A Design of Compact Ultra-Wide Band Antenna

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***Abstract* - In this article, a new ultra-wideband (UWB) antenna for UWB application is proposed. This antenna is designed** with the operation **of bandwidth from 3.1 GHz to 10.6 GHz. The purpose is to design a simple and compact antenna with broad bandwidth VSWR ≤ 2. Antenna characteristics such as radiation pattern, maximal gain are also thoroughly investigated.**

Keywords — Ultra-wide band (UWB), Ultra-wide band (UWB) antenna, printed antenna, planar antenna, slot antenna.

I. INTRODUCTION

In recent years wireless communication systems have been quickly developed with a lot of smaller portable devices. So as to meet the need of reducing the size of the devices, the antenna attached to these portable devices should have small sizes. Printed antenna is the choice that matches the design requirements above. On the other hand, to achieve high data rate, bandwidth broadening is an important requirement to real life applications. Therefore, antenna reducing in size together with bandwidth broadening has been a trend for designing antenna in real-life applications. It has been a new important point not only in wireless communication systems but also in other applications such as: high definition television, mobile television, wideband internet, online game, multimedia entertainment. A solution is using devices which perform in broad bandwidth from 3.1 to 10.6 GHz. For this reason, printed antenna with broad bandwidth has attracted a lot of attention of antenna researchers and designers.

Recently there have been many antenna designs with broad bandwidth. These designs have different shapes, sizes and materials, but the common goal is the compactness, easy making and low cost. The designs with the form of defected ground structure plane radiation [1], piercing radiation into semi-circle [2], cutting different edges of radiation plane [3], defected ground structure [4], dipole antennas [5], [6], printed antenna [7], printed antenna with defected ground structure [8] and slot antenna [9]. These methods are all used to design antenna with ultra-wide bandwidth. Therefore, the author suggests a new ultra-wide band antenna based on piercing radiation plane to achieve an ultra-wide band antenna. This antenna is not only designed in simple shapes, easy making and compact size but also made of popular material with low cost. From the proposed structure, the author has calculated the parameters Voltage standing wave ratio (VSWR), radiation pattern of the antenna.

II. ANTEN DESIGN

A. Design choices

1) Design option: The chosen ultra-wide band antenna is the flat antenna with small, compact and slim structure which fits the overall structure of UWB devices. Therefore, the antenna must be put on a dielectric sheet to reduce the effects of VSWR, to extend the bandwidth and to support antenna. Both the radiation and reflecting surfaces are planar structures, at the same time, it is also convenient for making based on printed circuit technology. Antenna was designed by the method of electric dipole.

2) Material choice: In order to design the antenna that not only meets the technical requirements of an ultra-wide band antenna but also facilitates the processing and manufacturing of antennas with reasonable cost, the author has selected copper as material for antenna and for the ground plane, the dielectric is FR4 with dielectric constant $\varepsilon = 4.4$ and loss factor $\tan\delta = 0.02$.

3) The objective of the design: Introducing a simple antenna structure, flat, compact size, operating in the frequency range from 3.1 GHz to 10.6 GHz with VSWR ≤ 2, ensuring isotropic radiation.

B. Antenna Structure

To achieve optimal antenna structure, the authors adjusted the antenna size to find the optimal size: resizing dielectric plate, radiant panels, the size of the holes drilled on the radiation plate (change the radius of cutting bottom edge of the radiation plate, change the rectangular and square carved dimensions), adjust the width and the length of electrical circuit, change the size of the ground plane. Finally, the author has selected the optimal structure of ultra-wide band antenna structure which is shown as in Figure 1. The size parameters of the antenna are represented as in Table 1.

