Small Sized Compact MIMO Antenna for WLAN Gadgets

Manmeet Kaur[1], Parminder Singh[2]

[1]Institute of Engineering and Technology
[2]Doaba Institute of Engineering and Technology

Abstract: ***In this research, we have developed a multiple-input multiple-output (MIMO) multipath fading channels based antenna for indoor compact MIMO applications. In this research, we have simulated the proposed antenna using MATLAB environment. A detailed performance analysis has been performed by taking various performance parameters in account for indoor and outdoor wireless local area networks (WLAN). The proposed MIMO antenna is developed for WLAN applications in the bandwidth of 2.4–5.0. Our simulation results found the best size of compact MIMO antenna, which is 29.7 mm length and 38.03 mm length for all WLAN frequencies. The antenna for 5.0 GHz band only would be the smallest one when compared to the other frequencies. It is also observed that the radiation resistance and Gain decreases with the rise in the frequency, whereas efficiency marginally decreases on the edge frequency bands on both higher and lower levels. Efficiency gives its highest performance values with 3.0GHz frequency band. Character Impedance stays almost constant in all of the experiments.***

Keywords: MIMO, WLAN, Antenna, multipath fading channel

1. Introduction

In the wireless communication system, multiple antennas became very popular because of their sudden change in efficiency, capacity and speed of data transmission. The purpose of this thesis is to describe MIMO and ultra wide bands. For better understanding of multiple antennas, antenna mechanism, antenna characteristics and basic parameters are discussed here. Wireless communications were mainly used for the voice and smaller data transfers. For large data transfers we used wired communications. In recent years, there has been a quick change in wireless multimedia applications. As a result, the demand of wireless communication with high data transfer rate is increased but with the traditional antennas this is not possible because of multipath fading and interference. The transmitter antenna transmits signal to the receiver antenna but the transmitted signal face many obstacles like trees, buildings etc and the signal becomes faded and distorted. This is called multipath fading. To improve the multipath fading and to improve the signal quality we used multiple antennas.

There are four types of multiple antennas: SISO, SIMO, MISO and MIMO. SISO has one antenna at the transmitter and one antenna at the receiver. SIMO has one transmitter antenna and multiple antennas at the receiver. Here one signal is transmitted and the multiples are received. MISO has multiple antennas at transmitter and one antenna at the receiver. MIMO has multiple antennas at transmitter and receiver. MIMO technology has many advantages. We can remove multipath fading and interference with the help of MIMO technology. We can also increase the efficiency, signal quality with MIMO technique. Orthogonal frequency division multiplexing (OFDM) is a type of frequency division multiplexing modulation technique which is used to transmit larger amount of data. OFDM divides the data into smaller sub signals and transmitting data simultaneously at different frequencies. The main reason of using OFDM with MIMO is that OFDM is having the ability of turning a frequency-selective MIMO fading channel into multiple flat fading channels. Multiple antenna techniques are used in many areas like WIFI, WIMAX, cellular networks, ultra wide band and WLANS etc.

2. Literature Review

Li Liu and S. W. Cheung have proposed Compact MIMO Antenna for Portable Devices in UWB Applications. This is a compact sized MIMO antenna developed for portable UWB applications. The antenna is made of two major technologies: planar-monopole antenna elements with microstrip-fed printed on one side of the substrate. Jian-Feng Li and Qin-Xin Chu have developed Compact MIMO Antenna with Simple Decoupling Method with a simple decoupling method, which is designed of MIMO antennas, the mutual coupling between the antenna elements is the mainly due to the induced ground currents. M. H. Mokhtar and his associates have invented a Compact Slotted Microstrip Patch Antenna for RFID applications. This is a compact slotted microstrip patch antenna designed to work on 2.40-2.45 GHz CST software. P. Subbulakshmi and associated have designed and characterized Corporate feed rectangular Microstrip patch array antenna. The antenna is made of 4-Element microstrip patch antenna array with corporate feed or excitation. The new patch antenna is designed using high frequency simulation software SONNET and FEKO. Tzu-Chun Tang, *et. al. proposed* Design of Antenna on Glass Integrated Passive Device for WLAN Applications. An antenna miniaturization technique that can substantially miniaturize an antenna to allow its incorporation into a compact package for WLAN (2.4–2.484 GHz) applications is proposed. Mohammad S. Sharawi, et. al. have developed an 800 MHz 2 x 1 Compact MIMO Antenna System for LTE Handsets. In this paper, a compact size 2 x 1 multiple-input–multiple-output (MIMO) antenna system operating in the 800 MHz band is proposed for long term evolution (LTE) handsets. Buon

