



## Implementation of a MIMO QAM-OFDM-Based Wireless LAN System

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**ABSTRACT:** In This Paper addresses the performance issue of Orthogonal Frequency Division Multiplexing (OFDM) based WLANs operating in the presence of nonlinear high power amplifiers (HPAs), narrowband interference (NBI) or jammer and channel estimation error in Rayleigh fading channels for Single Input Single Output (SISO) and Multiple Input Multiple Output (MIMO) antennas and channel estimation error. Finally, we propose a new algorithm to minimize the nonlinear distortion introduced by nonlinear HPAs and a new receiver structure that offers superior performance in fading channels. The performance of a SISO-OFDM system which is impaired by nonlinear HPAs, NBI and channel estimation error is significantly improved when the proposed scheme is deployed. In addition to analytical models that are under study to an IEEE 802.11n WALN system and present both theoretical and simulation results.

**Keywords:** Rayleigh fading, Multiple Input Multiple Output, IEEE 802.11n WALN

### I. INTRODUCTION

In this paper, we propose an efficient method for MIMO-OFDM system with two-transmit and two-receive (2x2) antennas. The system supports two MIMO-OFDM schemes, SFBC-OFDM and SDM-OFDM, in order to achieve higher performance and throughput. However, symbol detection processes for these two schemes have high computational complexity, In order to reduce the complexity; we propose a cost-efficient algorithm for SDM-OFDM and novel hardware architecture for MIMO-OFDM systems. The proposed system with shared-architecture, where similar functional blocks are merged and share the hardware resources, can be used for not only SDM-OFDM but also SFBC-OFDM systems. The proposed system reduces the logic gates by 54% and the occupation ratio by 12.8% compared to a conventional system employing two individual detectors. Therefore, the proposed system will be a vast contribution to the low complexity design of MIMO-OFDM systems, since the MIMO-OFDM system is one of the largest modules in the systems, in which the low complexity design is a very important issue.

### II. OFDM REVIEW

OFDM can be considered as a special case of Frequency Division Multiplexing (FDM) which has

been used for a long time to carry more than one signal over a telephone line. FDM is a technique that uses different frequency channels to carry the information of different users. Each channel is identified by the center frequency of its transmission. To ensure that the signal of one channel does not overlap with the signal from an adjacent one, guard intervals were added between two different channels. Like FDM, OFDM uses different frequency channels to carry information.

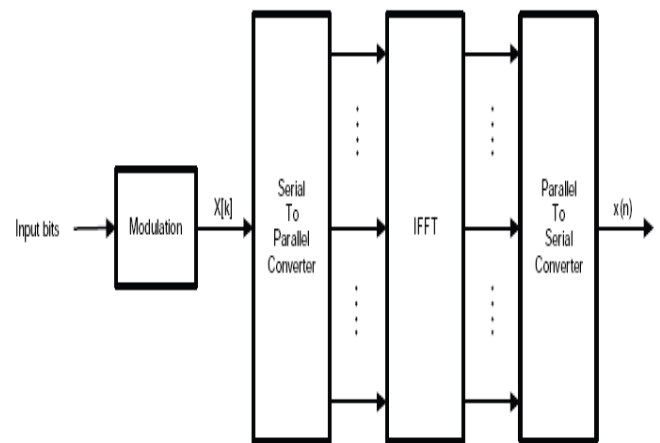


Fig. 1. Simplified OFDM transmitter.

Understand how an OFDM-based wireless communication system operates, one can imagine that the bandwidth of the traditional broadband channel is divided into several orthogonal and narrowband subchannels which are typically referred to as subcarriers in literature. In the frequency spectrum, signals in subcarriers overlap on top of one another in a fashion that when one signal is at its peak value, the values for the other signals in the subcarriers are zero.

### III. OFDM TRANSMITTER AND RECEIVER STRUCTURES

A simplified version of the OFDM transmitter and receiver are presented for the purpose of describing the basic structure of an OFDM system. The OFDM transmitter is shown in Fig. and consists of a modulator, serial to parallel converter, Inverse Fast Fourier Transform (IFFT), and parallel to serial converter.

