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Data transmission and reception in mimo-ofdm system using 16-qam technique

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Abstract
In this paper MIMO (Multiple Input Multiple Output) configuration provides enhanced capacity with the same transmit power. OFDM (Orthogonal Frequency Division Multiplexing) is a multicarrier technique that offers high spectral efficiency. OFDM combined with MIMO offers increased reliable high data rate transmission, multiplexing gain, diversity gain, improve the link, system capacity and frequency variant over broadband wireless channels. MIMO- OFDM configuration is found to perform better against multi-path fading and the varying channel conditions, interferences, than the conventional technologies. In this paper, the channel estimation & BER performance of a MIMO-OFDM are evaluated on the basis of error reduction and better system designing using popular IFFT/FFT & 16-QAM modulation formats. The final performance of the system with different parameters is tested by using MATLAB code word.

Keywords: MIMO-OFDM, 16-QAM, IFFT/FFT, BER, SNR

1. Introduction

The MIMO-OFDM system is the combination of the MIMO technique and OFDM technique, which is enhancing the capacity, improve the link reliability high data rate transmission also can provide robustness against frequency-selective and time-variant channels, and obtained spatial multiplexing gain & diversity gain for future broadband wireless communication and also use for avoid Inter Symbol Interference (ISI) & Inter Carrier Interference (ICI). A comparison is made between the presented estimation techniques, showing the advantages and disadvantages of each one. The main objective of this paper is to present an analysis for channel estimation & BER estimation against different challenges of wireless communication system. It also minimize transmission power required (translates to SNR), and minimize bandwidth (frequency spectrum) used. MIMO is an important part of modern wireless communication standards such as IEEE 802.11n (Wi-Fi), 4G, 3GPP Long Term Evolution, WiMAX and HSPA+ [3].

This paper is organized as follows: section II & III provides fundamental idea of MIMO & OFDM techniques, respectively. Section IV presents modulation methods to perform faster transmission in MIMO-OFDM system. Then, in section V, the simulation results are presented. Finally, in section VI brings final conclusion of this paper and at last paper references are given.

2. MIMO-OFDM System

The high growth and demand of Multimedia application services and growth of contents of wireless application lead to increasing interest to high speed communication. Multiple input and multi output (MIMO) system are today considered as one of most important research area of wireless communication. In the case of MIMO system capacity increase and BER reduces. Channel capacity is defined as the maximum rate at which data can be transmitted with small error probability [5]. Here we uses different technique like spatial multiplexing, diversity process & quality of design process to full fill the need of modern digital wireless communication technique.

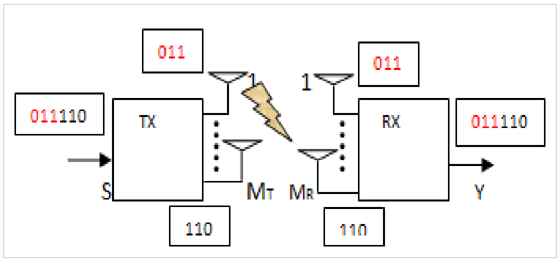

Fig. 1: Block diagram of a MIMO system.

From the above diagram MIMO systems use multiple antennas in the transmitter and receiver sides. The signals are sent by transmitter antennas are received by the receiver antennas and then combined, in order to achieve a reduction of error or a increasing of capacity of the system. Mathematically, if a signal $S_j(t)$ is transmitted from the j[th] transmitted antenna, the signal receive at the i[th] receive antenna. The input output relation is given by [2],

$$y_i(t) = \sum_{j=1}^{M_T} h_{i,j}\, S_j(t),\ i = 1, 2, \dots M_R \qquad (1)$$

Here we take M_T transmit and M_R receive antennas with input data stream is S and output data stream is Y. MIMO has higher capacity as compare to other system..The MIMO capacity is given by,

$$C = M_t M_r B log_2(1 + S/N) \qquad (2)$$

Where C is known as capacity, B is known as bandwidth, S/N is known as signal to noise ratio. M_t is the number of antennas used at the transmitter side & M_r is the number of antennas used at receiver side.

3. OFDM System Model

OFDM (Orthogonal Frequency Division Multiplexing) is becoming a very popular multi-carrier modulation technique for transmission of signals over wireless channels. OFDM divides the high-rate stream into parallel lower rate data (N number) and hence prolongs the symbol duration, thus helping to eliminate Inter Symbol Interference (ISI). It also allows the bandwidth of subcarriers to overlap without Inter Carrier Interference (ICI) as long as the modulated carriers are orthogonal. OFDM therefore is considered as an efficient modulation technique for broadband access in a very dispersive environment. OFDM has developed into a popular scheme for wideband digital communication, whether wireless or over copper wires, used in applications such as digital television and audio broadcasting, DSL Internet access, wireless networks, power-line networks, and 4G mobile communications [7, 9].

