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## HYBRID SHAPED ULTRA-WIDEBAND ANTENNA

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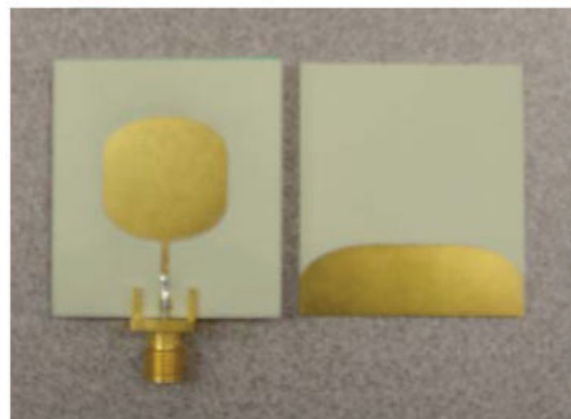
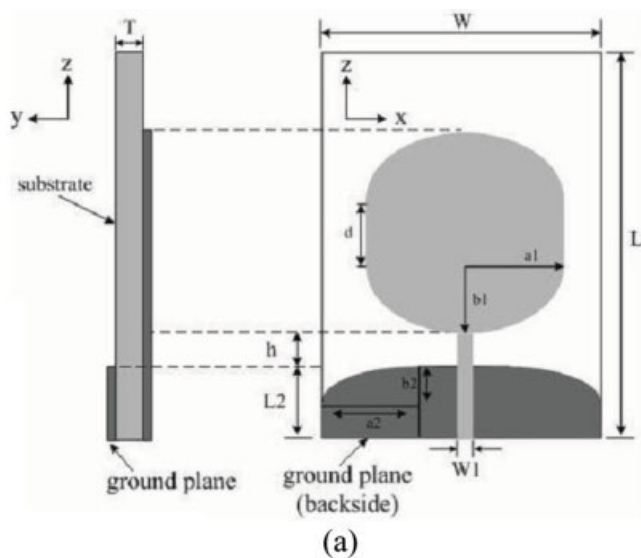
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**ABSTRACT:** A novel planar ultra-wideband antenna with hybrid shapes of the patch and the ground is presented. Simulation and measurement have been performed. A much wider impedance bandwidth has been achieved by the hybrid design for potential application in future UWB. The measured radiation patterns show good omnidirectional performance across the operation bandwidth. The modulation and distortion of the transmitted pulse are also shown. © 2007 Wiley Periodicals, Inc. *Microwave Opt Technol Lett* 49: 2412–2415, 2007; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.22746

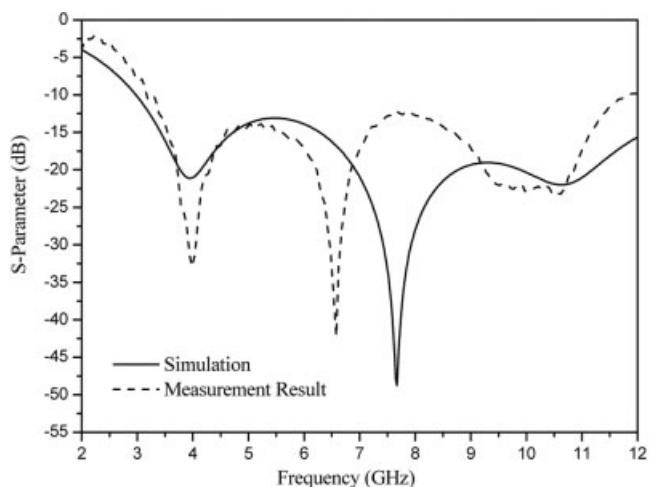
**Key words:** UWB antenna; hybrid shape; compact antenna; time-domain modulation

### 1. INTRODUCTION

Wireless multimedia systems are receiving increasing research and application interests. But improvements are still required to pro-