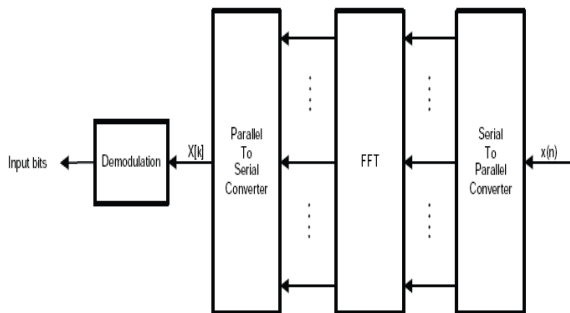


Fig. 2. Simplified OFDM receiver.

The channel model is omitted for now and it will be discussed in more detail later. The receiver which is composed of a serial to parallel converter, Fast Fourier Transform (FFT), parallel to serial converter and demodulation, is shown in Fig. In the absence of the channel, the received signal is what it is being transmitted, namely  $x(n)$ . After receiving  $x(n)$ , the signal is converted into parallel order and processed by FFT. Then it is converted back to serial order. The demodulation process maps the symbols back to bits based on the same mapping that the modulation uses. Assuming there is no noise or distortion imposed on the transmitted signal, the receiver is then able to recover the data perfectly. In most literature, the conversions between serial and parallel formats are often missing from the system block diagrams. The serial and parallel conversion blocks in the system block diagrams within this document will also be omitted and only represented by just a single IFFT or FFT blocks.

#### A. Why OFDM

OFDM has two main advantages over its competitors. One of which is the high bandwidth efficiency.

Another advantage that OFDM has is its robustness against the channel impulse response. In a typical wireless communication system, the transmitted signal is often severely degraded by the channel response. For a traditional single carrier system, the transmitted symbol usually occupies the bandwidth that is almost wide as the channel bandwidth. Within this channel bandwidth, both the magnitude and the phase of the channel impulse response can vary as a function of time depending on the environment. This would create problems since each part of the symbol experiences different gain and phase introduced by the channel response.

#### B. Wireless Local Area Networks

Wireless Communication is an application of science and technology that has come to be vital for modern existence. From the early radio and telephone to current devices such as mobile phones and laptops, accessing the global network has become the most essential and indispensable part of our lifestyle. Wireless communication is an ever developing field, and the future holds many possibilities in this area. One expectation for the future in this field is that, the devices can be developed to support communication with higher data rates and more security. Research in this area suggests that a dominant means of supporting such communication capabilities will be through the use of Wireless LANs. As the deployment of Wireless LAN increases well around the globe, it is increasingly important for us to understand different technologies and to select the most appropriate one. In this chapter we discuss about wireless LAN technologies and the concerned issues, will give a brief description of what wireless LANs are, the need of Wireless LAN, History of wireless LAN, advantages of Wireless Networks, with summarizing the related work on WLAN in academic area, Wireless LAN technologies, some risks attacks against wireless technologies, suggesting some recommendations to protect wireless LAN network from attack, Finally we propose some research issues should be focused on in the future. In a "Distributed" WLAN architecture, you need to reconfigure your access layer with the addition of each new AP. Since it is necessary to configure all virtual LANs (VLANs) on the switch port that is needed by each new AP, your network administrator needs to configure the wiring closet switches that each new AP connects to. For example, you may have a VLAN for guest access, a VLAN for corporate access, and a VLAN for special access (such as VoIP).

All these VLANs must be configured each time you add a new AP. With a “Centralized” WLAN architecture, it is infinitely easier to add APs when we send traffic to controller with Tunnel mode. The access layer is configured once at the handoff to the controller and the system manages the rest. The centralized controller provides rich functionality for automating deployment complexity, eliminating the need for frequent, error-prone changes to the access layer. You simply plug in the AP and it automatically self-configures. Still if we required some AP to be configured for (bridge mode) sending traffic locally in “Centralized” WLAN architecture, those AP’s it is necessary to configure all virtual LANs (VLANs) on the switch port that is needed.