Kiong Lau have proposed an Antenna Design Challenges and Solutions for Compact MIMO Terminals. The design of antennas for compact multiple-input multiple-output (MIMO) terminals is a challenging feat, due to the space constraint and the physical structure of the terminal. Pengfei Xia, Shengli Zhou, Georgios B. Giannakis have proposed Multiantenna Adaptive Modulation with Beamforming Based on Bandwidth-Constrained Feedback. In this paper, authors have addressed the problem of adapting to time-varying channel conditions and fading to increase rate, with rate-limited feedback. To solve the problem, authors have Investigated adaptive modulation system based on transmit beamforming with rate-limited feedback. Jointly design the feedback strategy and transmission parameters for rate-limited feedback. W.C. Freitas Jr, F.R.P. Cavalcanti, A.L.F. de Almeida, R.R. Lopes have proposed Exploiting Dimensions of the MIMO Wireless Channel: Multidimensional Link Adaptation. In this paper, authors have provided a solution the problem of dynamically adaptation of the signal transmission parameters (modulation, coding rate, antenna structure) to the current conditions of the wireless channels. Shengli Zhou, Georgios B. Giannakis proposed Adaptive Modulation for Multiantenna Transmissions with Channel Mean Feedback. In this paper, authors have addressed the problem of adapting to time-varying channel conditions and fading to increase rate, CSI imperfections (estimation errors & feedback delays). They have proposed a solution to design adaptive modulation scheme for multi-antenna transmissions with channel mean feedback and Investigate adaptive trellis-coded multi-antenna modulation.

3. Result Analysis

The result analysis of the compact MIMO antenna is performed after the implementation of the proposed antenna. The proposed antenna has been developed using MATLAB simulator installed on a Windows 7 machine with Core i3 Intel Processor and 2GB of RAM. At first, the major task was to get the size of the antenna for various applications. A complete module has been designed in the MATLAB simulator for the calculation of the antenna size and relevant performance parameters. The performance parameters considered in the simulation are Length of the antenna, Width of the antenna, Radiation resistance, Efficiency, Gain and Characteristic Impedance.

