VNU Journal of Science, Natural Sciences and Technology 27 (2011) 205-209

Antenna for MIMO systems

Tran Minh Tuan[1,*], Bui Le Phuong Linh[2]

[1]*National Institute of Information and Communications Strategy, 115 Tran Duy Hung, Hanoi, Vietnam*

[2]*Faculty of Electronics and Telecommunications, VNU University of Engineering and Technology, 144 Xuan Thuy, Hanoi, Vietnam*

Received 27 April 2011

Abstract. This paper concentrates on studying, designing and manufacturing a three port antenna applied for MIMO systems. This antenna can work in 2.4 GHz and 5.2 GHz frequencies, which are used for WLAN. Antenna is printed on FR4 substrate with size of 50 mm x 50 mm, thickness of 1.2 mm and relative permittivity of 4.4. The propose antenna is experimentally studied.

Keywords: MIMO antennas, Three ports antenna, antennas for WLAN.

1. Introduction

Multi-Input Multi-Output (MIMO) systems become one of solutions for wireless communications. With multiple antennas, MIMO wireless communication systems can increase channel capacity without requiring additional spectrum or transmit power. Moreover, the multipath rich environment enables multiple orthogonal channels between receiver and transmitter. This system allows users can send or receive data in parallel channels with the same bandwidth.

Large size of transmit and receive antenna arrays is one of the problems of MIMO systems. Many types of antennas have been studied for MIMO. After studying three types antenna coupling in [1], it is concluded that the three ports orthogonal polarization antenna gives the highest capacity. This structure has been investigate in [2] and [3] too. In this paper, this type of antenna is studied in order to be used more effectively. The antenna can work not only in the band 2.5GHz as in [2-4] but also can work in dual bands (2.5 GHz and 5.2 GHz). The dimension of the element antenna is only 50mm x 50mm x 1.2mm. We propose to achieve dual bands from individual antennas in order to the MIMO systems.

2. Design and simulation

A. Single antenna

A single printed dipole antenna includes two arms. Each arm has two branches. One branch give the resonant frequency at f_1= 2.4 GHz. Other one is shorter to adjust the resonant frequency at f_2 = 5.2 GHz.Microstrip feed line on the bottom and balun on the top are connected by a via hole(structure of balun is explained in [5]) We use substrate of FR-4 epoxy with thickness 1.2 mm, ε = 4.4. The CST

* Corresponding author. Tel.: 84-4-35565043.
E-mail: tm_tuan@mic.gov.vn

Microwave® software is used to design and simulate this antenna.

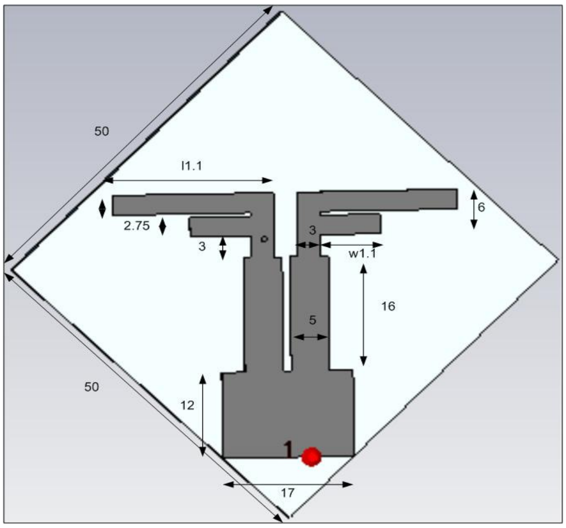

Fig 1. Top view.