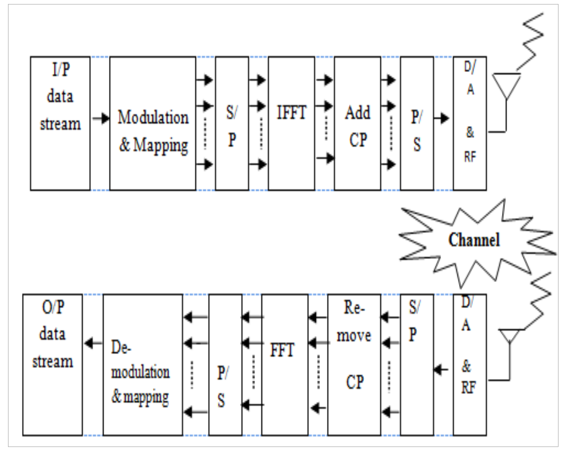

Fig. 2: Block diagram of an OFDM system.

In this system, a multicarrier system implemented using an inverse FFT to act as a modulator and an FFT to act as a de-modulator. The subcarriers are individually demodulated and the transmitted symbols are separated by a time guard interval with cyclic prefix that improves the performance of the system. The addition of this extra interval is performed by copying the end of the OFDM symbol at its beginning. The purpose of the guard interval is to avoid ISI and provide robustness against multipath channels. Due to the multipath channel, each OFDM subcarrier is affected by attenuation and a phase rotation. To receive the symbol correctly, the receiver must be able to estimate the channel frequency response.

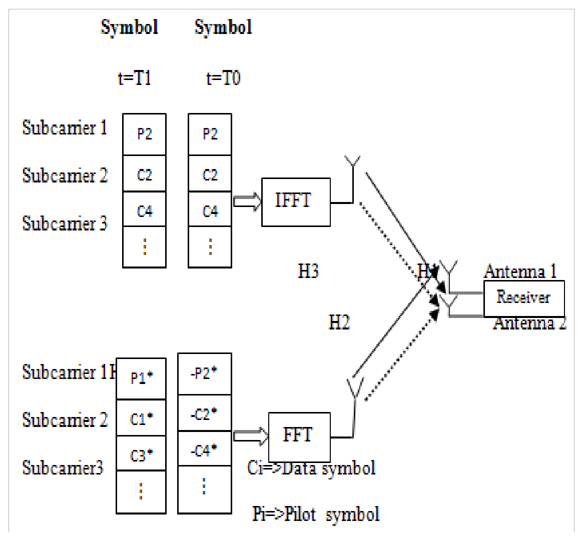

Fig. 3: Channel estimation for MIMO-OFDM systems

4. Modulation Technique

In BPSK modulation the phase of carrier is modulated according to the modulating signal. It has one fixed phase when the data is at one level, the phase is different by 180 degree. At the receiver side exact signal is recovered by the help of de-modulation technique [6].

By allowing the amplitude to vary with the phase, a new modulation scheme called Quadrature amplitude modulation (QAM), which is both an analog and digital modulation technique. It conveys two analog message signals, or two digital bit streams, by modulating the amplitudes of two carrier waves, using the amplitude-shift keying (ASK) digital

modulation technique or amplitude modulation (AM) analog modulation technique. The advantage of using QAM is that it is a higher order form of modulation and as a result it is able to carry more bits of information per symbol, given in table 1. A 16-QAM constellation diagram is given in figure 6 & 7 [1].
The transmitted M-ary QAM symbol i can be expressed as

$$S_i(t) = \sqrt{2/T_s} * a_n * cos(2\pi * fc) - \sqrt{2/T_s} * b_n * cos(2\pi * fc) \quad (3)$$

Where $i = 1,2, \dots \dots \dots M$ & $0 < t < T_s$
Where a_n and b_n are amplitudes taking on the values and

$$a_n, b_n = \pm a, \pm 3a, \dots \dots \dots \pm (log_2 * M-1)a \quad (4)$$

Where M is assumed to be a power of 4 for M-QAM modulation.
The parameter $'a'$ can be related to the average signal energy (E_s) is given by

$$a = \sqrt{\frac{3E_s}{2}} * (M-1) \quad (5)$$

Table 1: Bits rate and different form of QAM and PSK

Sl. No.	**Modulation**	**Bits per symbol**	**Symbol rate**
1.	BPSK	1	1*bit rate
2.	QPSK	2	1/2 bit rate
3.	8PSK	3	1/3 bit rate
4.	16QAM	4	1/4 bit rate
5.	32QAM	5	1/5 bit rate

5. Simulation Results and Discussion

The capacity of MIMO system is given by the formula as [10],

$$C = M_t M_r B log_2(1 + S/N). \quad (6)$$

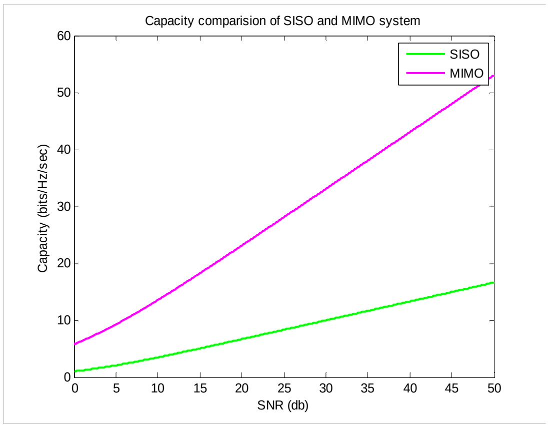

Fig. 4: Capacity vs. SNR for SISO/MIMO system.