The designed antenna is placed on the FR4 dielectric sheet with the length $L = 32$ mm, width $W = 32$ mm, thickness $h = 1.6$ mm. Rectangular radiation surface width $w_2 = 13$ mm, length $l_2 = 15$ mm, thickness $t = 0.02$ mm, the size of the cut on radiation as follows:

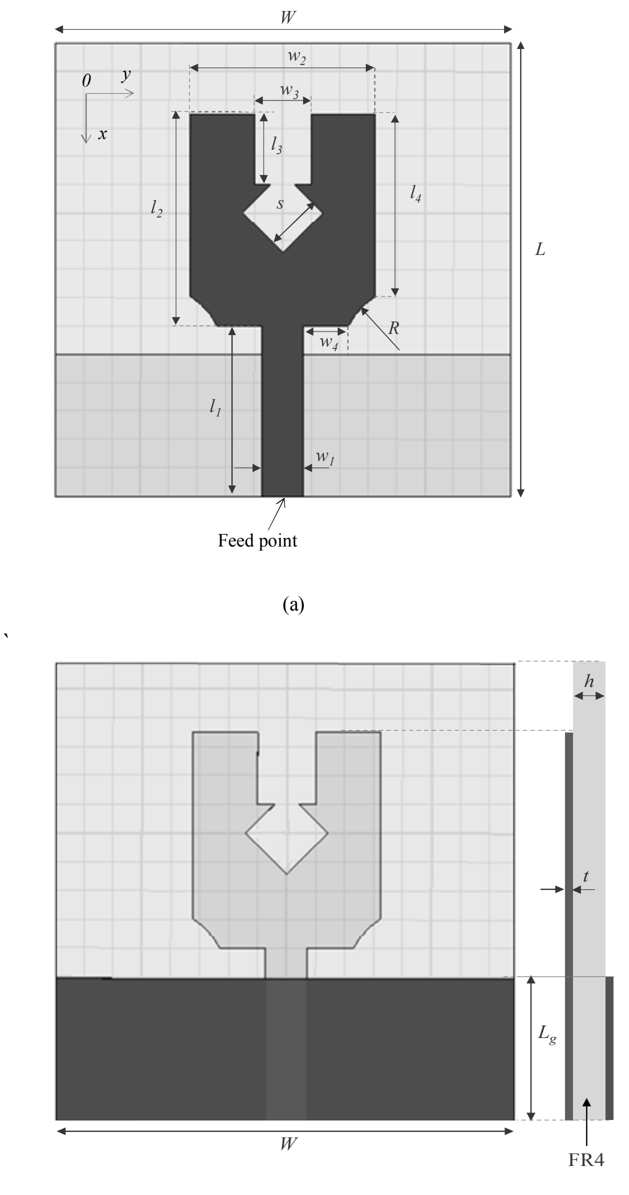


Fig. 1. Configuration of the UWB antenna.
(a) top view, (b) side view and (c) bottom view.

Rectangular hole with the width $w_3 = 4$ mm, length $l_3 = 5$ mm, thickness $t = 0.02$ mm.

- Square hole with the edge $s = 4$ mm and angled at 45^0.
- The bottom edge hole of the antenna with the turning radius $R = 4.8$ mm, the rest size of the radiation plate $w_4 = 3.1$ mm, $l_4 = 13$ mm.

Electric circuit has the width $w_1 = 2.9$ mm, length $l_1 = 12$ mm, thickness $t = 0.02$ mm. Ground plane has the width $L_g = 10$ mm, length W = 32 mm and thickness $t = 0.02$ mm.

TABLE 1

THE OPTIMUM GEOMETRICAL PARAMETERS (MM)

Parameter	Value	Parameter	Value	Parameter	Value
L	32	L_g	10	l_4	13
W	32	s	4	w_1	2.9
h	1.6	l_1	12	w_2	13
t	0.02	l_2	15	w_3	4
R	4.8	l_3	5	w_4	3.1

C. *The simulation of the designed antenna*

From the antenna structure of Figure 1, Ansoft HFSS simulation program (the finite element method) is used for calculating the parameters of the antenna. This was carried out in the frequency range from 3 GHz to 11 GHz.

Voltage standing wave ratio (VSWR) of the proposed antenna is shown in Figure 2. In Figure 2, the VSWR of the antenna is less than 2 in the frequency ranges from 3.07 GHz to 11 GHz. Thus, the band antennas cover the overall frequency range operation of the UWB device.

