Proposal of two Ultra-Wide Band Antennas for UWB-MIMO

Ngo Thi HUONG#, Le Trong TRUNG#, Nguyen Quoc DINH#

Department of Fundamental of Radio and electronic engineering, Le Quy Don Technical University, Ha Noi City, Viet Nam

E-mail: huong4nhim@gmail.com, trungmach6@gmail.com, dinhnq@mta.edu.vn

***Abstract* - In this paper, the authors propose 2 structures of UWB antennas: one operates as a magnetic dipole with the size of 15 mm × 26 mm × 1.6 mm and the other operates as an electric dipole with the size of 9 mm × 64 mm × 1.6 mm. The proposed antennas can work in the frequency band 3.1-10.6 GHz with VSWR ≤ 2. They also can be used in MIMO system to reduce the mutual coupling between antenna elements.**

***Keywords* - Ultra-Wide Band (UWB), Ultra-Wide Band Antenna, printed antenna, planar antenna, slot antenna.**

I. INTRODUCTION

Recently, a number of techniques have been developed to achieve high data rate in wireless communication systems. Among those, the Ultra-Wideband Multi Input Multi Output (UWB-MIMO) transmission technique is one of the most promising techniques as it can achieve a very high data rate of more than 1Gbps. The UWB-MIMO technique combines the advantages of the UWB communication and MIMO transmission. It has very wide working frequency band from 3.1 GHz to 10.6 GHz. In the UWB-MIMO devices, the antenna plays an important role and normally required to be small and the mutual coupling between antenna elements must be very low. An approach to reduce the mutual coupling is using a combination of electric dipole and magnetic dipole.

UWB antennas can be implemented in the form of dipole antennas [1], [2], printed antenna [3], printed antenna with defected ground structure [4] and slotted antenna [5]. These antennas can be used for UWB applications within slotted reflection plane. In this paper, the authors propose 2 structures of UWB antennas: one operates as a magnetic dipole with the size of 15 mm × 26 mm × 1.6 mm and the other operates as an electric dipole with the size of 9 mm × 64 mm × 1.6 mm. Although, their length is quite long, their width is quite narrow comparing to other proposed UWB antennas. The proposed antennas can work in the frequency band 3.1-10.6 GHz with VSWR ≤ 2.

II. ANTENNA DESIGN

The structures of the antennas are shown in Fig. 1 and Fig. 2. The antennas are flat, small, thin and thus suitable for UWB applications. The antenna is made from FR4 material which has the dielectric permittivity of $\varepsilon = 4.4$ and dissipation factor of $\tan\delta = 0.02$.

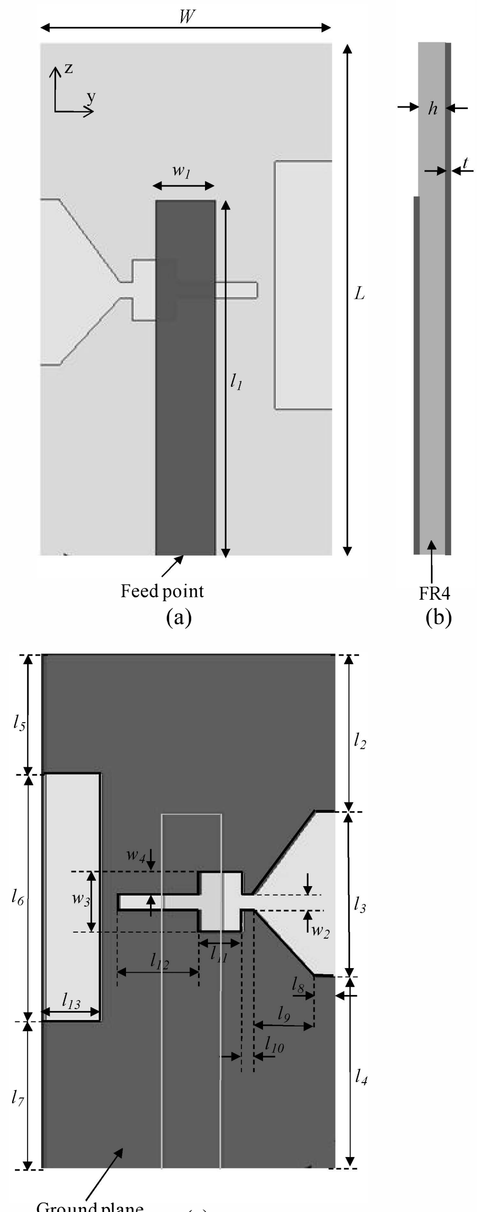


Fig. 1. Configuration of the UWB antenna. (a) top view, (b) side view, (c) bottom view.