From the above figure MIMO system has greater capacity as compare to SISO system for wireless communication.
The figure 5 shows that total 216 numbers of modulated & mapped bits are transmitted and received in MIMO-OFDM system and all parameters value are used in Matlab code is given in table 2.

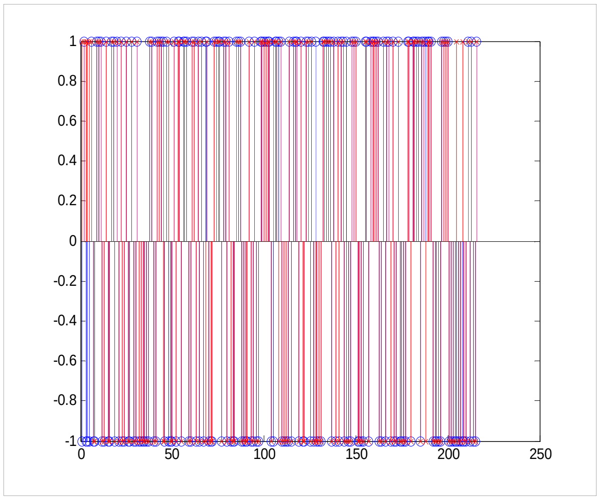

Fig. 5: Total numbers of bit transmitted & received in MIMO-OFDM system

Table 2: Parameters used for MIMO-OFDM system

Sl. No.	Parameter name	Description
1	No. of Channels	4
2	No. of Carriers	4
3	Bits/channel	54
4	Transmitted bits(n)	216
5	IFFT frame	4
6	SNR(BPSK)	40db
7	SNR(QAM)	20db

The bit error rate comparison analysis is given in table number 3, which shows that QAM technique has less error for MIMO-OFDM system [4, 6].

Table 3: BER comparison between BPSK & QAM

Sl. No.	No. of Channels	Modulation	BER
1	4	BPSK	0.0309
2	6	BPSK	0.0648
3	4	QAM	0.00012

The below figure 6 shows that the QAM binary symbol mapping with M=16 order.

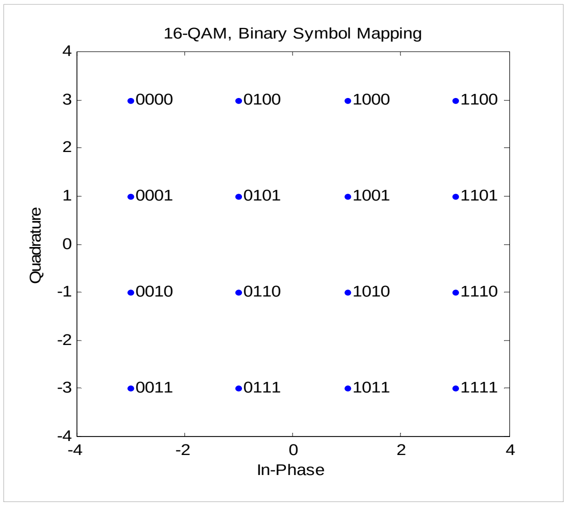

Fig. 6: Binary symbol mapping of 16-QAM

The below figure 7 shows that the 16-QAM circular type constellation diagram. Where orange dot indicates transmitted signal and blue dots indicates received signals [8].

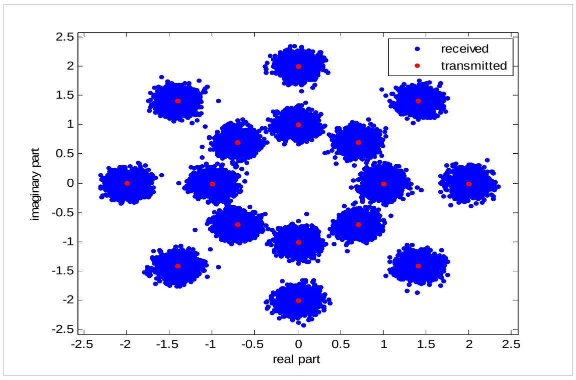

Fig. 7: Constellation diagram of 16-QAM

6. Conclusion

In this paper, we present and simulated data rate transmission, reception and performance of MIMO-OFDM system using modulation technique (16-QAM). At first we analyze that the multi input multi output is a very attractive technique for Multicarrier high data transmission process in multipath fading system, given in figure 4 and binary symbol mapping is given in figure 6. By the help of IFFT/FFT & 16-QAM type modulation technique we achieve faster computation, high datarates and for long distance transmission with BER=0.00012 and SNR=20dB as compare to IFFT/FFT-BPSK modulation technique with BER=0.0648 for 4 number of channels, which is given in Table 3 and figure 5. By selecting a higher order format of QAM, the data rate of link can be increased.

7. References

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