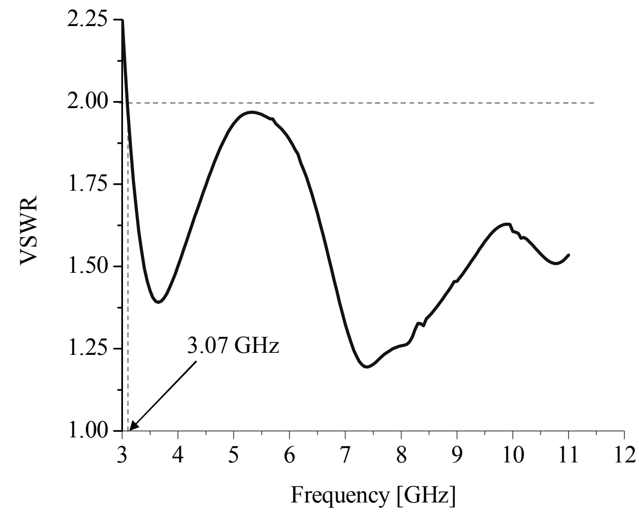
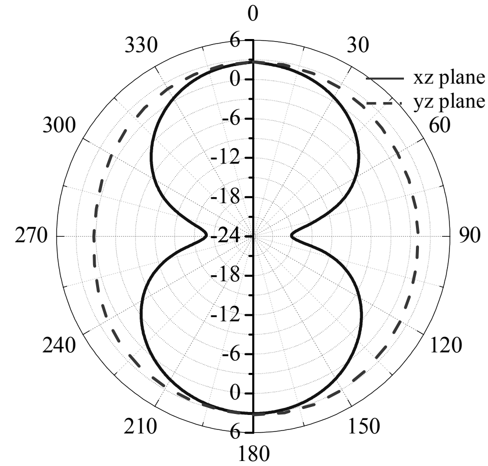
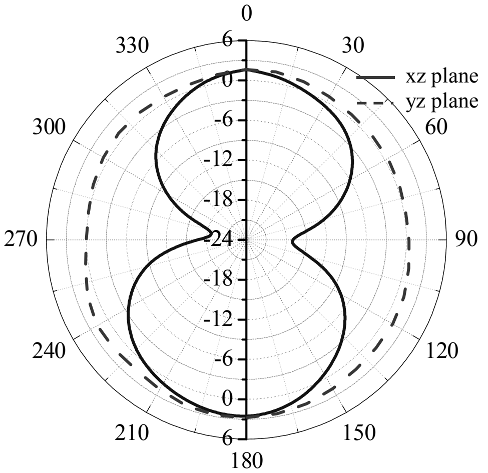


Fig. 2. Simulated VSWR versus frequency



(a)



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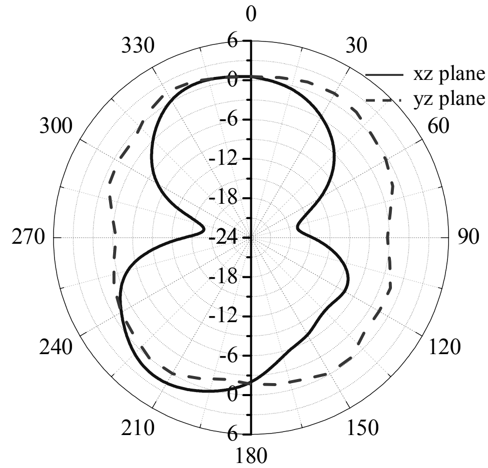
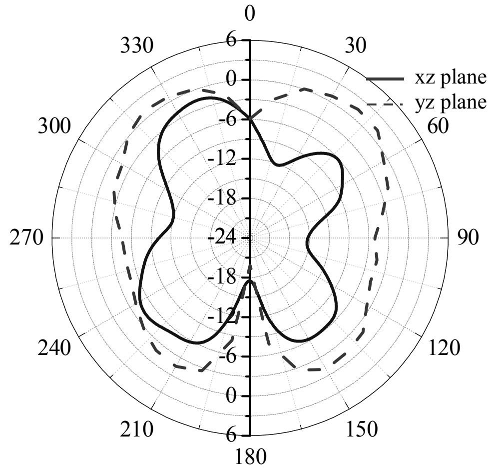
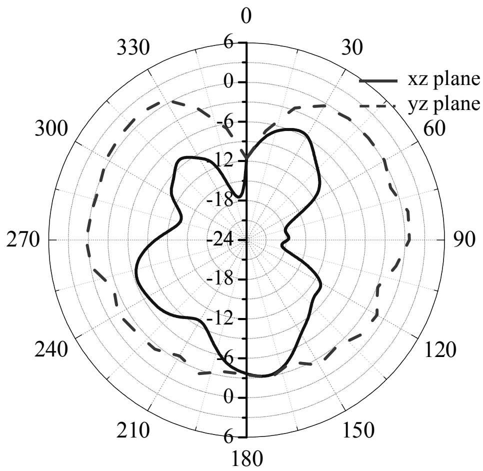


