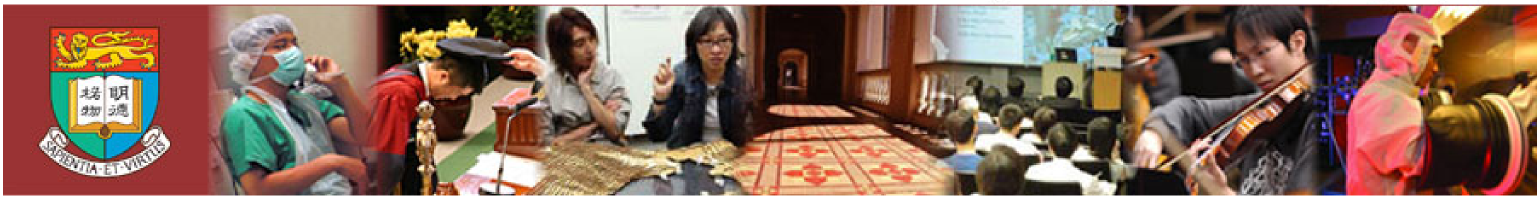

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A Compact Ultrawideband MIMO Antenna

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***Abstract*—A multiple-input multiple-output (MIMO) antenna having a very compact size of 40×26 mm^2 is proposed for portable ultrawideband (UWB) applications. Two planar monopole antennas with microstrip-fed are used as the elements of the MIMO antenna and are placed perpendicularly to each other to achieve pattern diversity. Two stubs are etched on the ground plane to enhance isolation between the two elements and increase the impedance bandwidth of the MIMO antenna. Results show the MIMO antenna can cover the entire UWB band from 3.1-10.6 GHz with an isolation of larger than 16 dB throughout the frequency band.**

Index Terms*—*multipole-input multipole-output (MIMO) antenna, Ultrawideband (UWB) antenna, pattern diversity

I. INTRODUCTION

In 2002, the Federal Communications Commission (FCC) authorized the unlicensed use of 3.1-10.6 GHz spectrum for wireless applications with low power emission [1]. Since then, the ultrawide band (UWB) technology has been developing rapidly in the applications of short-range high data-rate communications, radar imaging, cancer sensing, etc. Many antennas have been designed for UWB applications [2, 3]. However, the UWB systems with such wide bandwidths suffer from multipath fading. Recently the multiple-input multiple-output (MIMO) technology has been proposed to overcome the multipath fading problem and to increase the channel capacity for UWB systems [4-18].

One of the major challenges in the designs of MIMO UWB systems is the compact size with low mutual coupling (or high isolation) between the antenna elements. Various methods have been proposed to design compact MIMO antenna with low coupling between antenna elements for portable UWB applications. In [4-11], a commonly used method of placing decoupling structures of various shapes between two symmetrically-placed antenna elements was proposed to enhance isolation. In [12, 13], the method of combining two different types of antenna elements to provide different patterns with low correlation was studied. In [14-18], the method of using perpendicular feedings to achieve pattern diversity and polarization diversity was studied. Among these designs, some were not able to operate in the entire UWB allocated by the FCC [4, 5, 8, 12, 13] or did not have a common ground plane [10, 18] which made them difficult for uses in practice. Others were not compact enough or needed complicated feeding structures [14-16].

In this paper, a planar MIMO antenna is proposed for portable UWB applications. The proposed antenna consists of two planar monopole elements placed perpendicularly to each other and achieves a compact size of 40×26 mm^2. Two simple stubs and a ground strip are used to increase the isolation between the two elements and increase the bandwidth.

II. ANTENNA DESIGN

The proposed MIMO antenna is shown in Fig. 1, which was designed on the substrate Rogers R4350B, with a dielectric constant of 3.5, a loss tangent of 0.004 and a thickness of 0.8 mm. The antenna consisted of two planar monopole elements, denoted as PM 1 and PM 2 in Fig. 1, placed perpendicularly to each other and fed by 50- Ω microstrip lines through port 1 and port 2, respectively. The ground planes of the two PMs were printed on the other side of the substrate. A short strip was used to connect the two ground planes, forming an *L*-shaped common ground for the whole antenna. A small rectangular slot was cut on the upper edge of the ground plane underneath each feed line for impedance matching. Two stubs, stub 1 and stub 2 as shown in Fig. 1, were used on the ground plane to enhance isolation between the two elements and also help broaden the impedance bandwidth.