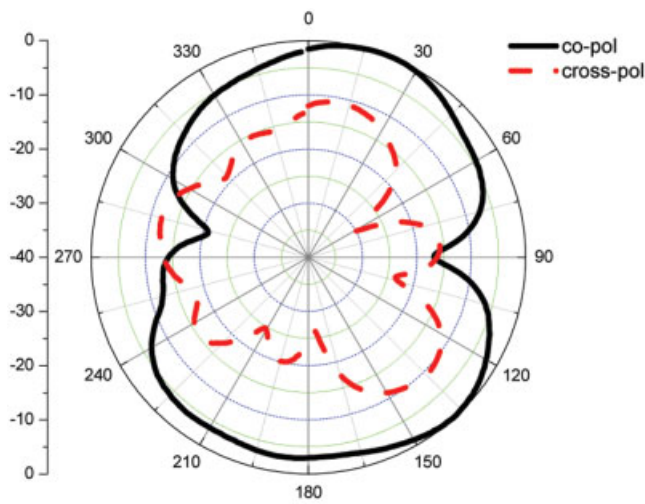
**Figure 1** (a) Geometry of the hybrid shaped UWB patch antenna, (b) photograph of the designed antenna. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]



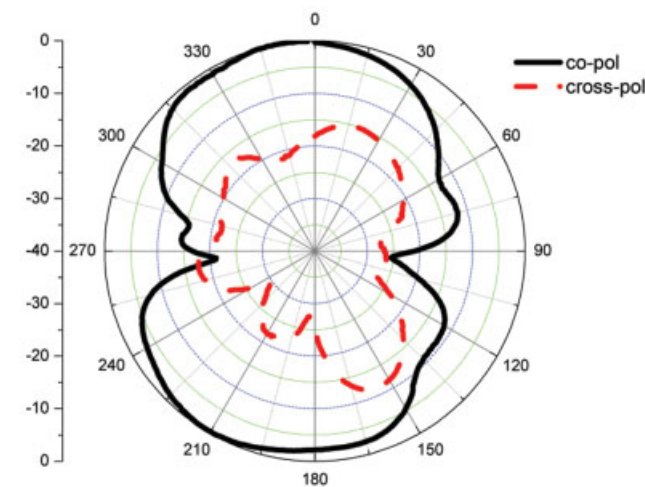
**Figure 2** Simulated (solid) and measured (dash) return loss of the antenna

vide higher data-rate links, for instance, the transmission of video signals. Therefore, ultra-wideband (UWB) communication systems are currently under investigation and the design of a compact wideband antenna is very essential. To overcome the inherently narrow bandwidth of microstrip antennas, various techniques have been developed to cover the entire UWB bandwidth, such as L-/F-shaped probe to feed the patch [1, 2], triangular patch [3], U-/V-slot monopoles [4, 5], and etc.

In this article, we present a compact patch antenna using hybrid shaped patch as well as the ground, which exhibits better UWB operating characteristics. Because of the hybrid shape effects, a good match to antenna's input impedance is achieved over the entire 3.1–10.6 GHz band, by optimizing parameters of the proposed antenna. Moreover, for UWB systems using time-domain modulation schemes, any distortion of the transmitted pulse shape will increase the difficulties of the detection at the receiver. The distortion induced by the proposed antenna has been presented. It shows the distortion is very small, and thus this proposed antenna has good potential in practical UWB communications.

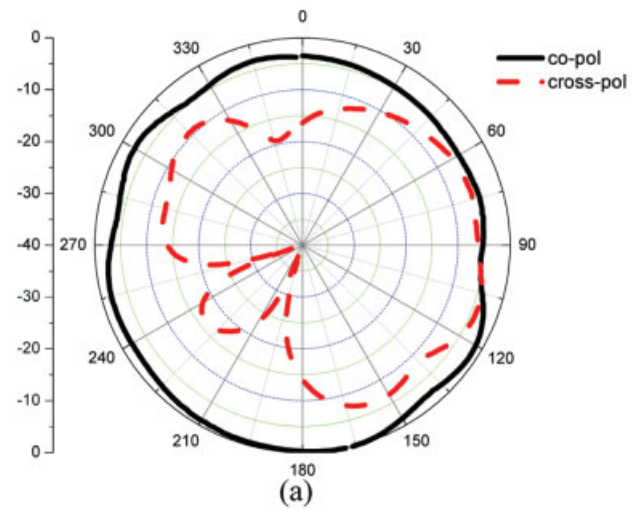


(a)

