International Journal of Innovations in Engineering and Technology (IJIET)
http://dx.doi.org/10.21172/ijiet.102.30

Implementation of MIMO-OFDM System Based on MATLAB

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Abstract- MIMO-OFDM forms the basis of 3G/4G technology. Massive MIMO is considered as core technology in 5G. In this project, a multi-path Rayleigh fading channel environment is introduced. Then Multiple input multiple output (MIMO) and orthogonal frequency division multiplexing (OFDM) are individually implemented and their characteristics are studied. An environment to simulate a combined MIMO-OFDM system using space time block coding (STBC) is constructed using MATLAB. The results of 2x2 and 4x4 MIMO-OFDM system are compared and analysed with the system performance parameters such as signal to noise ratio and bit error rate.
Keywords – Wireless communication, MIMO-OFDM, Channel modelling, Channel simulation

I. INTRODUCTION

Generally, it is considered that multiple input multiple output and orthogonal frequency division multiplexing (MIMO-OFDM) technology is the absolutely necessary space interface technology for beyond the third or fourth generation mobile communication system. For beyond 3G/4G, there exist two severe challenges: the multi-path fading and the bandwidth efficiency. OFDM can effectively resist the multi-path fading, but advantages on bandwidth efficiency is limited.

Using MIMO can effectively improve the wireless channel volume and the bandwidth efficiency without increasing bandwidth and no antenna transmitting power. At a certain extent, the multipath portions are partially used in MIMO, that is, MIMO system can resist the multipath fading but is lack of advantage for frequency selective fading. Today, two methods are used to deal the frequency selective fading in MIMO systems: using the equalization techniques or using the OFDM techniques. So, MIMO combined with OFDM is the more widely used. MIMO-OFDM can provide higher data sending rate than the single one. It is not practical to collect the MIMO-OFDM channel parameters completely by field testing under various environmental conditions. So, it is necessary to build a virtual transmitting environment by simulation tools so as to obtain the system channel parameters in real applications.

II. CHANNEL ESTABLISHMENT

A channel estimation block is useful for modelling the mobile wireless communication system. In order to study the changes a signal undergoes when it is sent into the channel, we must establish a channel and specify its parameters. In our study, we are studying the changes the signal undergoes when it is sent through a Rayleigh fading channel. Rayleigh fading is caused by multipath reception. A signal propagates in multipath once it is transmitted. Rayleigh channel accounts for all the objects in the environment that scatter the radio signal before it reaches the receiver. All the scattered radio signals interfere constructively or destructively at the receiver. This results in fading. The deep fade points in the graph are the points where the signal information is completely lost. Additional white Gaussian noise is also added to the channel. There is often movement of the transmitter or the receiver which may cause a change in the path lengths and the signal level will vary. Hence Doppler shift is also incorporated in the characteristics of the channel.

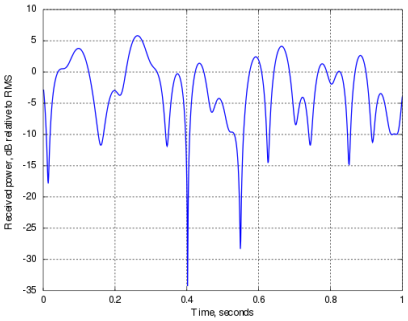

Figure 1. Fading

III.OFDM

Orthogonal frequency division multiplexing is a method of encoding digital data on multiple carrier frequencies, which are orthogonal to each other. In multipath channel, most conventional modulation techniques are sensitive to inter symbol interference. Fading is also another major problem that is encountered in multipath communication. OFDM is the solution to both these problems. OFDM is significantly less sensitive to inter symbol interference and it also helps reduce signal fading by a significant margin.

Orthogonal frequency division multiplexing is a method of digital signal modulation in which a single data stream is split across several separate narrowband channels at different frequencies to reduce inter symbol interference and crosstalk. The original data stream that in a conventional single-channel modulation scheme would be sent serially are transmitted in parallel but at lower speed in each sub stream relative to the original signal. This means that the symbols that are sent in sub stream are longer and spaced further apart.

