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TWO NEW LOADED COMPACT PLANAR ULTRA-WIDEBAND ANTENNAS USING DEFECTED GROUND STRUCTURES

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Abstract—In this paper, two new line-fed loaded planar antennas are proposed for ultra-wideband applications. The first antenna is a circular patch with a circular ring as a Defected Ground Structure (DGS). A 50 Ohm microstrip line passes through the antenna which is symmetrical between the feed and the load. The impedance bandwidth of the first antenna with S11 < -10 dB is more than 10 GHz, from 3 GHz to more than 13 GHz, in both simulation and measurement. It will be shown that the antenna has quite a stable radiation pattern and also high gain over its bandwidth. The second configuration is a rhomboidal patch which a 50 Ohm microstrip line passes through it. A rhomboidal DGS ring is employed to widen the bandwidth of the proposed antenna. The impedance bandwidth with VSWR < 2 is more than 10 GHz, from 3 GHz to more than 13 GHz, in both simulations and measurement. The second antenna has also quite a stable radiation pattern and high gain values in its frequency band. For these antennas, a wideband 50 Ohm load has been used. Finally, it should be mentioned that the antennas have very compact structures as well as very simple configurations.

1. INTRODUCTION

There is much interest today in developing ultra wideband (UWB) radio for short-range high-speed wireless communication networks [1]. The immunity to multipath interference is one the most important features of the UWB systems.

Good UWB antennas should have low return loss, Omni-directional or directional radiation pattern and high efficiency over the ultra wide bandwidth from 3.1 GHz to 10.6 GHz [2].

UWB radio systems according to FCC regulation use 7.5 GHz, from 3.1 GHz to 10.6 GHz, to transfer data. In order to efficiently reduce the radio interference of the mass data transmission, one problem in the antenna design for a UWB system is on how to realize or control the width of the required frequency band [2]. One of the most challenging desired developments is to make UWB radios up to full potential and design the UWB antennas for portable systems.

There are several ways to widen the impedance bandwidth of an antenna to design an UWB antenna. In [3], a piece of glass, much thicker than formal substrate thickness, has been used as substrate of an UWB antenna. Using a piece of thick glass as substrate of the antenna causes a very simple configuration, very low cost and a high impedance bandwidth which covers the whole FCC band.

In [4], a coplanar waveguide-fed tapered ring slot antenna is proposed for UWB applications and in [5] a wideband printed rectangular slot antenna with reflectors for unidirectional radiation patterns is investigated in which a U-shaped tuning stub is used to improve the matching.

Printed dipole antennas constitute an important class of printed UWB antennas [2]. The printed dipole configuration has been used to introduce a coupled planar dipole UWB antenna in [2] and an Edge-Fed Printed Dipole UWB Antenna, using leakage-blocking slots, in [6].

In [7], electromagnetic energy absorption in the homogeneous and layered human body models due to body-worn UWB antennas is investigated by two typical small planar UWB antennas; a printed UWB disc monopole and an UWB slot antenna.

In this paper DGS is employed to propose two novel UWB antennas. First, a new loaded circular UWB antenna with circular DGS ring will be introduced. Second, a loaded rhomboidal UWB antenna which consists of a rhomboidal DGS ring will be proposed.

2. ANTENNA CONFIGURATION

As it was already mentioned, two novel loaded planar antennas with Defected Ground Structures will be introduced.

The first antenna consists of a loaded circular patch with a circular DGS ring.

The second antenna is a loaded rhomboidal patch with a rhomboidal DGS ring.

The simulation results have been obtained from two most reliable full-wave softwares, Ansoft HFSS and CST Microwave Studio.

2.1. A Loaded Circular UWB Antenna with a Circular DGS Ring

The geometry of the antenna is shown in Fig. 1. The antenna is symmetric around the main patch which a 50 Ohm microstrip line passes through it, fed from one side and loaded from the other side. A circular DGS ring is employed to widen the impedance bandwidth of the antenna.