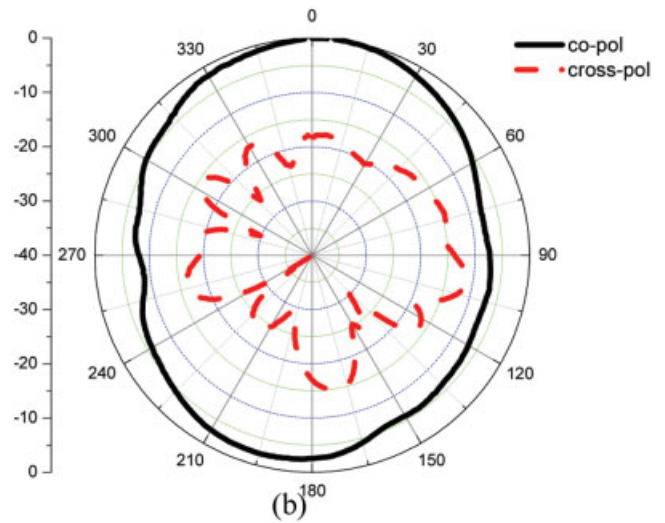


(b)

**Figure 3** *E*-plane: (a) 4 GHz (b) 7 GHz. [Color figure can be viewed in the online issue, which is available at [www.interscience.wiley.com](http://www.interscience.wiley.com)]

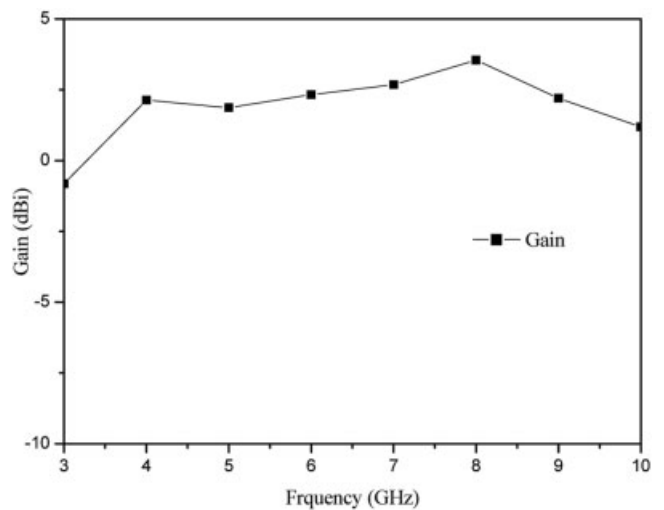


(a)



(b)

**Figure 4** *H*-plane: (a) 4 GHz (b) 7 GHz. [Color figure can be viewed in the online issue, which is available at [www.interscience.wiley.com](http://www.interscience.wiley.com)]



**Figure 5** Measured antenna gain in boresight vs. frequency

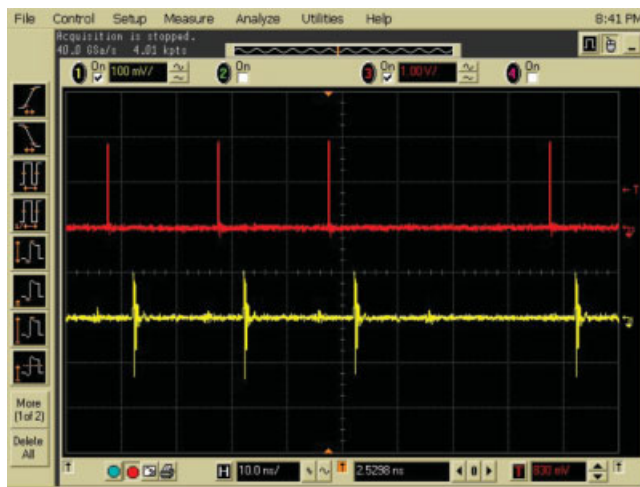
## 2. STRUCTURE

To emit the modulated UWB pulse efficiently, a novel hybrid shaped antenna is proposed, as shown in Figure 1. Antenna part is formed by two ellipses with a rectangle to smooth out the discontinuity of the overlapping areas. The ground plane is also formed in a similar way. By selecting optimal parameters of the proposed antenna, it is found that return loss has good match to  $50 \Omega$  over the entire UWB frequency band.

The antenna was fabricated on a Rogers substrate having 20 mil thickness and relative dielectric constant of 3.46. The area occupied by the antenna aperture is only  $35 \text{ mm} \times 35 \text{ mm}$ . The antenna is simulated by CST<sup>TM</sup>. From the simulation, the optimal dimension of  $T = 0.5 \text{ mm}$ ,  $h = 20 \text{ mil}$ ,  $W = L = 35 \text{ mm}$ ,  $L_2 = 12 \text{ mm}$ ,  $W_1 = 1.16 \text{ mm}$ ,  $a_1 = 9.6 \text{ mm}$ ,  $a_2 = 12 \text{ mm}$ , and  $d = b_1 = b_2 = 6 \text{ mm}$  are selected.