Cyclic prefixing refers to the prefixing of a symbol, with a repetition of the end. OFDM makes use of cyclic prefixes to combat multipath by making channel estimation less complex. The cyclic prefix is created so that each OFDM symbol is preceded by a copy of the end part of that same symbol. The addition of the cyclic prefix adds robustness to the OFDM signal. The guard interval introduced by the addition of cyclic prefix to the system enables the effects of inter-symbol interference to be reduced. The cyclic prefix turns the linear convolution with the channel into a circular convolution. This enables us to use the single-tap equalization OFDM is so famous for.

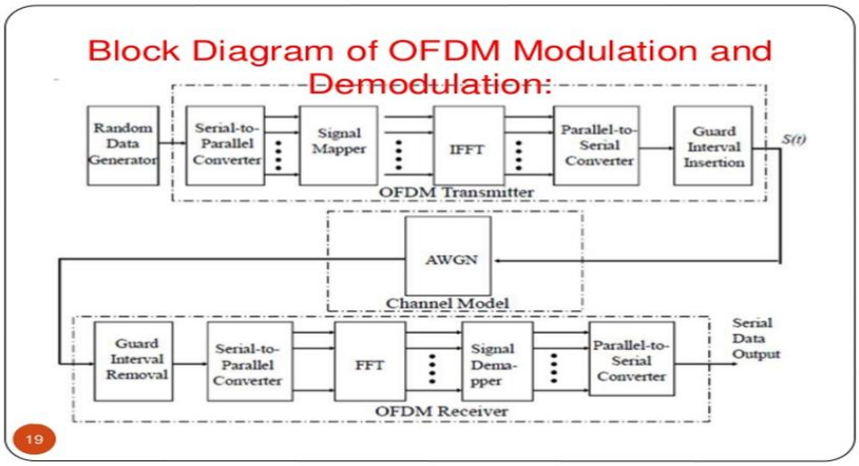

Figure 2.Block Diagram of OFDM

IV. MIMO

MIMO (Multiple Input Multiple Output) is a antenna technology in wireless communication. In this technology, various antennas are placed at the transmitter as well as on the receiver side. Signal from each antenna from the transmitter side reaches each antenna on the receiver side as shown in the below figure.

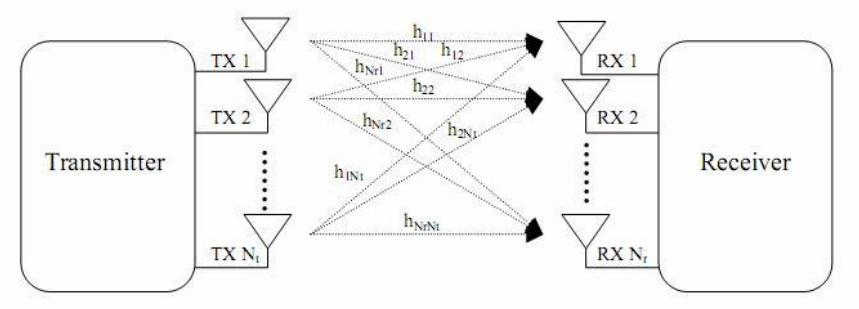

Figure 3. Block Diagram of MIMO

Let us consider an example of 2x2 MIMO,

n(1)= m(1)*h11 + m(2)*h21

n(2)= m(1)*h12 + m(2)*h22

Here n is Rx term, m is Tx. term and h is channel coefficient.
MIMO technology involves two concepts, they are spatial multiplexing and spatial diversity. The performance of a communication system is improved by using the above two concepts and reducing the multipath effect.
(1) Spatial Multiplexing is a concept which involves transmission of multiple data streams over multiple antennas. It is similar to frequency division multiplexing and time division multiplexing where data is transmitted over different spatial channels rather than different frequency or time slots.
(2) Spatial Diversity: The concept of diversity has already been introduced. Spatial diversity is a concept which involves transmission of the same data stream over different paths over the channel.