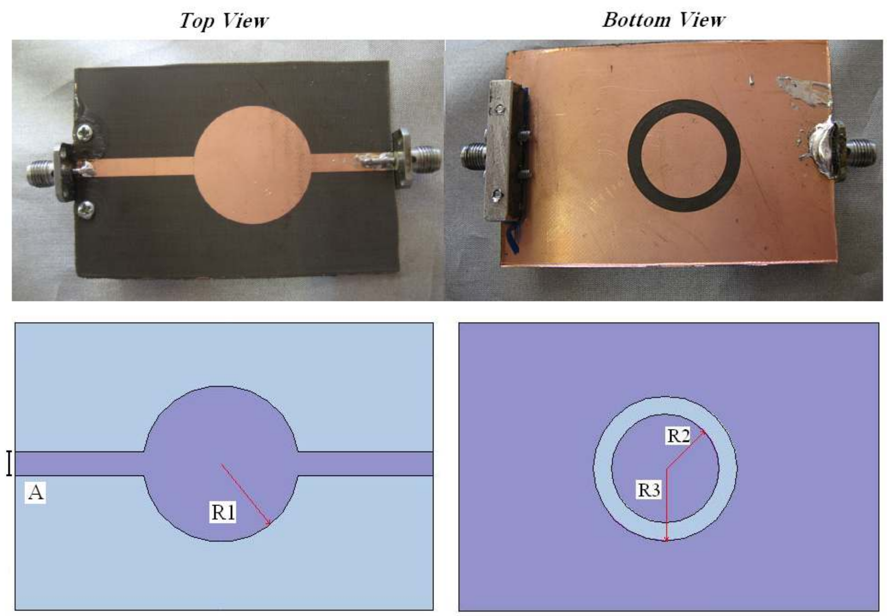

Figure 1. Top and bottom views of the circular UWB antenna with circular DGS ring.

The proposed antenna was designed on a Rogers RT/duroid 5880^{TM} substrate with dielectric constant $\varepsilon r = 2.2$ and height $H =$ 62 mil. The loss tangent is 0.0009. The dimensional details of the antenna are listed in Table 1.

Figure 3 shows the return loss ratio of the antenna, both in simulation with CST Microwave studio and Ansoft HFSS and measurement by the Agilent 8722D Network Analyzer (Fig. 2). The antenna impedance bandwidth with S11 < -10 dB is more than 10 GHz, from 3 GHz to more than 13 GHz, in both simulation and measurement. This bandwidth covers the whole FCC band and it is clear that the antenna can be used also for higher frequencies above

Table 1. The dimensions of the antenna shown in Fig. 1.

Symbol	Size
A	4 mm
R1	13 mm
R2	9 mm
R3	12 mm

the FCC band in various applications, for example this antenna can be a good alternative for satellite communication.

The antenna 2D radiation patterns at 4, 5, 6, 7, 8, 9 and 10 GHz in both E-plane and H-plane are shown in Fig. 4 and Fig. 5 respectively. The radiation patterns of the antenna show that the antenna has quite a stable radiation pattern all over its frequency band. The 3D far-field radiation patterns of the antenna, at 3, 5, 7 and 9 GHz, are illustrated in Fig. 6. Fig. 7 illustrates the simulated antenna far-field gain versus frequency which shows that the antenna has acceptable gain in most of its bandwidth. Finally the antenna Group Delay is shown in Fig. 8.

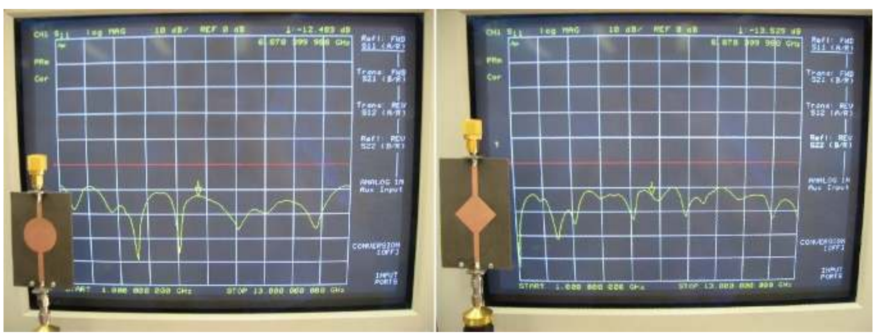

Figure 2. The measurement process of the antennas.