## 3. RESULTS

The prototype of the proposed antenna is shown in Figure 1(b). The reflection coefficient of the antenna is measured using an HP

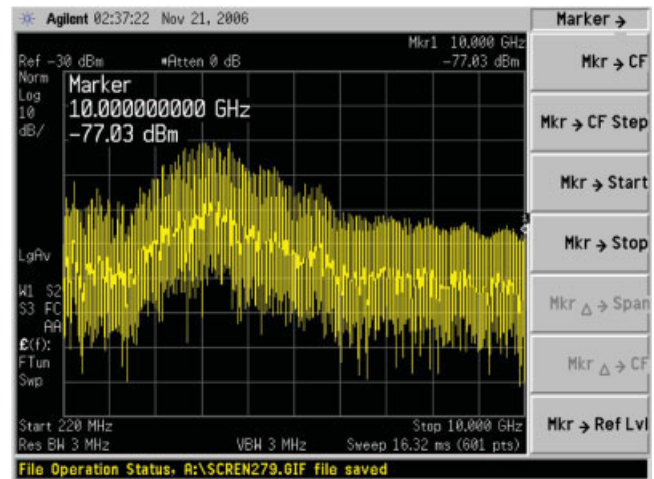


(a) Input and received signal



(b) Waveforms of the input and received signal.

**Figure 6** Measured impulse response of the proposed antenna. (a) Input and received signal, (b) waveforms of the input and received signal. [Color figure can be viewed in the online issue, which is available at [www.interscience.wiley.com](http://www.interscience.wiley.com)]



**Figure 7** Measured spectrum of the receive signal. [Color figure can be viewed in the online issue, which is available at [www.interscience.wiley.com](http://www.interscience.wiley.com)]

8510 Network analyzer. In Figure 2, the simulated and measured results are displayed. A good agreement between simulated and measured  $S$ -parameter has been obtained. It can be seen that over the whole range from 3.1 to 10.6 GHz, the return loss is much lower than  $-10 \text{ dB}$ .

The measured radiation patterns at 4 and 7 GHz over the bandwidth in the  $E$  plane ( $ZY$  plane) and  $H$  plane ( $XY$  plane) are plotted in Figures 3 and 4, respectively. The antenna gain is presented in Figure 5. The symmetry and omnidirection of those patterns with regard to frequency in both planes, is particularly important in a broadband point-to-point communication.  $E$ -plane patterns are similar with that of monopoles, and it is also found that the omnidirection in  $H$ -plane (see Fig. 4) is better at lower frequency.

Previous evaluation is not sufficient in cases where time-domain modulation schemes are used. The distortion of the pulse resulting from the dispersive nature of the antenna has also to be considered. In view of this, Figure 5 shows the pulse position modulation. The red curve represents the input signal and the yellow stands for the signal at the receiver antenna. It can be observed that the distortion of the transmitted waveform in the time domain is very small, which is important to retrieve the communication data.

Each box indicates 1 ns. Hence, the oscillation of the received signal only lasts within one box, as shown in Figure 6(b). Therefore, the proposed antenna with hybrid shapes can be implemented in the modulation scheme easily and efficiently. Finally the spectrum of the antenna emitted pulse sequence at the receiver is presented in Figure 7, where the pulse has been shaped such that its major spectrum energy occupies the FCC UWB band.

## 4. CONCLUSION

In this article, to improve the performance of microstrip UWB antenna and consider the modulation scheme, a new configuration of UWB patch antenna is designed. The measured  $S$ -parameter and radiation patterns show that the antenna can be used effectively for UWB communication. Measured waveforms and spectrum of the received signal demonstrate that the proposed antenna is suitable for UWB applications. Good agreement has been obtained between calculated and measured performance.