V. MIMO-OFDM USING STBC

Before understanding STBC (Space Time Block Coding), let us understand what is alamouti coding. This coding technique was one of the first to be introduced. One main advantage of this coding technique is that it requires only channel state information(CSI) at Rx end whereas other coding techniques involve CSI at both Rx and Tx. But it had certain limitations such as it worked only for cases where there are only two Tx antennas involved. Hence there was the introduction of Space time block coding.
Let us consider a space-time encoded communication system. In the below block diagram, the 'k' information bits are undergone error coding and introducing redundancy which results in n symbols (n>k). These codewords which are modulated are mapped onto different antennas using the space time encoder. Here, Nt corresponds to space dimension and p corresponds to symbol period over time dimension.

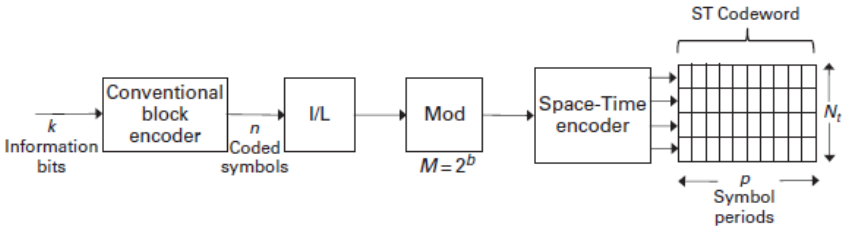

Figure 4. STBC Block Diagram

Multiple Input Multiple output(MIMO)-Orthogonal Frequency Division Multiplexing(OFDM) combination is part of advanced wireless communication technologies for 4G and 5G standards used in LANs (Local Area Networks) and mobile devices. It has various advantages because of the combination of MIMO and OFDM. It multiplies the capacity as MIMO technology is used in which multiple signals are transmitted over the channel and delivers high data rates as OFDM technology divides the channel into sub channels which are orthogonal to each other. It has high spectral efficiency even when there is no channel state information (CSI) employed.
Latest improvements in MIMO-OFDM are Multi-user MIMO, Massive MIMO which are employed in 5G technology.

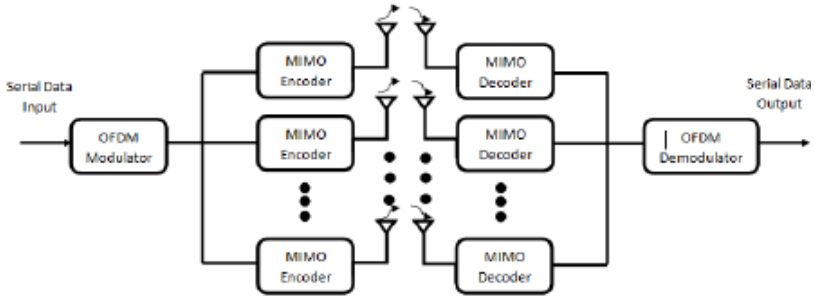

Figure 5. MIMO-OFDM Block Diagram

Serial Data is given to the OFDM Modulator and then the signal is transmitted over each antenna using the MIMO encoder with STBC coding. Rayleigh channel with AWGN is set up through which signal travels. At the receiver

side, MIMO decoders are used at each receiving antenna and one transmitted signal is taken to demodulate using the OFDM demodulator and the original data is obtained.