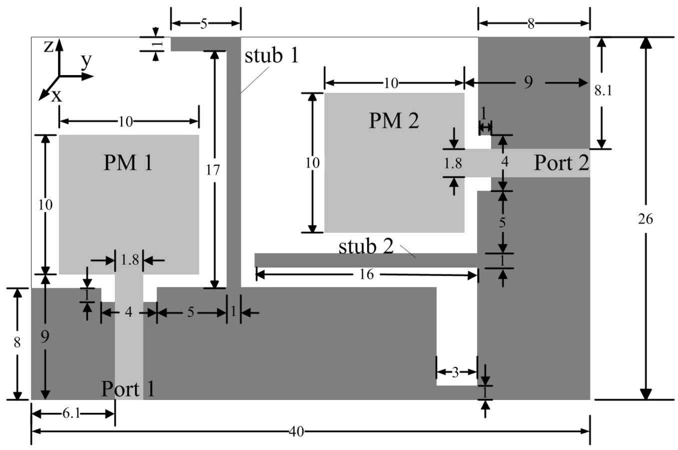
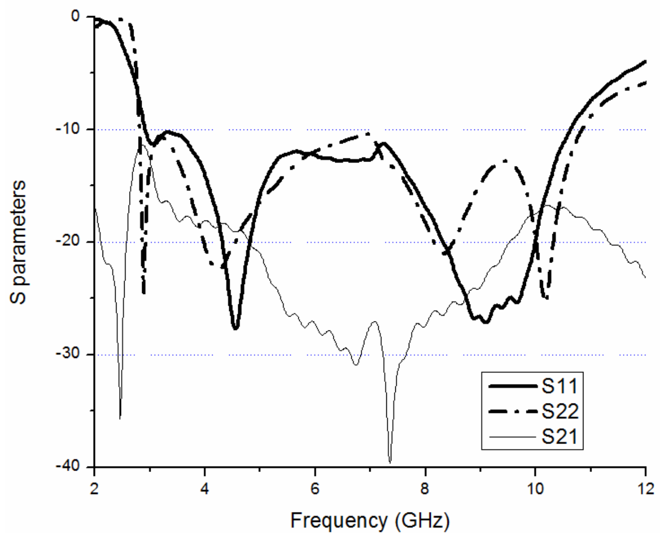


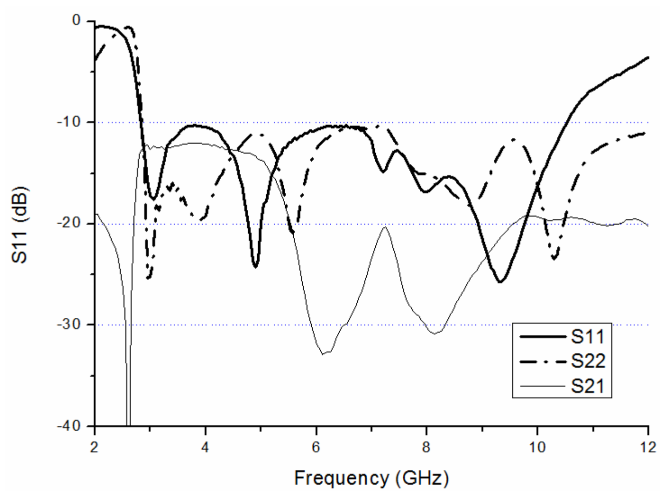
Figure 1. Geometry of proposed antenna (unit: mm)