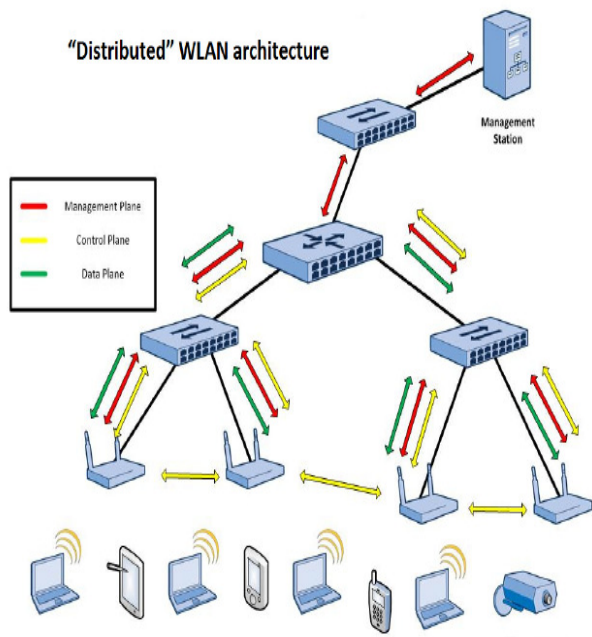


Fig. 3. Architecture of WLAN.

The use of wireless networking has grown rapidly, with organizations and home users extending their wired local area networks (LAN) to include wireless LANs (WLAN). The IEEE 802.11 (Wireless LAN) protocol has allowed for this seamless flow of data between the two types of LANs. WLAN users require the same level of security for their wireless data as they do for their wired LANs. However, wireless networks pose different security problems to wired networks. To gain access to a wired LAN, the attacker has to physically connect to the wired network. Wireless networks broadcast radio waves and an attacker with publicly available tools only has to be within range of the access point to initiate an attack. As attacks on wireless LANs have become more widespread [1], security has evolved from that offered in the original IEEE 802.11 protocol to the IEEE 802.11i protocol which is starting

to become widely used today. The evolution occurred in three main stages: the original IEEE 802.11b protocol, an intermediate stage with Wi-Fi IEEE 802.11i protocol.

In 2000, after successful attacks were demonstrated on the IEEE 802.11 security standard Wireless Equivalent Privacy (WEP) the IEEE and Wi-Fi Alliance commenced the design of the IEEE 802.11i standard which was ratified in 2004 and came into use in 2006. [17]. To offer interim protection, the Wi-Fi Alliance created their own subset of the 802.11i protocol called the Wi-Fi Protected Access (WPA).

#### IV. RESULTS

The random binary the varying data rate. Scatter plots of the received signal before and after equalization. From the plot of the equalized signal, you can tell which modulation type the system is currently using, because the plot resembles a signal constellation of 2, 4, 16, or 64 points. The power spectrum of the received signal before and after equalization, in dB. The dynamics of the signal's spectrum before equalization depend on the Fading mode parameter in the Multipath Channel block. The estimate of the SNR based on the error vector magnitude.

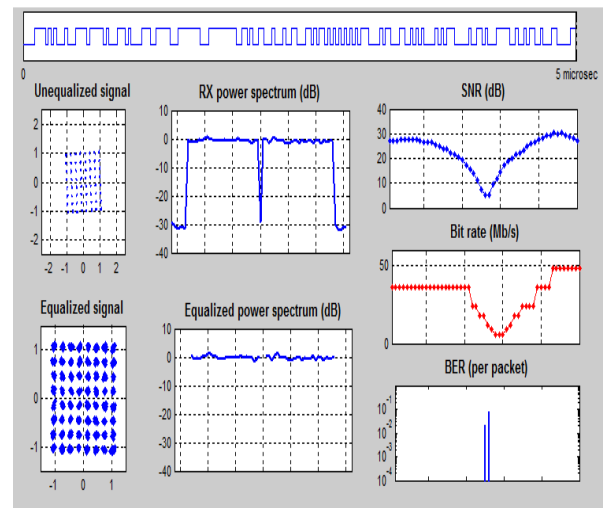


Fig. 4. Results for BPSK Technique.

The bit rate of the transmission, the bit error rate per packet, for most packets, the BER is zero. Because this plot uses a logarithmic scale for the vertical axis, BER values of zero do not appear in the plot. The following blocks display numerical results: The PER block shows the packet error rate as a percentage. The SNR block at the top level of the model shows an estimate of the SNR based on the error vector magnitude.

The SNR block in the Multipath Channel subsystem shows the SNR based on the received signal power. The Bit Rate block shows which of the bit rates specified in the standard is currently in use.