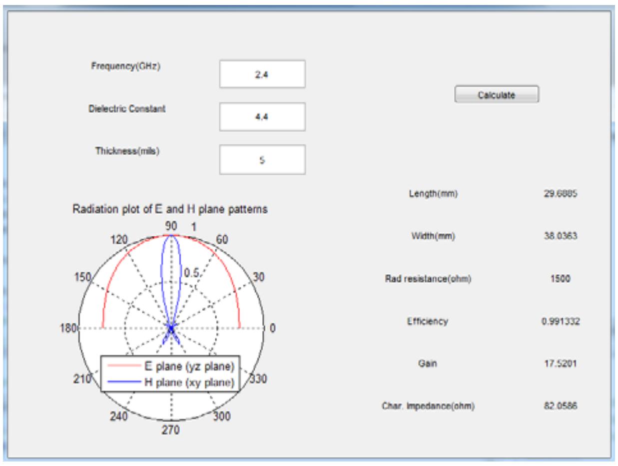

Figure 4.1: Performance Parameters at 2,4GHz

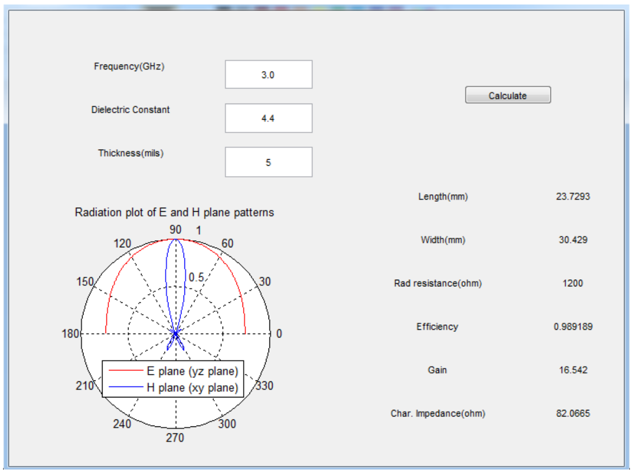

Figure 4.2: Performance Parameters at 3.0 GHz

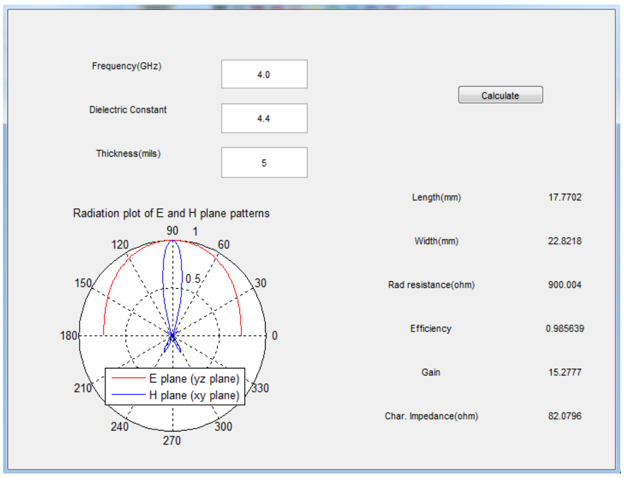

Figure 4.3: Performance Parameters at 4.0 GHz

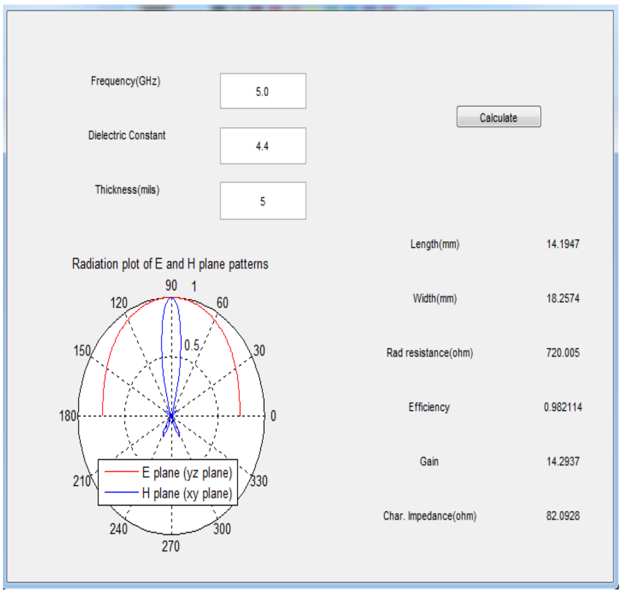

Figure 4.4: Performance Parameters at 6.0 GHz

The second, major objective was to decide upon the number of Receive and Transmission Antennas. The WLAN devices, for what this antenna is being developed are small in size and can have maximum 2 Rx and 2 Tx antennas. In this phase, there was a requirement to make the choice between the four antenna options.

Table 1: Input parameters and Output Performance and Design Parameters of Compact MIMO antenna for different transmission frequencies of WLAN communications

INPUT PARAMETERS					OUTPUT PARAMETERS					
Frequency (GHz)	Dielectric Constant	Thickness (mils)	Rx	Tx	Length (mm)	Width (mm)	Radiation Resistance (ohm)	Efficiency	Gain	Characteristic Impedance (ohm)
2.4	4.4	5	2	2	29.68	38.03	1500	0.9913	17.52	82.0586
3.0	4.4	5	2	2	23.72	30.42	1200	0.9891	16.54	82.0665
4.0	4.4	5	2	2	17.77	22.82	900	0.9856	15.27	82.0796
5.0	4.4	5	2	2	14.19	18.25	720	0.9821	14.29	82.0928

Table 2: The Options for Number of Rx and Tx Antenna

Receive	Transmit
2	2
2	1
1	2
1	1

A simulation for Signal-to-noise ration to Bit error rate has been performed to know the best performing combination from the above four. The simulation when run, have produced the following results.

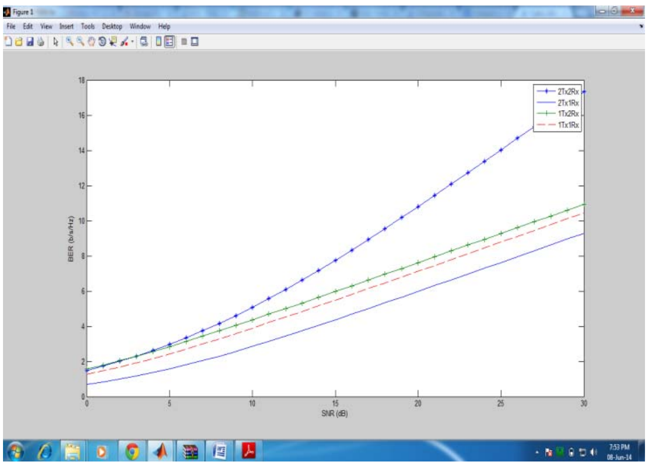

Figure 4.5: Simulation to know the best combination of Tx and Rx antennas

Besides, the BER is rising; it is also showing that Rx-Tx in 2-2 combination are most effective in delivering the data in comparison of the other available options. The final selection has been made with the 2x2 (Rx by Tx) combination.