III. RESULTS AND DISCUSSIONS

Computer simulation using the EM simulation tool, CST Microwave Studio, was carried out to study, design and optimize the proposed MIMO antenna, in terms of impedance bandwidth and mutual coupling between the two antenna elements. The simulated S parameters, S_{11}, S_{22} and S_{21} of the antenna are shown in Fig. 2 (a). It can be seen that the antenna an impedance bandwidth for $S_{11} < -10$ dB of 2.9-10.6 GHz, and a bandwidth for $S_{22} < -10$ dB of 2.8-10.8 GHz. Thus the antenna could operate in the frequency band from 2.9-10.6 GHz for both $S_{11} < -10$ dB and $S_{22} < -10$ dB, covering the entire UWB band specified by the FCC. Fig. 2 (a) also shows that in the UWB band from 3.1 to 10.6 GHz, the antenna had a mutual coupling of less than -16 dB between the two ports. Note that in most of the designs in [7, 11, 15, 16], a mutual coupling of less than -15 dB was considered to be enough for good isolation.



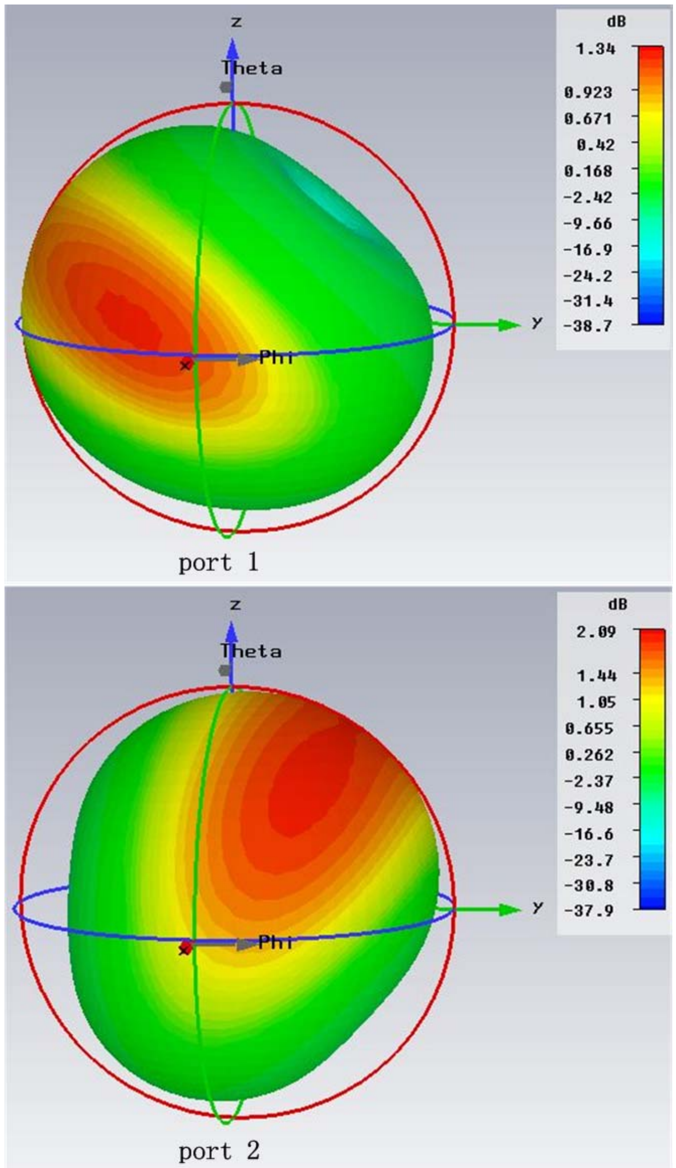
(a)