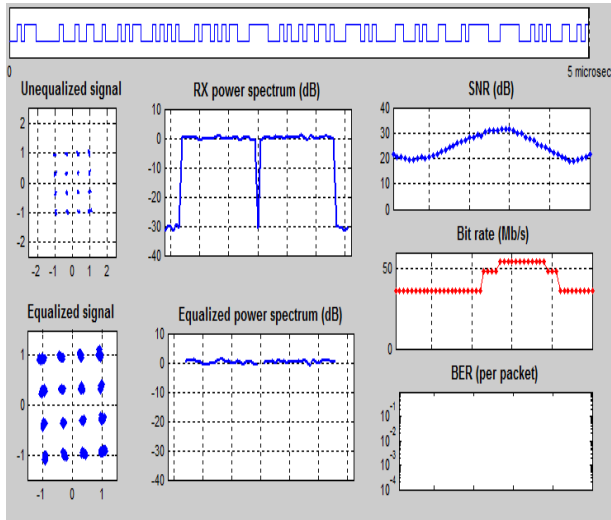


Fig. 5. Results for QPSK Technique.

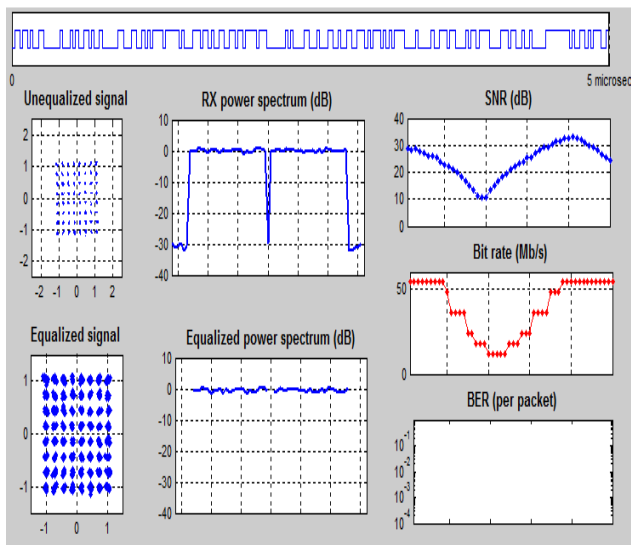


Fig. 6. Results for 16-QAM Technique.

We evaluate the performances of STBC and SFBC with ML decoder at the speed of 30kmph in ITU vehicular B channel. As the solid lines in Figure show, being contrary to STBC that achieves satisfactory performance, SFBC suffers from severe ISI so that it's PER performance presents an error floor. In the channel with large delay spread, the performance degradation of SFBC mainly comes from the ISI due to the frequency selectivity of the channel in a code block. Again, the residual ISI of MMSE decoder results in nearly 32 dB performance degradation of STBC.

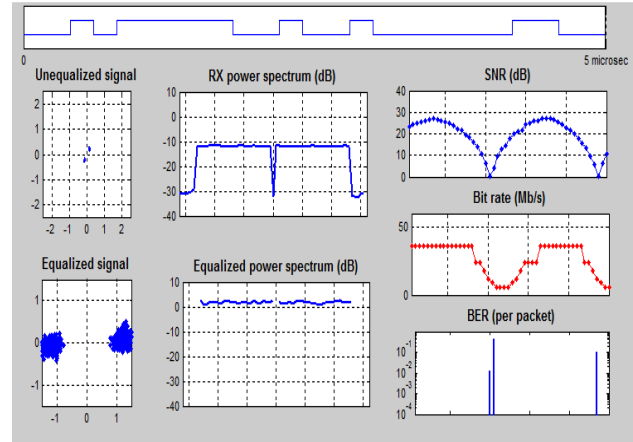


Fig. 7. Results for 64-QAM Technique.

Table 1: Comparison of Results for different Modulation Techniques.

Parameter	BPSK	QPSK	16 QAM	64 QAM
Time Period	5 micro.s ec.	5 micro.se c.	5 micro.se c.	5 micro.s ec.
Unequalized Signal	-1 to +1	-1 to +1	-1 to +1	-
Receiver Power	0 dB	0 dB	0 dB	-10 dB
SNR	30 dB	32 dB	35 dB	29 dB
Equalized Signal	-1 to +1	-1 to +1	-1 to +1	-
Equalized Power Spectrum	0 dB	0 dB	0 dB	0-4 dB
Bit Rate	50 Mbps	55 Mbps	55 Mbps	40 Mbps
BER/Package	$10^{-1}$ to $10^{-2}$	-	-	Up to $10^{-1}$

There are Comparative analyses of the result based on all eight parameter for four modulation techniques. And it is better from the previous work.