4. Conclusion and Future Work

In this research, the issue of compact size MIMO antenna for the WLAN enabled portable devices has been addressed. The Multiple Input Multiple Output (MIMO) antennas are generally capable of providing higher data transmission rates because of their multiple antennas. But the major hurdle now-a-days arise during the integration process of MIMO antennas in the ultra-slim, compact or other small WLAN enabled devices because of their size issues. It is easily understood able that if the number of Tx/Rx points will rise, also the size of the antenna will increase. Even a smaller increase in the antenna can cause the issue of incompatibility due to the size. In relation to its size, it should also perform well in terms of various data transmission performance parameters like Antenna's shape parameters Thickness, Length, Width along with its performance parameters Radiation Resistance, Efficiency, Gain and Characteristic Impedance. We have calculated the best sizes for the best performance of the compact sized MIMO antenna for WLAN applications. By taking the constant parameters of Antenna thickness, Dielectric Constant and Number of Rx & Tx antennas, we have performed various antenna simulation experiments with changing frequency levels within the WLAN authorized frequency band. We have conducted the experiment with different frequencies in the WLAN band. The size of the antenna decreases with the rise in the frequency. Hence, it shows that if we needed an antenna for 5.0GHz frequency band only, it will be of the smallest size, whereas the antenna for sole 2.4GHz frequency band will be the largest in size. For the best performance in the whole WLAN frequencies, the size applied would be the one for the lowest frequency range. The size of the antenna for its best performance will be 29.7mm length and 38.03mm width for whole WLAN frequency band. The smallest size found in the experiments was 14.19mm length and 18.25mm width for the highest frequency band i.e. 5.0 GHz. It is also observed that the radiation resistance and Gain decreases with the rise in the frequency, whereas efficiency marginally decreases on the edge frequency bands on both higher and lower levels. Efficiency gives its highest performance values with 3.0GHz frequency band.

Character Impedance stays almost constant in all of the experiments. In our simulation we have worked on the simulation to find out the possible smallest size of the compact MIMO antenna. For ultra-small portable devices, they can programmed to work with higher frequencies only, which will facilitate the development of the compact MIMO antenna in its smallest size. There is always a possibility of improvement in the existing work. The further experiments can be conducted on the proposed antenna for further reduction in its size. The fabrication of these antennas can be also done in the future.

References

[1] Buon Kiong Lau and Zhinong Ying, "Antenna Design Challenges and Solutions for Compact MIMO Terminals", iWAT, vol. 1, pp. 70-73, IEEE, March 2011.
[2] Jian-Feng Li, Qin-Xin Chu,, "Compact MIMO Antenna with Simple Decoupling Method", European Microwave Conference, vol. 43, pp. 774-777, IEEE, Oct. 2013.
[3] Li Liu, S. W. Cheung, *Senior Member, IEEE*, and T. I. Yuk, "Compact MIMO Antenna for Portable Devices in UWB Applications", IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. 61, NO. 8,pp. 4257-4264, IEEE, AUGUST 2013.
[4] M. H. Mokhtar, M. K. A. Rahim, Senior Member, IEEE, N. A. Murad, Member, IEEE and H. A. Majid, Member, IEEE, "A Compact Slotted Microstrip Patch Antenna for RFID applications", International Conference on RFID Technologies and Applications, vol. 1, pp. 1765-1769, IEEE, 2013.
[5] Mohammad S. Sharawi, Sheikh S. Iqbal, and Yanal S. Faouri, "An 800 MHz 2 x 1 Compact MIMO Antenna System for LTE Handsets", IEEE Transactions On Antennas And Propagation, Vol. 59, No. 8, pp.3128-3131, IEE, August 2011.
[6] P. Subbulakshmi, R. Rajkumar, "Design and Characterization of Corporate feed rectangular Microstrip patch array antenna", ICECNN, vol. 1, pp. 547-552, IEEE, 2013.
[7] Pengfei Xia, Shengli Zhou, Georgios B. Giannakis, "Multiantenna Adaptive Modulation with Beamforming Based on Bandwidth-Constrained Feedback", IEEE Transaction on Communications, Vol. 53, No.3, pp. 526-531, IEEE, March 2005.
[8] Shengli Zhou, Georgios B. Giannakis, "Adaptive Modulation for Multiantenna Transmissions with Channel Mean Feedback", IEEE Transaction on Wireless Communications, Vol. 3, No.5, pp. 1626-1632, IEEE, September 2004.
[9] Tzu-Chun Tang, *Student Member, IEEE*, and Ken-Huang Lin, *Member, IEEE*, "Design of Antenna on Glass Integrated Passive Device for WLAN Applications", IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, VOL. 12,pp. 1204-1207,IEEE 2013.
[10] W.C. Freitas Jr, F.R.P. Cavalcanti, A.L.F. de Almeida, R.R. Lopes, "Exploiting Dimensions of the MIMO Wireless Channel: Multidimensional Link Adaptation", IEEE Conference, vol. 1, pp. 924-928, IEEE, 2005