The Ansoft HFSS software with finite element method was used to vary antenna dimensions to find the optimal structure for the antenna. The dimensions for the optimized antenna are shown in Tables 1 and 2.

TABLE 1
THE OPTIMUM GEOMETRICAL PARAMETERS
(ANTENNA MODEL1, MM)

Parameters	Values	Parameters	Values	Parameters	Values
L	26	w_4	1.1	l_7	7.5
W	15	l_1	18	l_8	1.1
H	1.6	l_2	7.9	l_9	3.1
t	0.02	l_3	8.4	l_{10}	0.6
w_1	3	l_4	9.7	l_{11}	2.2
w_2	0.8	l_5	6	l_{12}	4.1
w_3	3	l_6	12.5	l_{13}	3

TABLE 2
THE OPTIMUM GEOMETRICAL PARAMETERS
(ANTENNA MODEL 2, MM)

Parameters	Values	Parameters	Values	Parameters	Values
L	64	l_2	3	l_7	5
W	9	l_3	10	w_1	2.25
H	1.6	l_4	13	w_2	0.5
T	0.02	l_5	1.5	w_3	1.8
l_1	12	l_6	24		

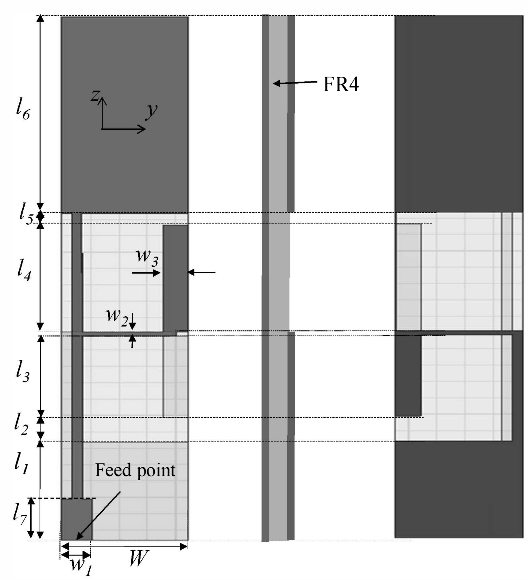


Fig. 2. Configuration of the UWB antenna. (a) top view, (b) side view, (c) bottom view.

The first antenna is designed on FR4 substrate with the dimensions of $26 \times 15 \times 1.6$ mm^3. The feeding line has the dimensions of $18 \times 3 \times 0.02$ mm^3 and located on the radiation plane of the antenna. The ground plane takes the whole copper layer on the other side of the substrate. The layer is 0.02 mm thick and is slotted as shown in Fig. 1. The dimension parameters are shown in Table 1.

The second antenna is designed on FR4 substrate with the dimensions of $64 \times 9 \times 1.6$ mm^3. It includes 4 main parts as shown in Fig. 2. The dimension parameters after optimizing are shown in Table 2.

The purpose here is to design a simple and compact antenna that can operate in the whole frequency band 3.1 ~ 10.6 GHz with VSWR $\leq$ 2. Also, these antennas can be used for UWB applications within slotted reflection plane.

III. RESULTS AND DISCUSSION

The antennas proposed in Fig. 1, and Fig. 2 were simulated and theirs parameters are investigated in the frequency band from 3 GHz to 11 GHz using simulation software HFSS (using finite element method).

The VSWR of the proposed antennas is shown in Fig. 3.