VI. SIMULATION RESULTS

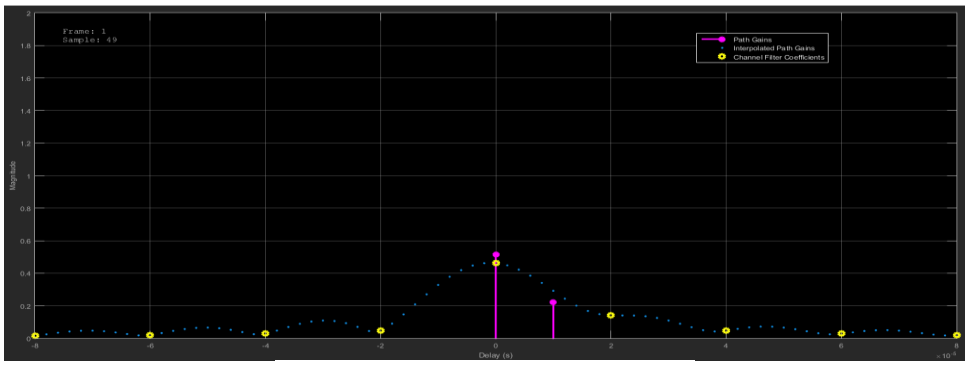

Figure 6. Rayleigh Channel for SNR=1

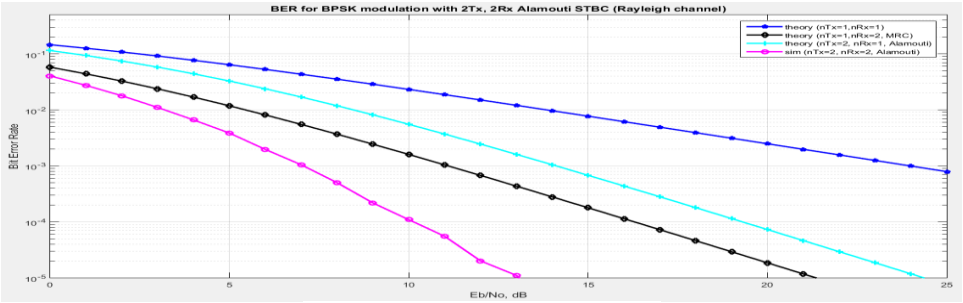

Figure 7.BER vs SNR for MIMO

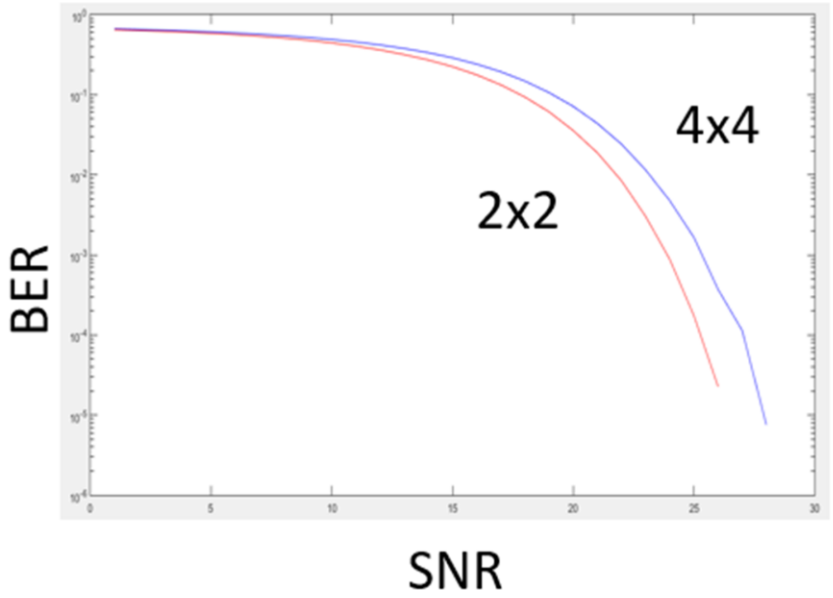

Figure 8.BER vs SNR for MIMO-OFDM

VI. CONCLUSION

Based on summing up the work of our predecessors, we brings forward a simple MIMO-OFDM wireless communication system. The system structure is very simple and it is simulated by matlab. The experiment results show that the system has good performance when there are more antennas especially the number of the receiver antennas is greater than that of the transmitter antennas and the other conditions are the same. But, the increase of the carrier number can decrease the system performance because of the interference between each sub-carrier. Future scope of MIMO-OFDM is multi-user MIMO, Massive MIMO. Also, 2x2 or 4x4 MIMO can be extended to NxN MIMO.

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