9]. In proposed design, measured isolation is achieved by etching a slot in ground plane. It is observed that etching helps reduce isolation on lower band and on higher band it increases isolation. Isolation can be increased by achieving a neutralization point between antenna elements as it depends mainly on the surface current flowing between them. This neutralization point depends on wavelength. In lower frequencies because of much large wavelength, the surface current and near field radiation pattern add significantly to coupling. Fig. 5 shows the simulated and measured result that S_{21} is less than -12.5dB from 0.8 GHz to 2.1 GHz and -20 dB above 2.1 GHz up to 3.5 GHz.

III. RESULTS AND DISCUSSION

Fig. 6 shows 3D plot at 0.9 GHz, 1.8 GHz, 2.1 GHz, 2.4 GHz, 2.7 GHz and 3.4 GHz. It shows that lower 0.9GHz radiation pattern is omnidirectional while at higher frequencies it is quasi-omnidirectional. Figure 7 shows Peak realized gain; the proposed MIMO antenna has a steady gain greater than 2.8dBi over the entire frequency band i-e from .8 GHz to 3.5 GHz of the proposed design and very high gain of 6.7 dBi at 0.9 GHz. Fig-8 shows the radiation efficiency. The compact wide band planar MIMO antenna has more than 80% efficiency over most of the operating frequency band.

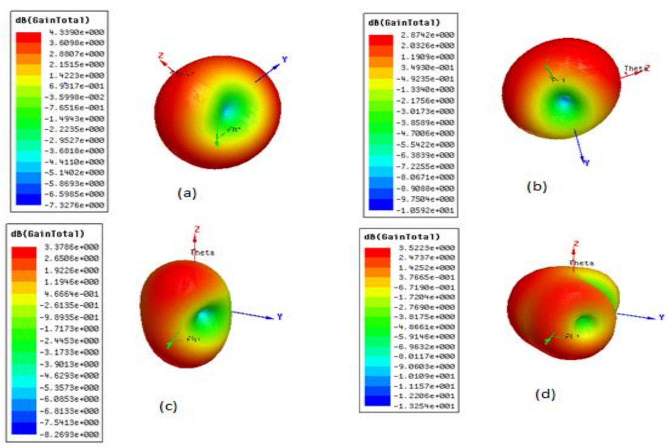

Fig. 6. 3D radiation pattern

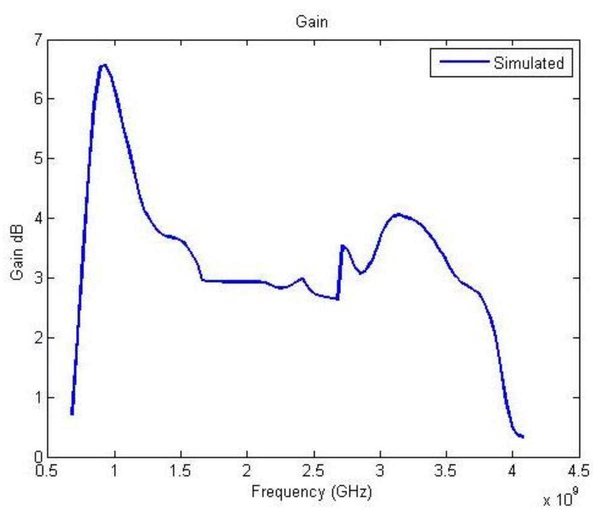

Fig. 7. Simulated Realized Peak gain

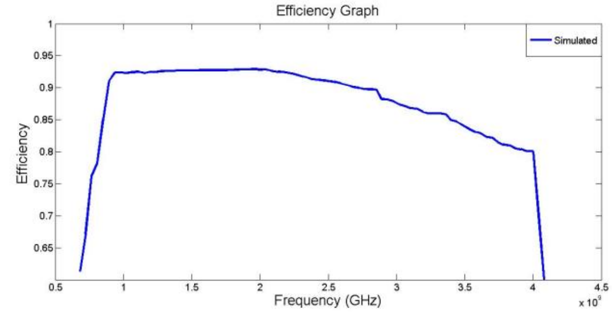

Fig. 8. Simulated Efficiency

A. Diversity Performance

Efficient MIMO system is characterized by spatial diversity and channel independence. The spatial diversity and channel independence is achieved by the reduction of the mutual coupling between antenna elements. Envelope Correlation Coefficient (ECC) is a very important parameter that helps to analyze the diversity performance. ECC is calculated using either the radiation patterns as in [10] or by using the S-parameters as per the method presented in [11].

$$ECC = \left| \frac{|S_{12}S_{11}^{*} - S_{21}S_{22}^{*}|}{|(1-|S_{22}|^2-|S_{12}|^2)(1-|S_{11}|^2-|S_{21}|^2)|^{1/2}} \right|^2 \quad (1)$$

In this paper we used s-parameters to calculate ECC by using equation (1). For practical application ECC value less than 0.5 is acceptable for mobile phones. Fig. 9 shows measured ECC is less than 0.36 over complete operating frequency band, which is all right for mobile phones.

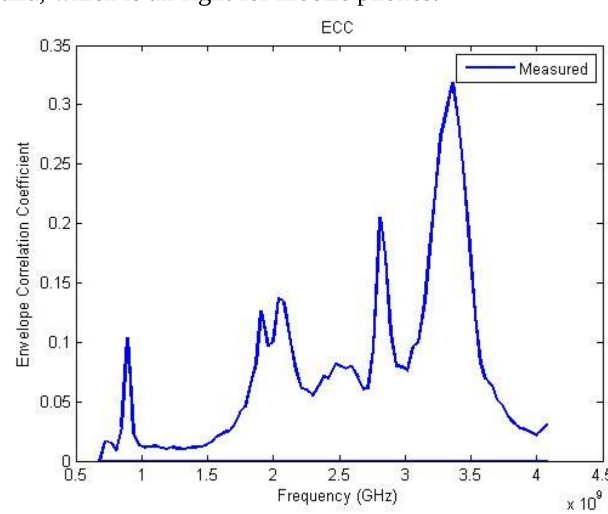

Fig. 9. Measured ECC

IV. CONCLUSION

In particular this paper compact planner two port MIMO antenna with wideband width and high gain is presented. The proposed antenna is simulated and fabricated, which achieves a wide bandwidth from 0.8GHz to 3.5GHz covering 2G/3G/4G bands and Wi-Fi (2.45GHz). High isolation between antenna elements, lower ECC and high diversity gain makes the design of the compact planner wide band MIMO antenna a suitable candidate for mobile phone applications.

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