2.2. A Loaded Rhomboidal UWB Antenna with a Rhomboidal DGS Ring

Figure 9 illustrates the antenna configuration. A rhomboidal DGS ring is employed to widen the impedance bandwidth of the antenna.

The antenna was designed on a Rogers RT/duroid 5880$^{\text{TM}}$ substrate with dielectric constant $\varepsilon r = 2.2$ and height $H = 62$ mil.

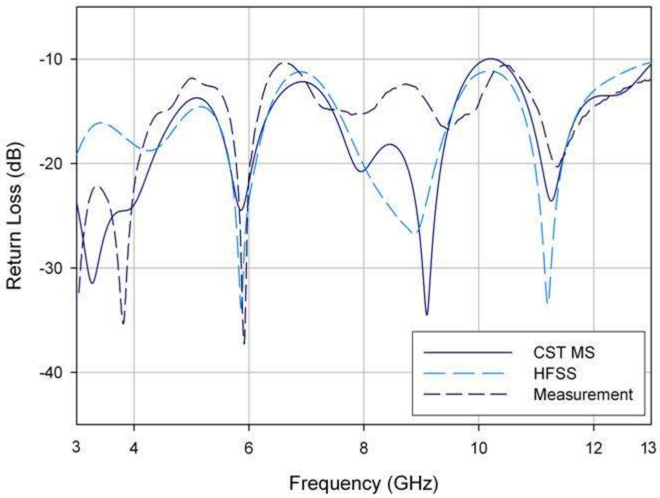

Figure 3. Both simulated and measured S11 of the first antenna.

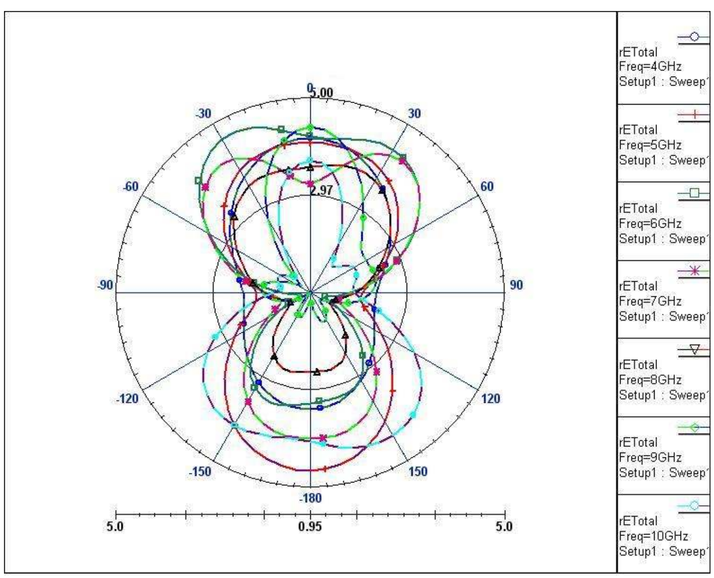

Figure 4. The antenna 2D radiation patterns in E-plane simulated by HFSS.