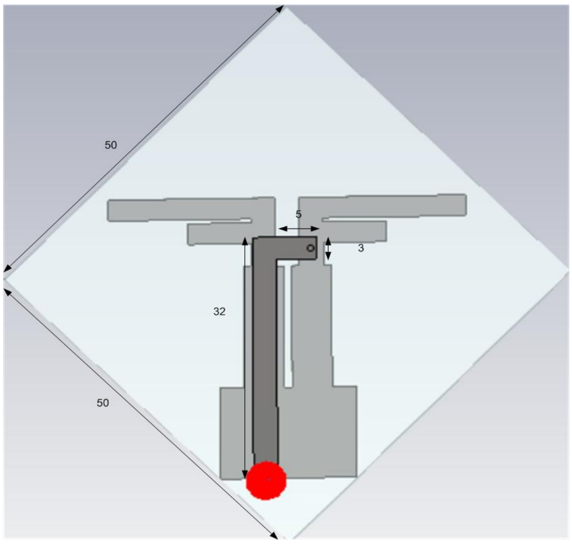

Fig 2. Bottom view.

The range of study frequency is from 1 GHz to 7 GHz. The simulation result is shown in Figure 3.

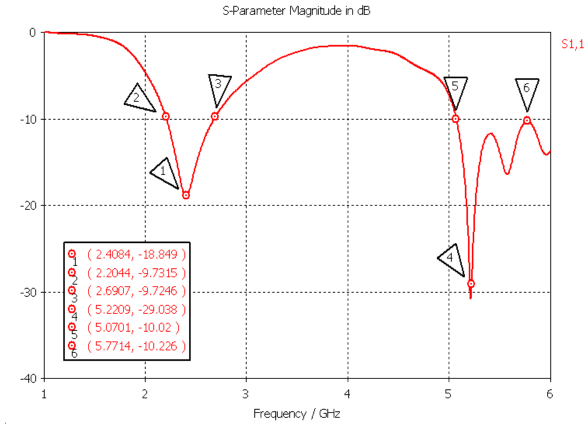

Fig 3. S Parameter.

B. Three Ports Orthogonal Antenna:

Based on the above single antenna simulation result, we combined three antennas to create a MIMO antenna. They are orthogonal one by one. The structure of MIMO antenna is shown in Figure 4 and its parameters are presented in Table1:

Table 1. Parameter of the antenna

	Length	mm
Longer arm Antenna 1	L1.1	22.5
Shorter arm Antenna 1	L1.2	8
Longer arm Antenna 2	L2.1	19
Shorter arm Antenna 2	L2.2	7.5
Longer arm Antenna 3	L3.1	20.5
Shorter arm Antenna 3	L3.2	7.8

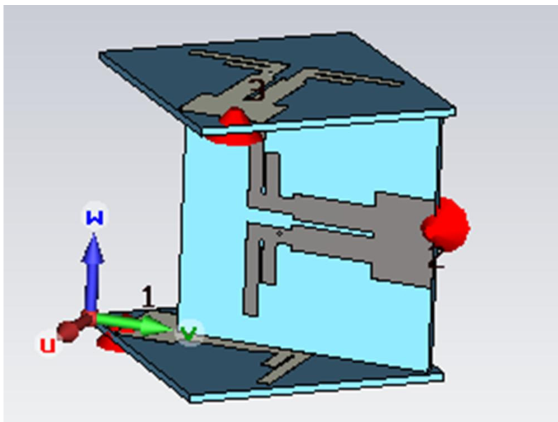

Fig 4. Structure Three Port Antenna.

The range of study frequency is from 1GHz to 6GHz. The simulation result is shown in Figure 5. At 2.4 GHz and 5.2 GHz, S parameters are -21dB and -30dB respectively.

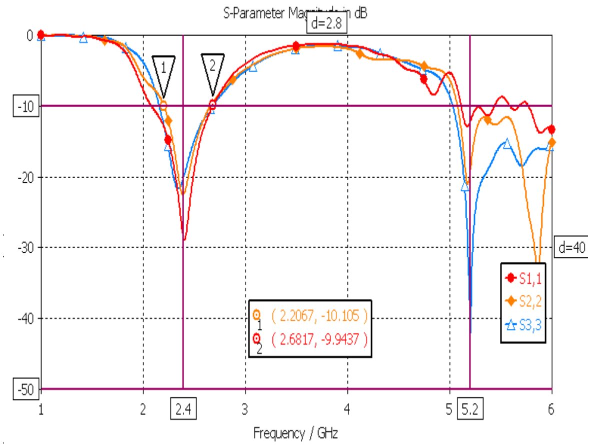

Fig 5. S parameter of Three Ports Antenna.