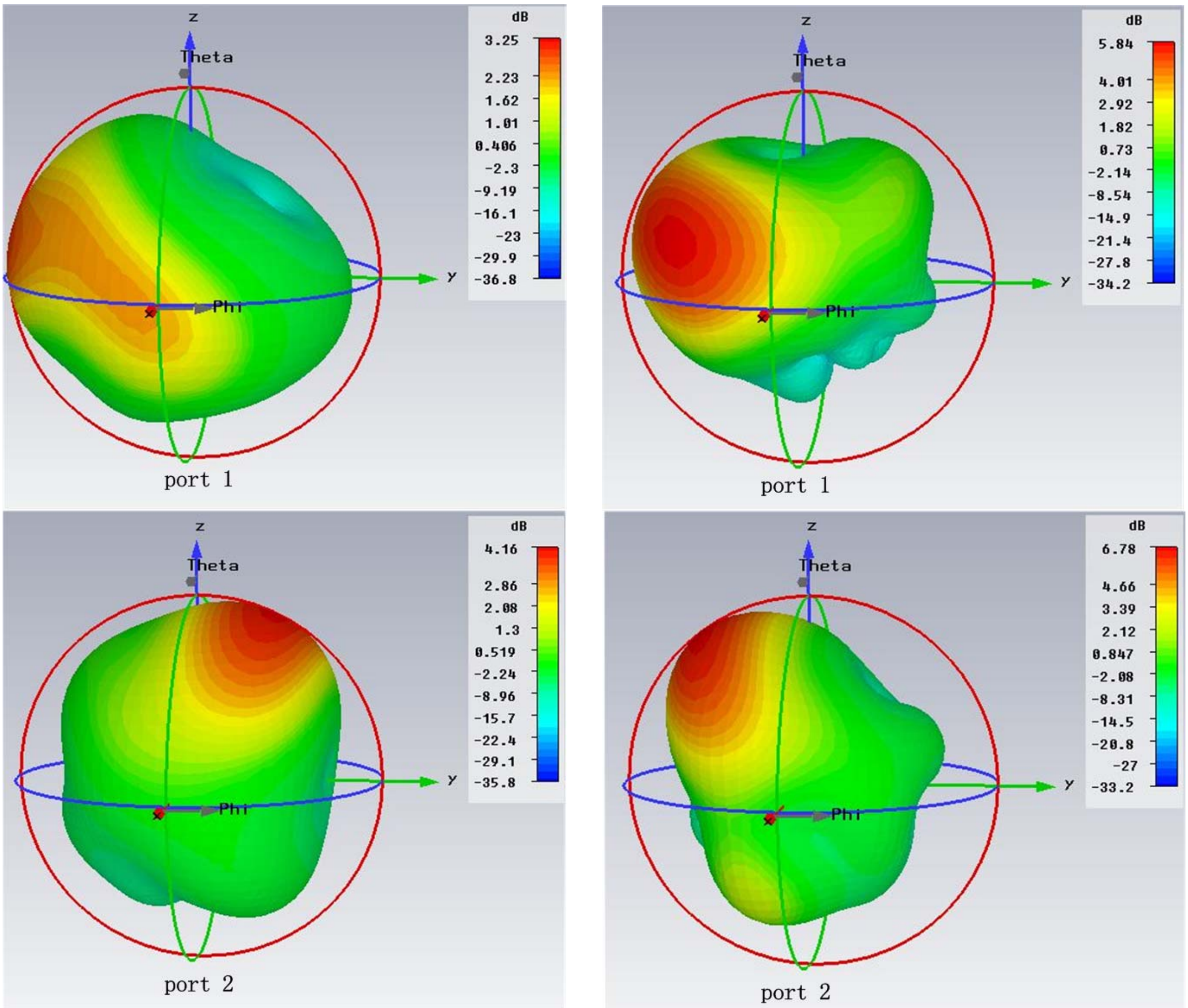
(b)

Figure 2. S parameters in (a) simulation, and (b) measurement.

The 3D radiation patterns of the MIMO antenna at 3, 7, and 10 GHz are shown in Fig. 3. In the studies, when one port was excited, the other was terminated with a 50-Ω load. It can be seen the antenna had different radiation patterns for the excitation by either of the two ports. When port 1 was excited, Figs. 3 (a) and (b) show that, at 3 and 7 GHz, the antenna had a main radiation direction towards left upper space and a null in the right upper space. But when port 2 was excited, the antenna had a main radiation direction towards right upper space. It can be seen that the radiation patterns excited by ports 1 and 2 were complementing to each other. At 10 GHz, Fig 3 (c) shows that the patterns were little more complicated due to the higher-resonant modes. However, the radiation patterns were still complementing to each other when ports 1 and 2 were excited. Thus the antenna can use pattern diversity to overcome multipath fading.