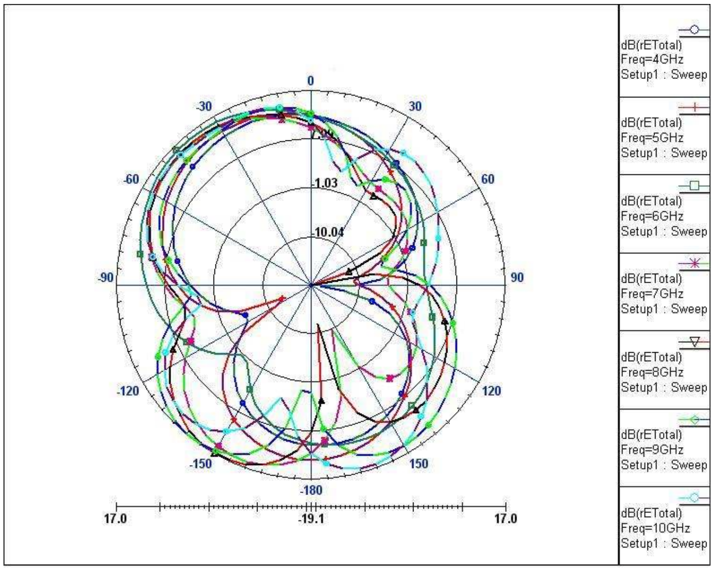

Figure 5. The antenna 2D radiation patterns in H-plane simulated by HFSS.

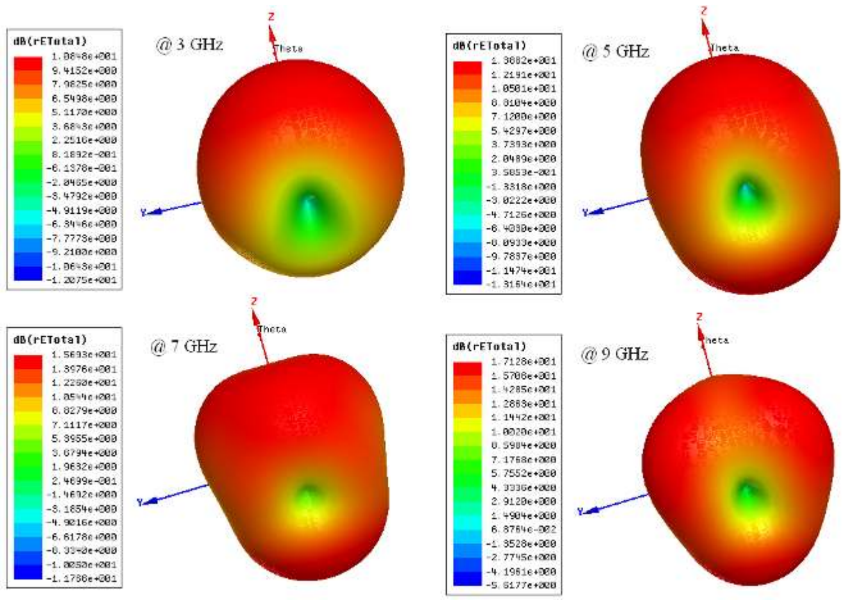

Figure 6. The antenna 3D far-field radiation patterns simulated by HFSS.

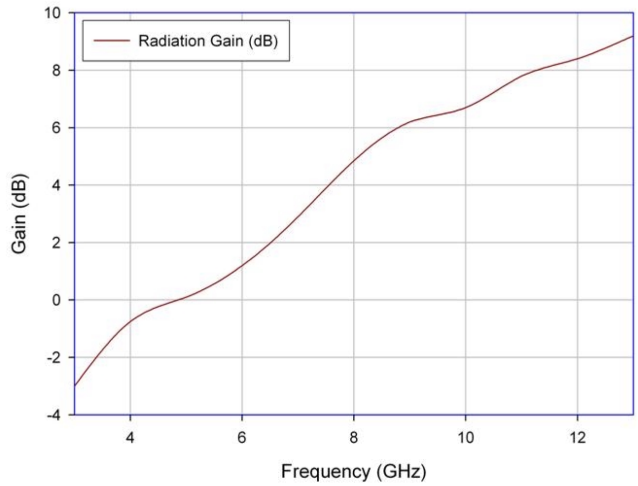

Figure 7. The antenna gain versus frequency.