In the Figure 6, S parameters represent isolations between each couple antennas. For two desired frequency band, the isolation is acceptable.

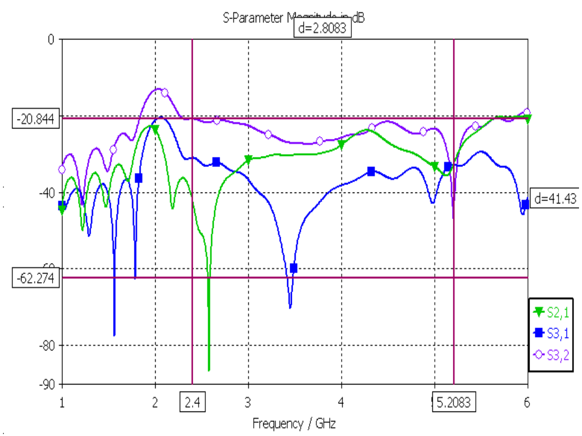

Fig 6. Forward Parameters.

Radiation Patterns of the antenna are shown in the Figure 7 and 8:

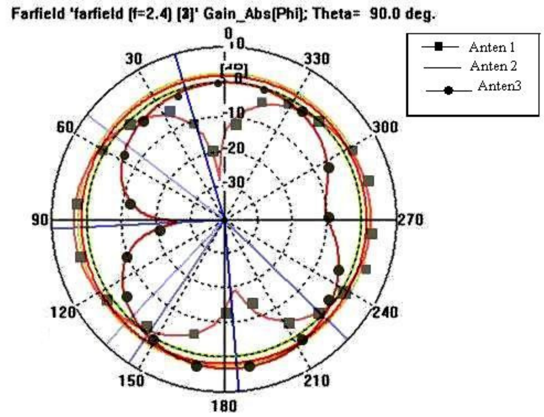

Fig 7. Radiation Pattern at 2.4GHz.

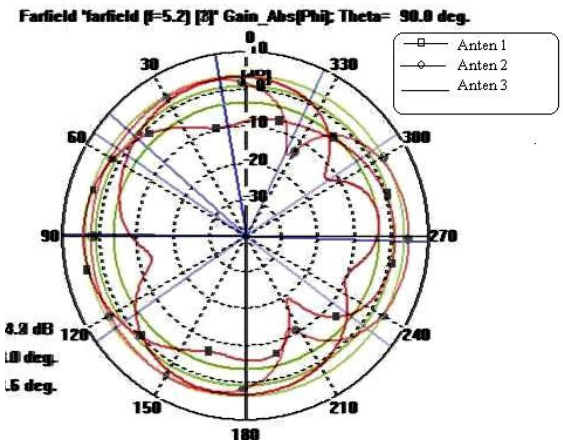

Fig 8. Radiation Pattern at 5.2 GHz.

3. Measurement

The actual antennas have been done and measured by Network Analyser.

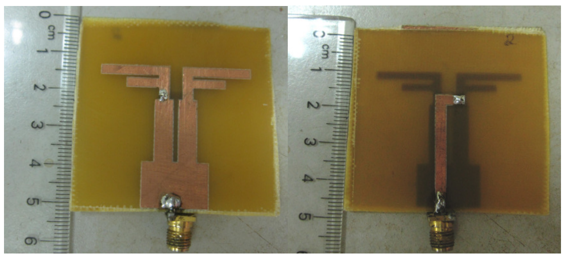

Fig 9. Top/bottom view of single antenna.

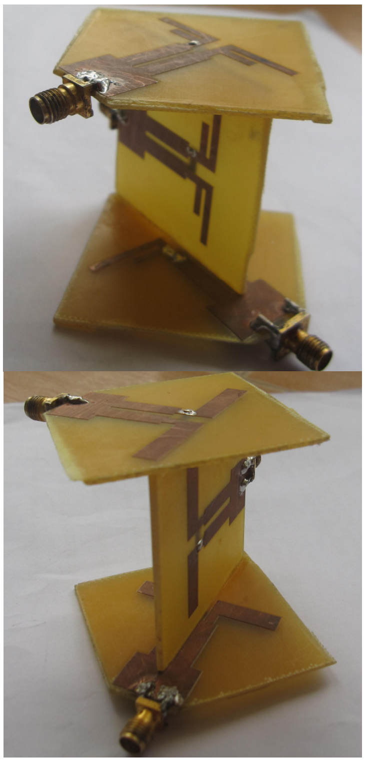

Fig 10. The MIMO antenna.