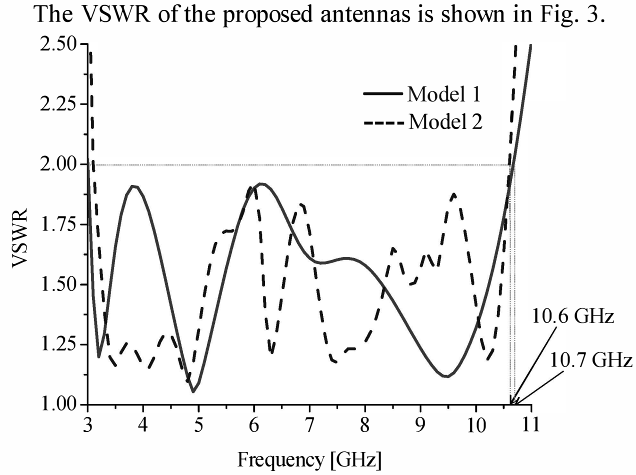
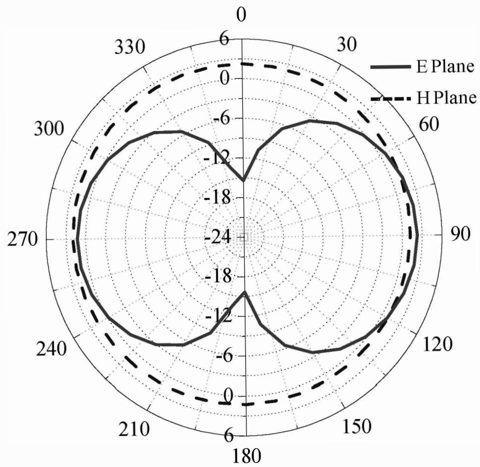


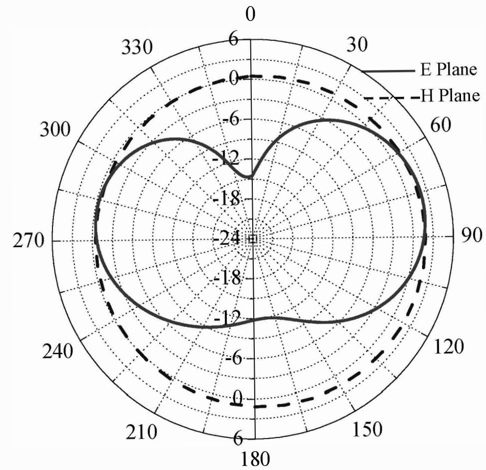
Fig. 3. Simulated VSWR versus frequency

As one can see in Fig. 3, the VSWR of the first antenna is less than 2 for the frequency band of 3 ~ 10.7 GHz which is corresponding to 112.4% (compare to central frequency). The VSWR of the second antenna is less than 2 for the frequency band of 3.1 ~ 10.6 GHz which is corresponding to 109.5% (compare to central frequency).

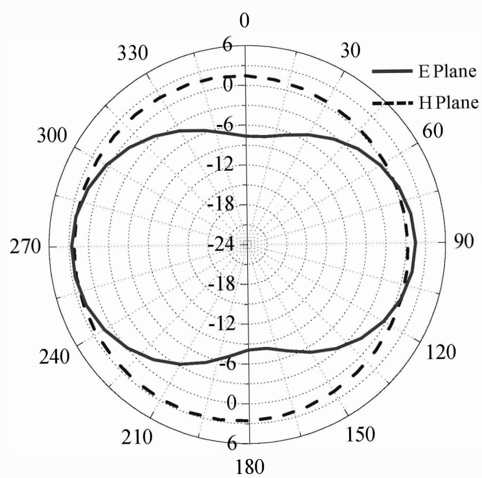
Thus, both are performing well in the working bandwidth of UWB devices. Since the frequency band for UWB applications is very wide, the radiation patterns of the antenna need to be investigated at different frequencies in the entire bandwidth. Antenna radiation patterns at the frequencies of 3.1 GHz, 5.0 GHz, 7.0 GHz, 9.0 GHz và 10.6 GHz are shown in Fig. 4, and Fig. 5, respectively. The solid line shows the pattern in the E-plane and the dashed line shows the pattern in the H-plane.