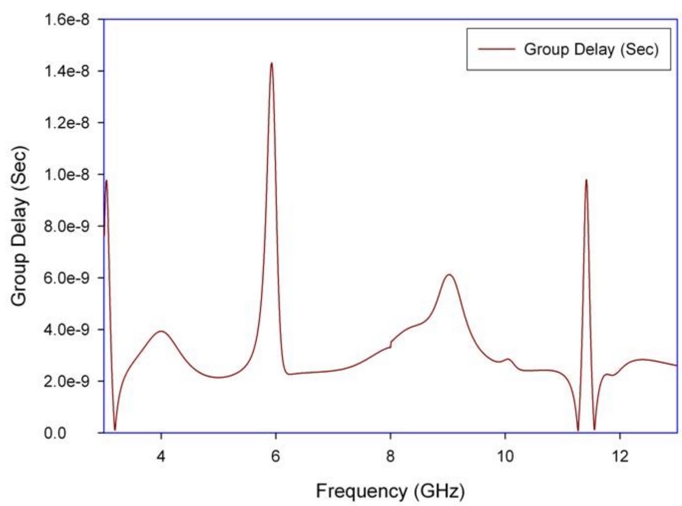

Figure 8. The antenna group delay (sec) versus frequency.

The loss tangent is 0.0009.

The dimensional details of the antenna are listed in Table 2.

Figure 10 shows both the simulated and measured Return Loss ratio of the proposed antenna. The antenna has been simulated by CST Microwave Studio and Ansoft HFSS.

The S11 of the antenna is measured by the Agilent 8722D Network

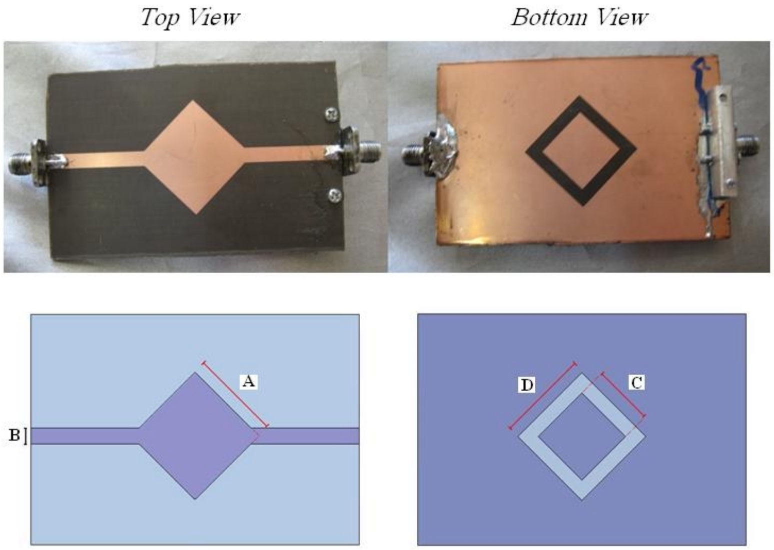

Figure 9. The Rhomboidal antenna with rhomboidal DGS ring.

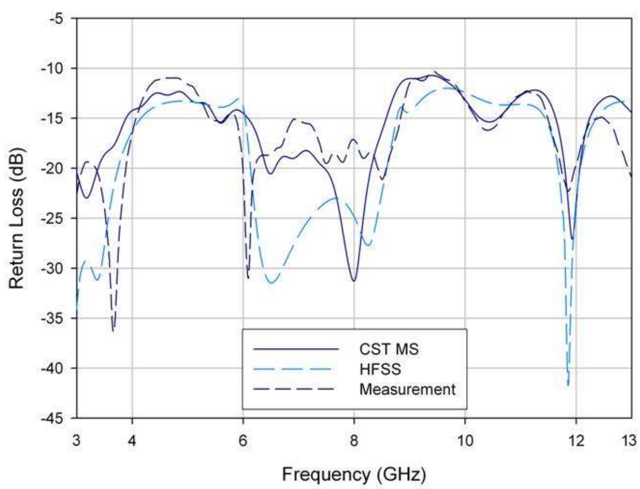

Figure 10. The simulated and measured S11 of the second antenna.

