Novel Compact UWB MIMO patch antenna for 3G/4G Wireless Communication Applications

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Abstract

In this paper, two proposed compact UWB Microstrip patch antenna configurations have been analyzed, investigated and optimized using the Zeeland-simulator. The presented UWB antennas resonate at two contiguous ultra widebands: UWB1=5.5 GHz from 6.16 to 11.7 GHz and UWB2=5.3 GHz from 10.91 to 16.18 GHz with overlapped band about 800 MHz from 10.85 to 11.7 GHz. These antennas have been simulated together on one FR-4 substrate to operate as an UWB MIMO antenna. The coupling between the antenna ports has been evaluated and optimized as function of the antenna separation. It has been varied from -14 dB to - 30 dB within the two operating bands.

Keywords- Compact; Broadband; Dual-band; Patch antennas; MIMO

I. INTRODUCTION

UWB technology has received a great deal of attention in the wireless world several years ago. Due to its large bandwidth and immunity to multipath interference, UWB technique has been used for high data rate communication systems, high accuracy radars, position and tracking, imaging and remote sensing. Specifically, UWB antenna as an essentially component in any UWB wireless communication systems. it can provide an attractive features such as wide bandwidth, high radiation efficiency, directional and/or Omni-directional radiation pattern, and compact profile. Since the release of the UWB spectrum by Federal Communication Commission (FCC) in 2002, much attention has been given to the design of the UWB antennas. A large number of UWB antenna structures have been analyzed and proposed to satisfy this spectrum requirement. In fact, to achieve the 3G/4G wireless communication system constrains, the antenna should be a wideband as well as compact in size. In addition, the antenna characteristic must be optimized over the whole operating frequency range. First, the two proposed UWB antennas have been simulated by the full-wave electromagnetic simulator (Zeeland). Second the two UWB patch antennas are simulated on a single substrate to form the required UWB MIMO antenna. This paper is organized as follows. The design of two individual UWB antennas and their combined structure is described in section II. Section III deals with simulated results and discussion. The paper is concluded in section IV.

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II. PATCH MIMO ANTENNA COFIGURATION AND DESCRIPTION

A basic conventional patch antenna configuration has been designed to resonate at 7.5 GHz without incent (within the middle of 3G/4G band). The basic patch dimensions are 9.1mm length and 12.4mm width. The patch is mounted on a single FR-4 substrate (ε_r = 4.2, 1.6 mm height, and tangential loss of 0.02) and the conductor thickness is assumed to be 0.035mm. These patch dimensions has been selected to designed a compact UWB antenna with transmission line feed of 50 Ohm. Two antenna configurations have been proposed to operate in the 3G/4G frequency band. These antenna configurations have either horizontal or vertical U-slots. The patch edges have been tapered 45°. The first antenna configuration has double vertical u-slots as shown in Fig.1-a, and it is referred to as DVUS patch antenna. The second one has double horizontal U-slots as shown in Fig.1-b. This antenna configuration is referred to as DHUS patch antenna. A short circuit has been designed using a planar array of "N" identical vies distributed around the slot edges with different locations as shown Fig.4-a and Fig.4-b. The main objective of our design is to widen the antenna bandwidth using the two spaced slots and short circuit through vies allocation. The orientation of the two U-slots controls the operating frequency band occupied by each antenna while the vies geometry (spatial vies distribution) increases bandwidth of each antenna.

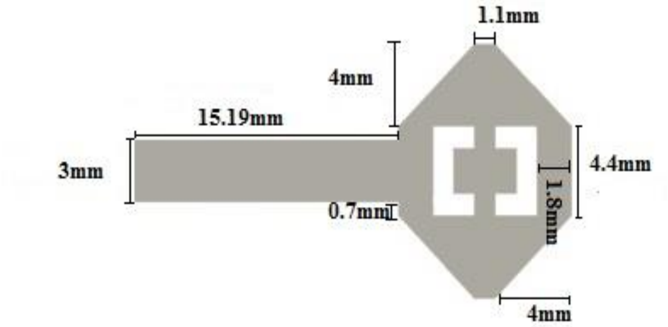

Fig. 1-a DVUS patch antenna with 45° tapered edge

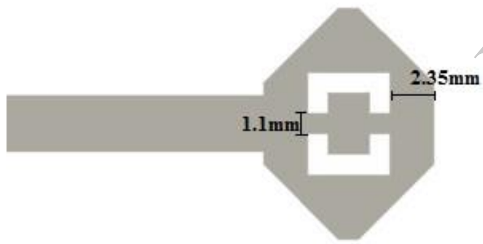

Fig. 1-b DHUS patch antenna with 45° tapered edge

III. SIMULATION RESULTS

The presented antenna configurations are simulated using Zeeland software and the results are presented in Fig.2 and Fig.3. The conventional patch has multi resonance frequencies due to the mismatch between the patch and the feed line (Incent has not been used). The U-slots shift the patch resonance frequencies to the higher frequency band.