The Inter-Ports Isolation (or mutual coupling) is shown in the figure 14.

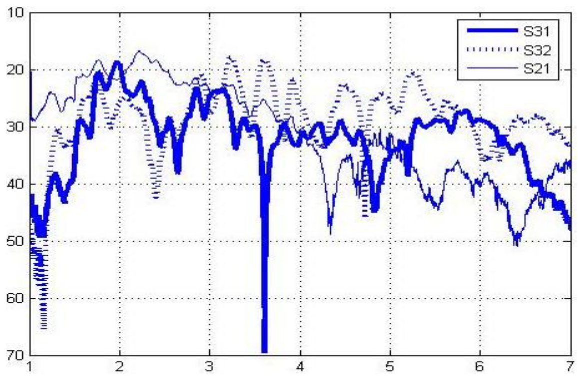

Fig 11. Forward Parameter.

Mutual couplings are smaller than -18dB between ports 1, 2, 3.

The actual MIMO antenna well achieves in dual bands. S-parameter results are shown in Fig12a-b-c and are compared in table 2.

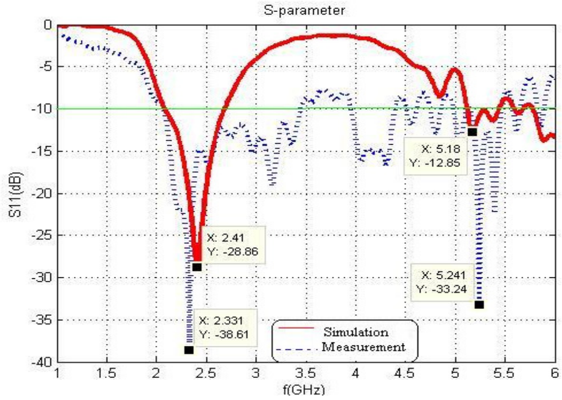

Fig 12a. Comparison of S11.

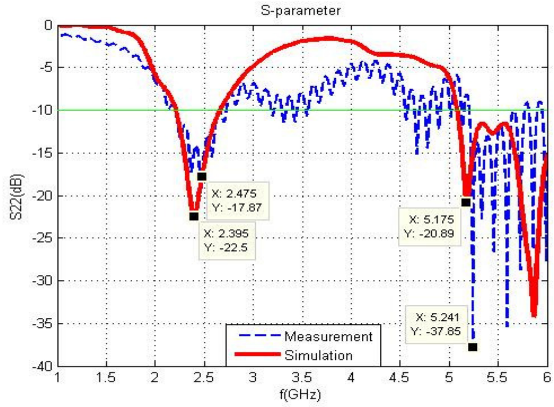

Fig 12b. Comparison of S22.

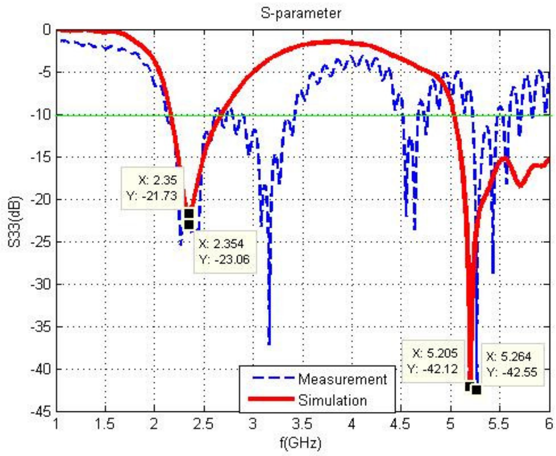

Fig 12c. Comparison of S33.