Analyzer (Fig. 2).

Both Simulated and measured impedance bandwidth of the antenna with S11 < -10 dB is more than 10 GHz, from 3 GHz to more than 13 GHz.

Figure 11 shows the simulated antenna far-field gain.

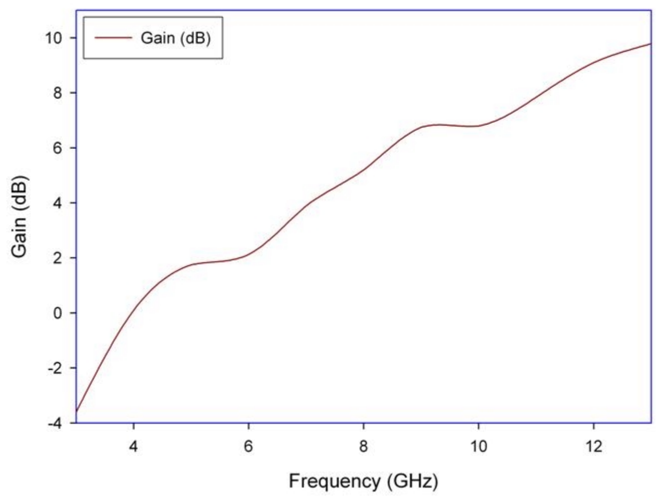

Figure 11. The antenna far-field gain versus frequency.

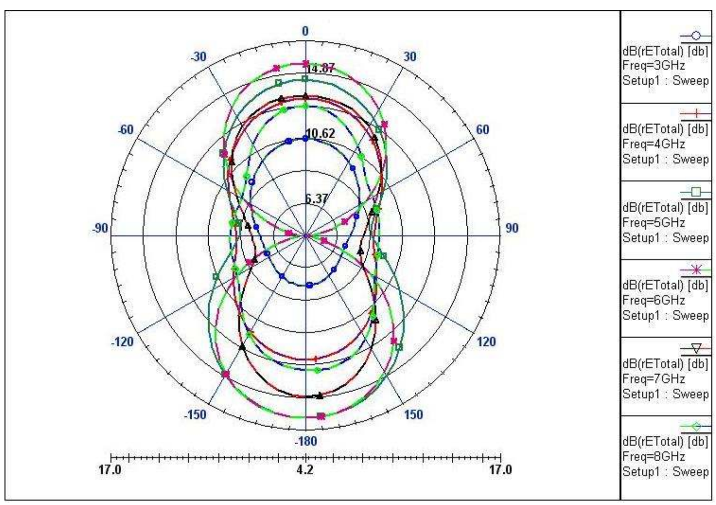

Figure 12. The antenna 2D radiation patterns in E-plane simulated by HFSS.

Figure 12 and Fig. 13 show the 2D view of the antenna radiation patterns at 3, 4, 5, 6, 7 and 8 GHz in E and H planes respectively.

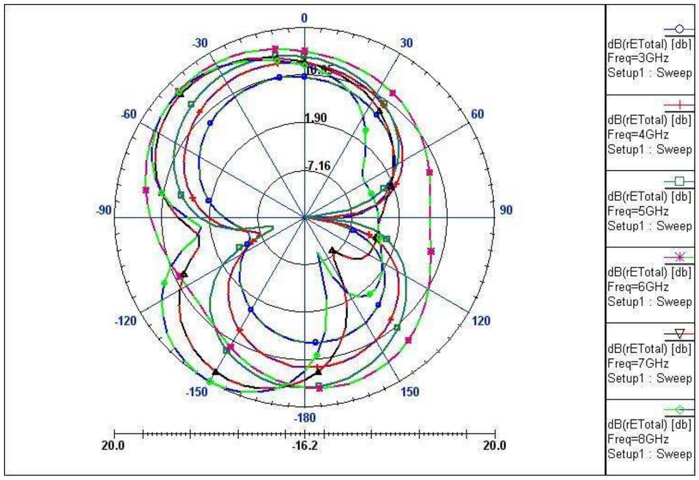

Figure 13. The antenna 2D radiation patterns in H-plane simulated by HFSS.