## ACKNOWLEDGMENT

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## BROADBAND PLANER ARRAY WITH SWITCHABLE POLARIZATIONS

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**ABSTRACT:** In this article microstrip planar array of eight elements is designed and simulated. It operates in the frequency range from 3.7 to 4.2 GHz. It gives gain of 17 dB. It can produce many types of polarizations such as  $E\theta$ ,  $E\Phi$ , right, and left circular. In all these polarizations the cross-polar level is around 20 dB lower than the copolar level (except for  $E\theta$ , for  $E\theta$  it is around 10 dB). The novel microstrip antenna element used in this article is constructed using parasitic patch and shorting pins. It gives wide bandwidth and various polarizations due to parasitic patch and shorting pins, respectively. The array is simulated using Agilent's ADS 2003A momentum software. © 2007 Wiley Periodicals, Inc. *Microwave Opt Technol Lett* 49: 2415–2419, 2007; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.22731

**Key words:** switchable polarizations; broadband planar array; microstrip antenna; shorting pins; electromagnetically coupled msa

### 1. INTRODUCTION

The band from 3.7 to 4.2 GHz is widely used for Satellite communication. To receive the signals from the satellite it requires High gain antenna (of around 32 dB). There are various types of antennas such as parabolic dish, planar arrays etc. that can give the required gain of around 32 dB. The drawback of parabolic dish at C band is its large size and can not be made conformal to the host surface.

In this article, efforts have been made to design planar array. The planar array is formed using microstrip antennas (or patches). These microstrip antennas should provide sufficient bandwidth. Unfortunately the micro strip antennas have very narrow bandwidth due to the fact that they are very thin. If thickness is increased to increase the bandwidth, the cost of the patch will rise and the radiation efficiency will decrease. Therefore other techniques are used to increase bandwidth. They are as follows.

#### 1.1. Planar Multiresonator Configuration [1]

In this method, in addition to the main patch parasitic patches are placed near and in the same plane as the main patch. This method gives 20% maximum bandwidth. The major drawback of this method is its large planer size.

#### 1.2. Impedance Matching Networks for Broadband Microstrip Antenna [2]

Impedance matching networks such as stubs are used to increase bandwidth. This method gives bandwidth around 10%. Hence it is clear that this method does not give more bandwidth.

#### 1.3. Aperture Coupled Stacked Multiresonators [3]

Stacked multiresonators with a slot in the ground plane can give maximum 70% bandwidth. The drawbacks of this method are complex design and poor front to back ratio.

#### 1.4. Electromagnetically Coupled Microstrip Antenna [4]

In this antenna stacked multiresonators or multilayers are used. The upper parasitic layer is electromagnetically coupled to obtain high bandwidth. The design is simple, gives high front to back ratio and enough bandwidth around (30%).

In the present design electromagnetically coupled microstrip antenna is used. It gives bandwidth of 500 MHz (from 3.7 to 4.2 GHz) or 20%. This antenna is useful for C band.

The planar array should be a compact one. The array can be compact if the number of patches in the array is less or minimum. To achieve this, the gain of the individual patch should be increased. Gain of the patch can be increased using (1) superstrates [5] (2) stacked patches. If superstrates are used to increase the gain we have to face following difficulties at this frequency.

1. Thicker superstrate should be used which degrades efficiency.
2. It affects bandwidth.
3. By doubling number of patches gain does not double.

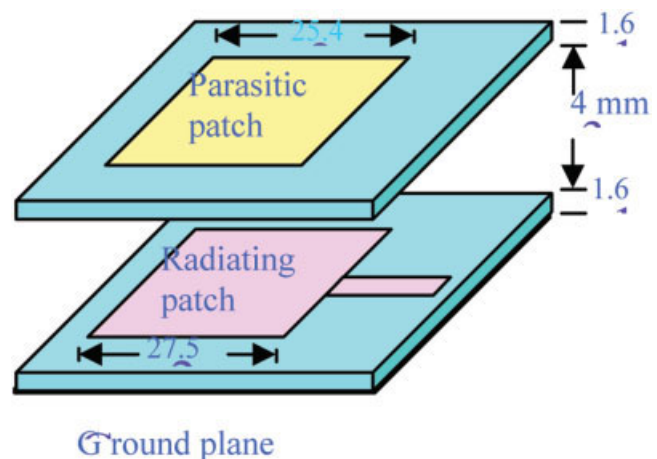
Last two difficulties are encountered in case of stacked patches [6].

Electromagnetically coupled microstrip antenna is used in this article. The single patch gives gain of 8.2 dB and bandwidth of 500 MHz (from 3.7 to 4.2 GHz). To obtain high gain of 32 dB, it requires such 256 patches. These patches are to be properly spaced and inter connected using appropriate matching networks. The size of this antenna array is 1 m<sup>2</sup>.

## 2. DESIGN

### 2.1. Design of Patch Antenna

The patch antenna consists of a ground plane, a radiating patch, and a parasitic patch as shown in Figure 1. The dielectric material used to



**Figure 1** Structure of the antenna. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]