(a) 3 GHz

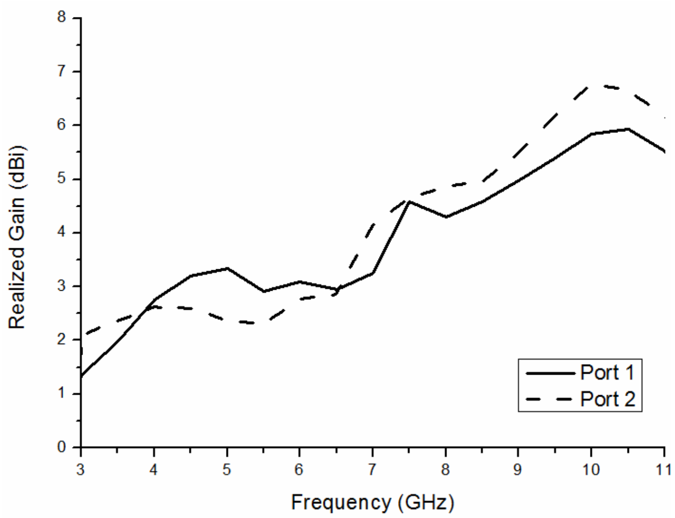


(b) 7 GHz

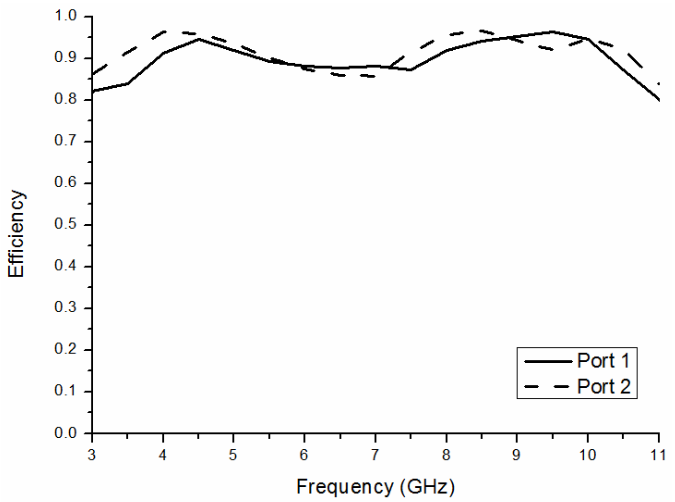
(c) 10 GHz

Figure 3. 3D-radiation patterns at (a) 3, (b) 7, and (c) 10 GHz

The realized gain and the efficiency of the proposed antenna are shown in Fig. 4. It can be seen in Fig. 4 (a) that the peak gains increase with the frequencies. This was because the radiation pattern became more directional at high frequencies, as can be seen in Fig. 3. When port 1 was excited, the gains of the antenna ranged from 1.5 to 6 dBi in the UWB band of 3.1-10.6 GHz, and when port 2 was excited, the gains ranged from 2.1 to 6.5 dBi. Fig. 4 (b) shows that the antenna had an efficiency of more than 80% in the UWB band of 3.1-10.6 GHz.



(a)



(b)

Figure 4. (a) Realized gain and (b) efficiency of MIMO antenna with port 1 or port 2 excited

IV. CONCLUSIONS

A UWB MIMO antenna having a compact size of 40×26 mm^2 was proposed for wireless device applications. The MIMO antenna consisted of two perpendicularly placed planar monopole antenna elements. Results have shown that the antenna could cover the frequency band from 3.1-10.6 GHz with an isolation of larger than 16 dB for UWB applications. The antenna provided different radiation patterns when either port was excited, which could be used to achieve pattern diversity to mitigate multipath fading.

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