Table 2. Comparison of S parameter

	Simulation		Measurement	
	2.4GHz	5.2GHz	2.4GHz	5.2GHz
S11	2.41GHz -28.06 dB	5.18 GHz -12.05 dB	2.33GHz -38.86dB	5.24 GHz -33.24 dB
S22	2.39 GHz -22.5 dB	5.17GHz -20,89 dB	2.47GHz -17.87dB	5.24GHz -37,85 dB
S33	2.35GHz -25.73	5.2GHz -42.12 dB	2.35 GHz -42.12dB	5.26GHz -42.55 dB

Bandwidth of each antenna (where S parameter = -10dB, correspond VSWR =2) is compared in table 3.

Table 3. Comparison of bandwidth

	Simulation		Measurement	
	2.4GHz	5.2GHz	2.4GHz	5.2GHz
S11	2.08-2.67 (0.6GHz)	5.11-5.29 (0.18GHz)	2.07- 2.68 (0.61GHz)	5.13-5.24 (0.11GHz)
S22	2.20-2.64 (0.44GHz)	5.08-5.34 (0.25GHz)	2.18-2.66 (0.49GHz)	5.22-5.48 (0.26GHz)
S33	2.15-2.67 (0.52GHz)	5.02-5.53 (0.51GHz)	2.2-2.64 (0.44GHz)	5.19-5.5 (0.3GHz)

Good agreement between the measurement and simulation is obtained. But, there are still some differences. The reason is that the real FR-4 permittivity is not exact as in theory (ε = 4.4) and the prototype may be not well manufactured.

4. Conclusion

With simple structure, this MIMO antenna has improved the quality of wireless communication. Moreover this antenna can operate at dual bands (2.4 GHz and 5.2 GHz), which are widely used for WLAN.

References

[1] *Naoki Honma, Riichi Kudo, Kentaro Nishimori, Yasushi Takatori, Atsushi Ohta, Shuji Kubot "Effectiveness of Terminal Antenna employing Orthorgonal Polarizations and Patterns in outdoor multiuser MIMO systems",* International ITG/IEEE Workshop on Smart Antennas, *Vienna, A-1220 Austria,* February 26-27, 2007.

[2] Dinh Thanh Le, Mashahiro Shinozawa, Yoshio Karasawa "Novel Compact Antennas for MIMO wireless communication System", *The 2010 International Conference on Advanced Technologies for Communications*, Ho Chi Minh City, Vietnam.

[3] Chi Yuk Chiu, Jie Bang Yan, David Murch Hong Kong technologies Group Limited "Compact 3-port orthogonally polarized MIMO antennas", *United States Patent, Patent No.: 7710343 B2,* May 4, 2010.

[4] Contantios I.Votis, Panos Kostarakis and Vasilis Christofilakis, "Design and Investigation on Printed Dipole Antennas Achitecture", *Journal of Communication and Computer*, ISSN 1548-7708, Volume 7, No.9 (Serial No.70), USA, September 2010.

[5] N. Michishita, H. Arai, M. Nakano, T. Satoh, T. Matsuoka, "FDTD analysis for printed dipole antenna with balun", *Microwave Conference*, 2000 Asia-Pacific, pp. 739-742.

Anten sử dụng cho các hệ thống MIMO

Trần Minh Tuấn[1], Bùi Lê Phương Linh[2]

[1]*Viện Chiến lược Thông tin và Truyền thông, 115 Trần Duy Hưng, Hà Nội, Việt Nam*

[2]*Khoa Điện tử - Viễn thông, Trường Đại học Công nghệ, ĐHQGHN, 144 Xuân Thủy, Hà Nội, Việt Nam*

Bài báo tập trung vào việc nghiên cứu, thiết kế và chế tạo một anten có 3 cổng sử dụng cho các hệ thống MIMO. Anten này có thể hoạt động tại các băng tần dành cho ứng dụng WLAN 2.4 GHz và 5.2 GHz. Anten được chế tạo trên tấm FR4 với kích thước 50 mm x 50 mm, độ dày 1.2 mm và hằng số điện môi là 4.4. Mẫu anten đã được chế tạo và đo thử trên thực tế.