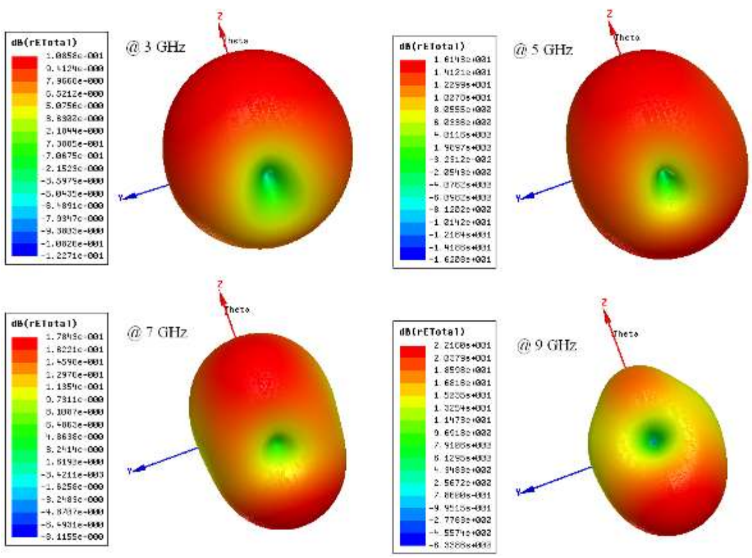

Figure 14. The 3D far-field radiation patterns of the antenna simulated by HFSS.

Figure 14 demonstrates the 3D far-field radiation patterns of the antenna at 3, 5, 7 and 9 GHz. It is clear that the radiation patterns of the antenna are almost similar at all frequencies.

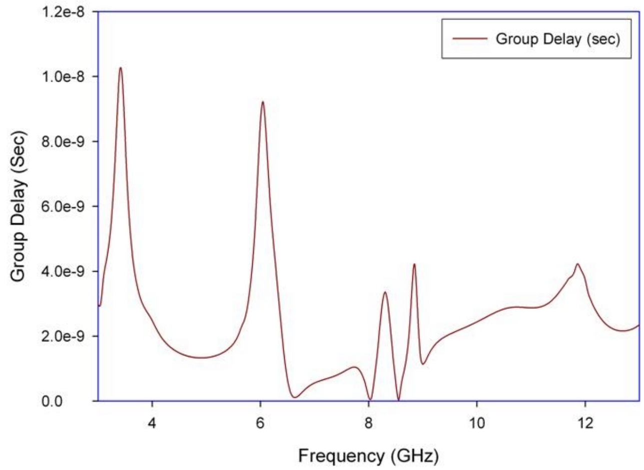

Figure 15. The antenna group delay versus frequency.

Table 2. Detail dimensions of the antenna shown in Fig. 9.

Symbol	Size
A	11 mm
B	4 mm
C	7.5 mm
D	11 mm

Finally Fig. 15 illustrates the antenna group delay versus frequency.

3. CONCLUSION

In this paper, two new compact UWB antennas were introduced. The most distinctive points which have to be mentioned about the antennas are as following:

- The impedance bandwidth of the antennas is more than 10 GHz which covers the whole FCC band, from 3.1 to 10.6 GHz.
- The antennas have acceptable gain in their whole bandwidth, from 3 to 13 GHz.

- The antennas have quite a stable radiation patterns in their bandwidth.
- The compact configurations with small dimensions and ease of fabrication make the antennas attractive for designers.

An important point in measurement is that the antennas have to be loaded by a 50 Ohm microwave load from one side and fed from the other side. The significance of this work lies in using defected ground structure to widen the impedance bandwidth of the antennas and means that further works can be done to investigate new Defected Ground Structures to reach any desirable characteristics in the antenna design.

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