(c)



(d)



(e)

Fig. 3.Radiation patterns of the antenna: (a) at 3.1 GHz; (b) at 5.0 GHz; (c) at 7.0 GHz; (d) at 9.0 GHz; (e) at 10.6 GHz.

Since the frequency range used for UWB is wide, we have to survey radiation pattern of the antenna at different frequencies in the band. Radiation pattern of the proposed antenna is shown in Figure 3 with the frequency of 3.1 GHz, 5.0 GHz, 7.0 GHz, 9.0 GHz and 10.6 GHz corresponding to Figures (a), (b), (c), (d), (e). In particular, solid line is the xoz plane, dashed line is the yoz plane.

From the results in Figure 3, the antenna radiation pattern at low frequency is isotropic radiation, at high frequency changes; however, it still satisfies the requirements set out for ultra-wide band antenna.

Figure 4 shows the highest gain of the antenna in the overall investigated frequency range. The highest gain of the antenna can be achieved 5.5 dBi at 8 GHz. Although this figure decreases in low frequencies, it still guarantees to be higher than 2.7 dBi at the frequencies range from 3.1 GHz to 10.6 GHz. Thus, the designed antenna still meets the requirements of an antenna used for UWB.

The proposed UWB antenna has the bandwidth covering the frequency ranges from 3.1 GHz to 10.6 GHz, small sizes (32 mm × 32 mm × 1.6 mm). This antenna satisfies the requirements set out for the application of portable devices using ultra wideband technology. On the other hand, the antenna structure in the coplanar, simple, compact and easy making which creates this antenna is the foundation for the design of MIMO ultra-wide band antennas.

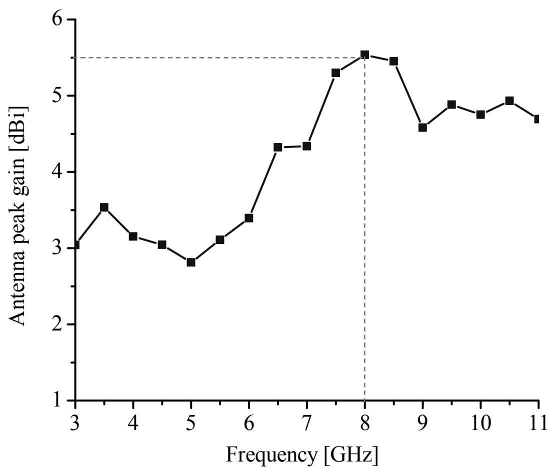


Fig.4. Antenna peak gain versus frequency

III. CONCLUSION

The paper proposed a new ultra wideband antenna design and has achieved some results as follows:

i) The designed antenna structure is small, compact, simple, so it is convenient for designing printed circuit technology.

ii) The designed antenna uses common materials to ensure low cost.

iii) Frequency with VSWR ≤ 2 GHz from 3.07 GHz to 11 GHz corresponding 115.8% as compared to the center frequency.

iv) Antenna radiation pattern is relatively equal throughout the working bandwidth. The maximum gain varies from 2.7 dBi to 5.5 dBi.

In the future, the author will continue to research and bring out the ultra-wide band antenna structures which are more compact and meet the technical requirements better in order to use for the portable ultra-wide band, and proposed antennas can be combined to other antennas to create smallest mutual coupling MIMO system.

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