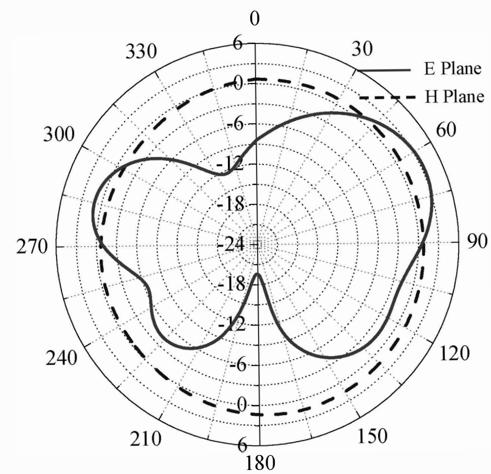
(a) 3.1 GHz



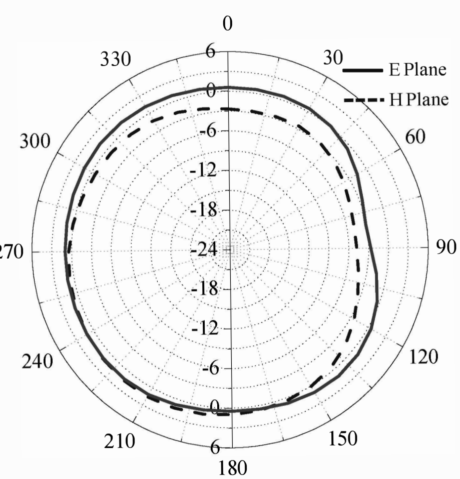
(a') 3.1 GHz



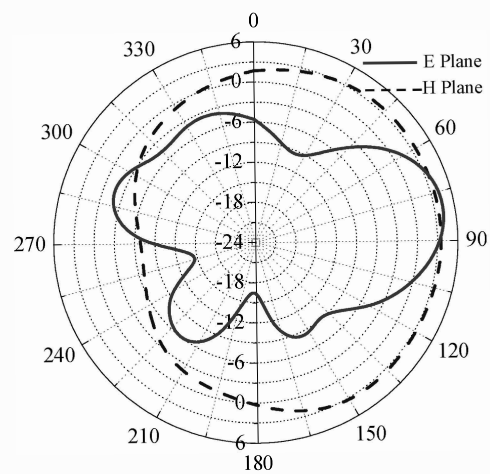
(b) 5.0 GHz



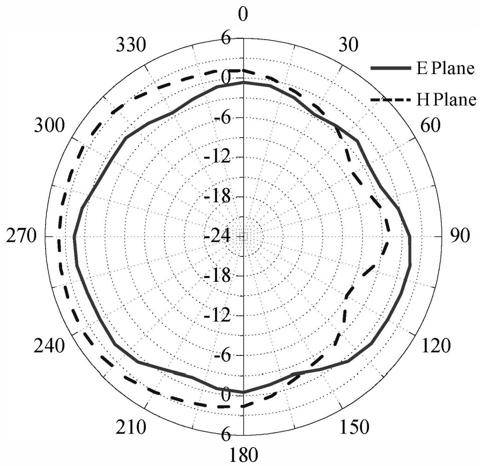
(b') 5.0 GHz



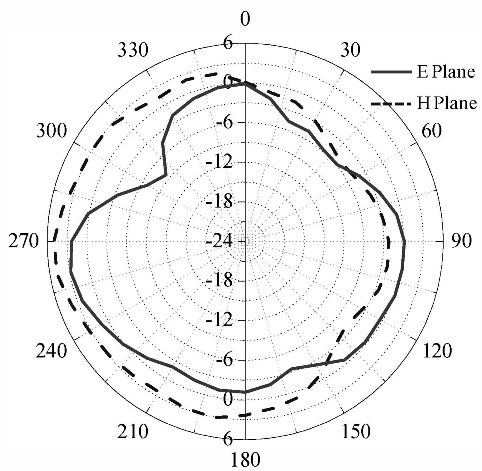
(c) 7.0 GHz



(c') 7.0 GHz

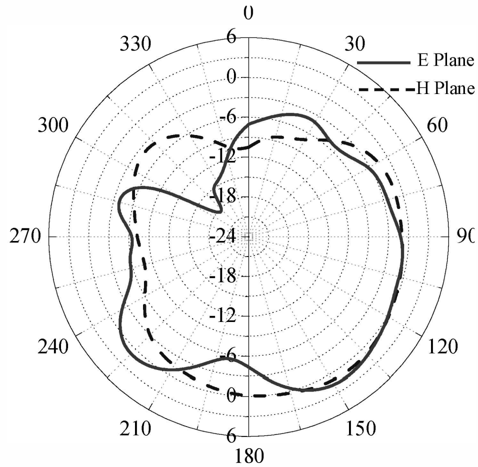


(d) 9.0 GHz

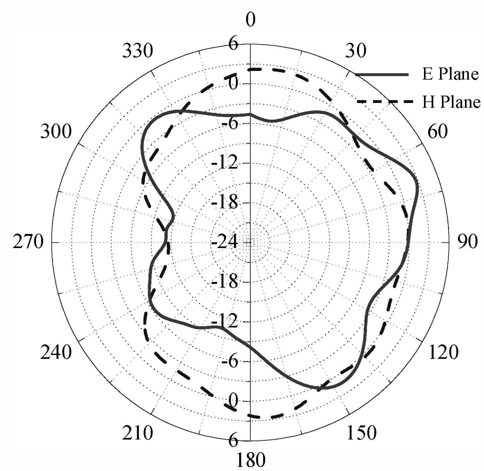


(e) 10.6 GHz

Fig. 4. Radiation patterns of the antenna model 1.