## V. CONCLUSION

In this Paper, we first presented the basic concept of Orthogonal Frequency Division Multiplexing (OFDM) and then we discussed briefly about its technical advantages such as superior performance in fading channels and disadvantages which include high peak to average power ratio (PAPR) and high sensitivity to frequency offset and phase noise. Next, we discussed the causes of the nonlinear distortion. The occurrence of the nonlinear distortion is due to the high PAPR in OFDM signals. As mentioned already, the high power amplifiers (HPAs) are often forced to operate in the nonlinear region due to the high PAPR in OFDM signals.

To mathematically demonstrate the effect of nonlinear distortion on the system performance, we presented the performance analysis of a Binary Phase Shift Keying (BPSK) OFDM system that was subject to a nonlinear HPA in the additive white Gaussian noise (AWGN) channel. For the purpose of simulation, all analytical models presented in the thesis were extended to an 802.11n WLAN system based on the IEEE 802.11n specification. By simulating an actual WLAN system, it would provide valuable insights to the performance of a system when it is subject to impairments such as nonlinear HPAs, narrowband interference (NBI), and channel estimation error. Based on simulation results, we found that a partial band jammer who had all its energy concentrated on a single subcarrier caused the most degradation to the performance. However, we also discussed the reasons of why this type of jammer was not practical in real situations. One of the reasons is the partial band jammer did not have perfect knowledge of the center frequency at which the desired signal was being transmitted on. This would lead to the situation where the partial band jammer could only affect the system performance through its inter-carrier interference (ICI) like interference. In addition, the effect of the ICI-like interference on the system performance highly depended on the location of the frequencies of subcarriers in the jamming signal with respect to the desired signal in the frequency spectrum. The further away the partial band jammer was, the less effective the ICI-like interference on the system performance. Another reason was that the system could simply turn off the subcarrier's frequency if the partial band jammer appeared within the frequency spectrum of the transmitted signal. In which case, the performance could improve slightly at the cost of loss in data rate. Following the conventional approach, the unconditional bit error rate (BER) was often obtained by integrating the conditional BER expression over a joint probability density function (PDF) of the magnitudes of the channel, its estimate and the phase difference between them. This inevitably led to the calculation of a triple integral. To facilitate the process of obtaining BER expression, we made use of the channel estimation error model. By utilizing the proposed channel estimation error model, we were able to simplify the BER expression from a triple integral to a single integral. Performance Analysis of MIMO-OFDM Systems:

- a) We extend our work to include the situations where OFDM systems have multiple transmit antennas, more specifically, an OFDM system that has two transmit antennas and one receive antenna.
- b) The MIMO-OFDM systems are subject to impairments such as nonlinear HPAs, jammer, and channel estimation error.
- c) In performance analysis, we utilize the proposed jammer model which is more practical compared to other models that are studied in literature.
- d) The analytical model is extended to a WLAN system based on the IEEE 802.11n standard and the simulation results are validated by the theoretical analysis for various combinations of impairments.

Next, we introduced the concepts of multiple input multiple output (MIMO) and Space Time Block Code (STBC). In addition, we presented performance analysis of an M-QAM MIMO OFDM for two and four transmit antennas with one receiver antenna with and without the normalization in the total transmit power. Based on the conventional approach and under the assumption of perfect channel estimation, the BER expression for two transmit antennas was a sum of three double integrals while it was sums of three quadruple integrals for the case of four transmit antennas. To simplify the BER expressions, we represented the Q function in its alternative form. Through mathematical simplification, we were able to reduce the complexity of the BER expressions for both two and four transmit antennas to a sum of three single integrals.

## VI. FUTURE WORK

One thing that was not done in this project was to monitor the WLAN traffic. This should be done if the company decides to expand their WLAN. By doing so, it would be possible to see where and when the capacity is insufficient. There might be a need for more APs or to upgrade the existing APs to a later standard, such as IEEE 802.11n. With an increasing number of mobile devices in the office, the company might want to make changes in the security of their guest WLAN. When such a WLAN is open, as it is today, it could be vulnerable to security attacks; hence this traffic might be separate from the other traffic in the office and given only a limited throughput.

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