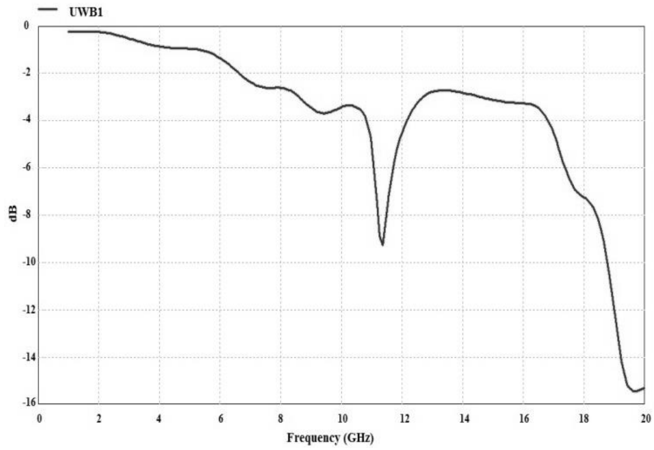

Fig.2 $|S_{11}|$ of the DVUS patch antenna without vies

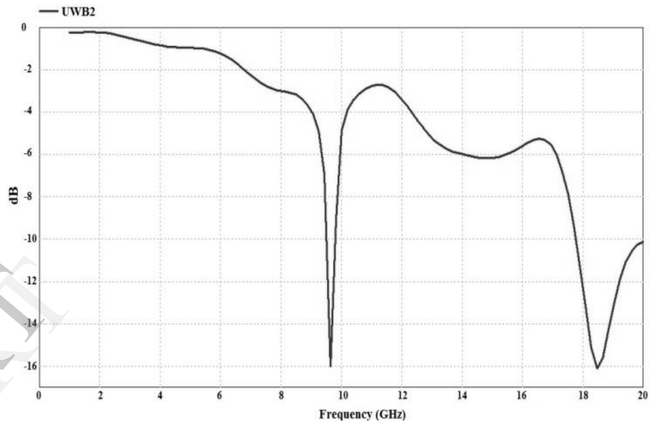

Fig.3 $|S_{11}|$ of DHUS patch antenna without vies

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IV. OPTIMIZATION OF THE UWB PATCH ANTENNA DESIGN

A parametric analysis has been performed to study the effects of the patch and the slot dimensions on the antenna characteristic. Many cases of study have been simulated and the obtained results have been investigated to optimize the required antenna characteristic. The objective of such optimization process is to end up with an antenna configuration achieves the current challenges of the 3G/4G-wireless communication systems. This includes two important factors: the operating frequency band and the antenna compactness. To achieve such goal, the optimization process is based on adding U-slots as well as a planar array of vies of different positions.

A. Adding a planner array of vies

This approach is to add a planar array of vies to each of the previously mentioned antenna configurations. The radius of each via is assumed to be of 0.1mm. The vies are located on the edges of the U-slots as shown Fig.4-a and Fig.4-b. Simulation results are illustrated in Fig.5. As it is clear from the figure, each UWB antenna has been occupied different frequency band. The first antenna resonates from 6.16 GHz to 11.7 GHz with band

5.5 GHz. The second one has a bandwidth of 5.3 GHz from 10.91 GHZ to 16.18 GHz.

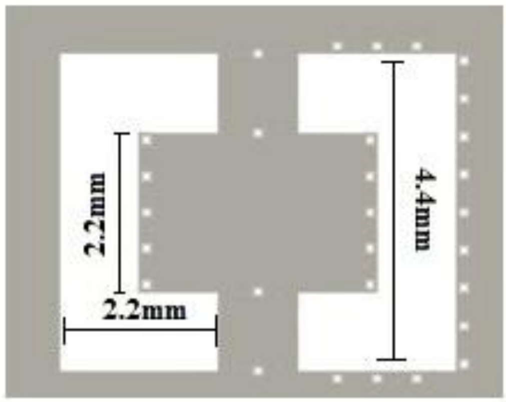

Fig.4-a DVUS with planar array of vies (N=28)

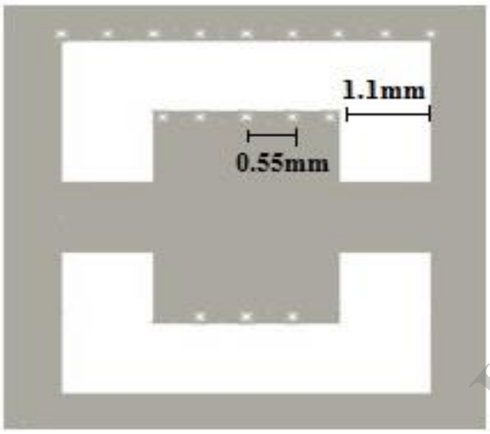

Fig.4-b DHUS with planar array of vies (N=17)