(d') 9.0 GHz



(e') 10.6 GHz

Fig. 5.Radiation patterns of the antenna model 2.

From Fig. 4, and Fig. 5 one can see that at low frequencies, the antenna radiates isotropic. At high frequencies, the radiation patterns change slightly but are still satisfies the requirement for UWB antennas.

Fig. 6 shows the peak gain of the first antenna and the second antenna in the H-plane within the entire bandwidth. The peak gain of the first antenna can reach its maximum of 5.2 dBi at 10.6 GHz. At low frequencies the peak gain reduces but is still greater than 2 dBi in the entire bandwidth. For the second antenna, its peak gain can reach to 5.0 dBi at 4.2 GHz. In the entire frequency band of UWB device, its peak gain reaches over 1 dBi.

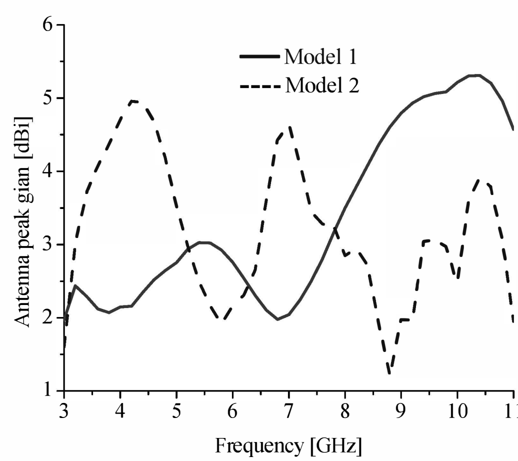


Fig. 6. Antenna peak gain versus frequency.

The proposed UWB antennas have the bandwidth that covers frequencies from 3.1 GHz to 10.6 GHz. They are small simple, and easy to produce. They are therefore appropriate for the applications in UWB devices. Thank to theirs small size and simple structure, the antennas themselves can be used in UWB - MIMO antenna.

IV. CONCLUSION

Two structures of small UWB antennas have been proposed. Their key properties can be listed as follow:

i) The proposed antennas have small, simple structure and therefore is easy to be manufactured as printed circuit.

ii) The antennas have VSWR ≤ 2 in the whole bandwidth from 3.1 GHz to 10.6 GHz.

iii) Antenna radiation patterns are relatively equal in the working bandwidth.

iv) One operates as a magnetic dipole, and the other operates as an electric dipole.

The future work will focus on combining 2 proposed antennas to calculate, optimize the structure of antenna for UWB - MIMO. The combination of electric dipoles and magnetic dipoles will reduce the mutual coupling between antenna elements in MIMO system.

ACKNOWLEDGEMENT

This research is funded by Vietnam National Foundation for Science and Technology Development (NAFOSTED) under grant number 102.01-2012.19.

REFERENCES

[1] L.D.Thanh, Y. Karasawa, "A novel compact Ultra-Wideband Dipole Antenna," Eurcap 2012.

[2] X.N. Low, Z.N. Chen, and S.P.See Terence, "A UWB Dipole Antenna With Enhanced Impedance and Gain Performance," *IEEE Trans. on Antenna and Propagation*, pp. 2959-2966, vol.57, no.10, oct. 2009.

[3] Z.N. Chen, S.P.See Terence, and X.Qing "Small Printed Ultrawideband Antenna With Reduced Ground Plane Effect," *IEEE Trans. on Antenna and Propagation*, pp. 383-388, vol.55, no.2, Feb. 2007.

[4] L.X. Li, S.S. Zhong, and M.H. Chen, "Compact Band-notched Ultra-Wideband Antenna Using Defected Ground Structure," *Microwave and Optical Tech. Letters*, pp. 286-289, vol. 52, no. 5, Feb. 2010.

[5] M. Gopikrishna, D.D. Krishna, C.K. Aanandan, P. Mohanan, and K.Vasudevan, "Compact Linear Tapered slot antenna for UWB applications," *Electronics letters*, 25th, pp. 1-2, vol.44, no.20, Sept. 2008.