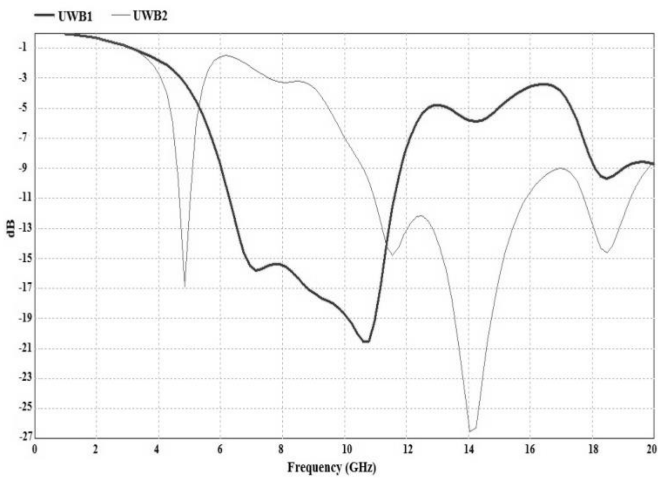

Fig. 5 $|S_{11}|$ of both DVUS and DHUS patch antennas with planar array of vies

B. UWB MIMO configuration

The UWB MIMO is shown in Fig.6. This antenna is consists of the two previously antennas etched on one RF_4 substrate. The separation between two antennas is optimized to minimize the coupling. The results of simulation are illustrated in Fig. 7. The bandwidth of each antenna is reduced due the coupling effect as compared to Fig. 5. The VSWR of MIO antenna is shown in Fig. 8. Low VSWR is achieved over the entire band (smaller than 2.0).

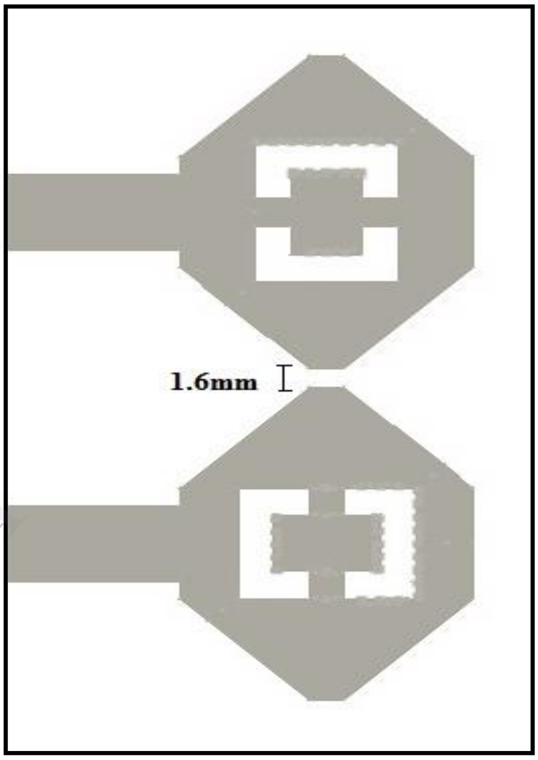

Fig.6 UWB MIMO patch antenna

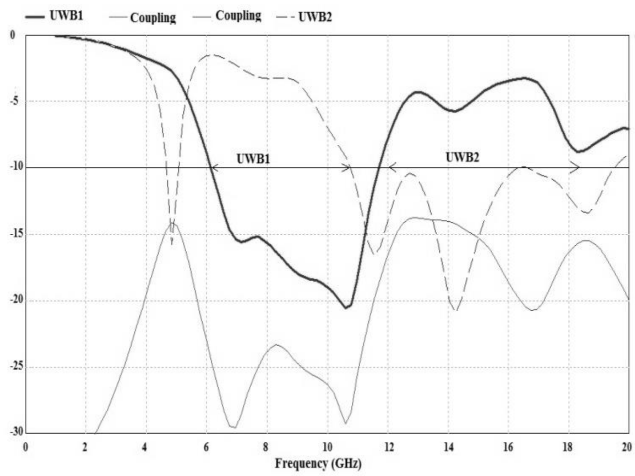

Fig.7 $|S_{11}|$ of UWB MIMO antenna

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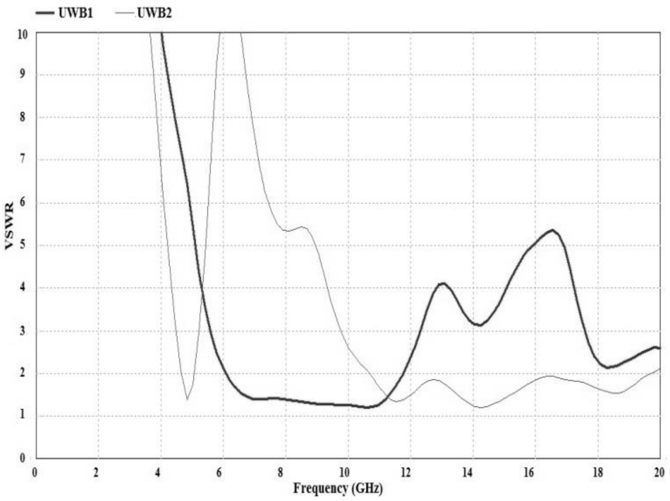

Fig. 8 VSWR of both antennas

VI. CONCULUSION

A compact ultra-wideband MIMO patch antennas have been analyzed, designed and simulated. The presented antenna achieves good coupling between antenna ports. The presented UWB MIMO antenna satisfies the required UWB characteristic. Future work will include a new approach to minimize the coupling between the two ports of UWB MIMO antennas.

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