A SURVEY ON MIMO OFDM WITH ADVANCED INDEX MODULATION

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Abstract: With increasing demand of high data rate applications at low cost wireless communication is key area of research the solution to this problem is OFDM (Orthogonal Frequency Division Multiplexing).to exploit an additional new dimension in OFDM frame coming from the state of each sub carrier – active or inactive a novel approach is used. This additional information is employed to transmit information in an on off keying (OOK) fashion. This survey provides a proposition for advanced scheme which solves the issue of Bit Error Propagation and reduction in PAPR (Peak to Average Power Ratio), reduced complexity, increases number of users to get access by reducing the bandwidth which comes from the new enhanced structure of IM- OFDM (Index Modulation).

***Index Terms* - Advanced Index Modulation, OFDM, QAM & MIMO.**

I. INTRODUCTION

IM-OFDM is a modification of the classical OFDM modulation scheme. Different frequency carriers are modulated with a signal from a scheme as a QAM (Quadrature Amplitude Modulation) in OFDM. To exploit an additional new dimension in OFDM frame coming from the state of each subcarrier-active or inactive a novel approach is used. This additional dimension is employed to transmit information in an on off keying (OOK) fashion. "To optimize power usage which is crucial in the current climate of green communication system" this is the motivation behind the new concept. Each active carrier receives the energy of an M-QAM symbol and energy of additional bit encoded in OOK fashion, thus performance of individual QAM and OOK is improved [1].
The same paper reports that IM-OFDM has ability to outperform the traditional OFDM modulation scheme in terms of BER (Bit Error Rate). In presence of additive white Gaussian noise (AWGN), IM-OFDM suffers from bit error propagation. This survey provides a proposition for a modified scheme which solves the issue of bit error propagation and reduction in PAPR, reduced complexity, increased number of users to access by reducing the bandwidth which comes from the new enhanced structure of IM-OFDM. In this paper we are considering the system model as proposed in previous works [1, 2].We provide this survey analysis of a given system using enhanced index modulation to reduce bit error propagation complexity of the system. The rest of the paper is organized as follows: in section 2, we illustrate the IM-OFDM for MIMO system. In section 3, we discussed advanced index modulation. In section 4, we present PAPR for a given system. Finally section 5 concludes the letter.

II. MIMO OFDM-IM

It employs T transmitter and R receive antennas. A total mT information bits enter the MIMO OFDM IM. These empty bits are split into T groups and m bits are processed in each branch of transmitter by OFDM IM modulation. This m bits are used to form Nf*1 OFDM IM block t=1, 2…T. in each branch of transmitter, where Nf is the size of fast Fourier transform (FFT).According to principle of OFDM IM, these m bits are split into n groups each containing p=p1+p2 bits which are used to form of OFDM IM sub blocks.[2] The SIM-OFDM carrier modulation scheme is given below.

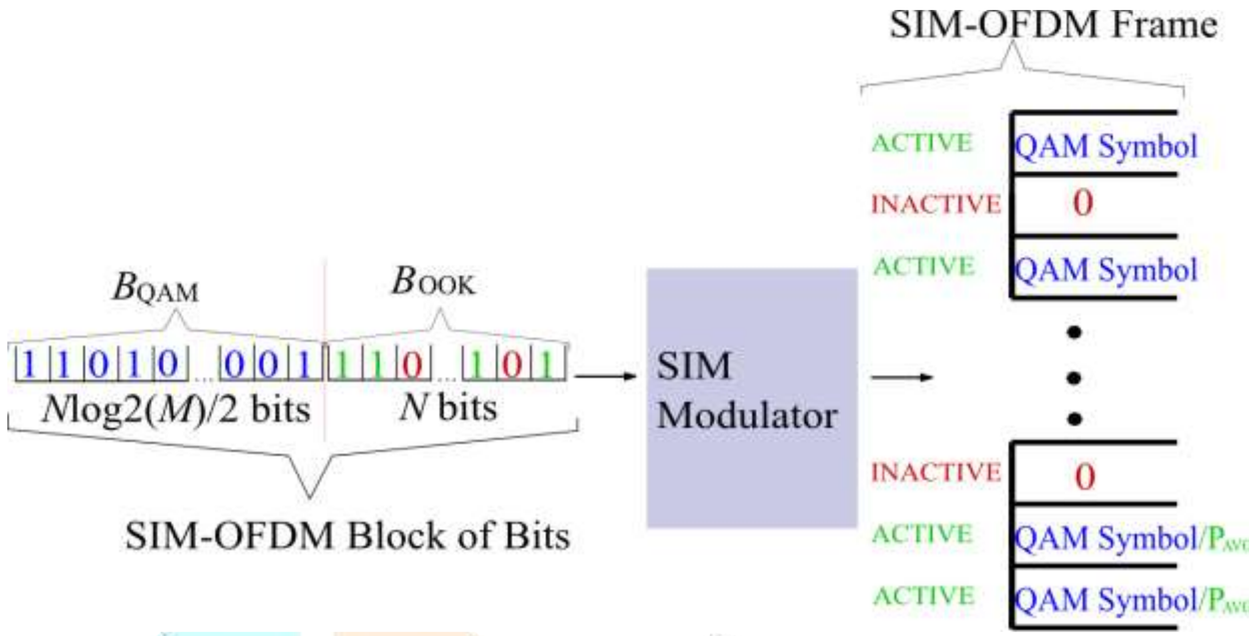

Fig1: SIM –OFDM carrier modulation scheme. Assumptions for this example are that 1 is majority bit in Book.

The functionality of this module can be summarized in two main functions. Firstly based on bit valve of each bit the subcarrier index modulator forms two sub sets from Book (ones and zeros). By comparing the cardinality of these subsets the type of majority bit value can be determined and these majority bits are set as a active and rest will be set as inactive. The amplitude values for first N/2 active carriers will be given to M-QAM constellation symbols necessary to encode BQAM. This is followed by N point inverse fast Fourier transform (IFFT) in order to obtain time domain signal. At receiver side the signal is transferred through FFT as in traditional OFDM then all subcarriers are inspected. Those subcarriers whose power is above certain threshold are marked as active and rest is marked as inactive. Then Book is reconstructed from detected states of carrier and N/2 active carriers are demodulated according to M-QAM scheme in order to reconstruct BQAM.

Two issues which limits the performance of this index modulation is first OOK detector at destination requires the usage of threshold and second an incorrect detection of carrier state not only leads to incorrect demodulation of M-QAM symbol it encodes, but also to incorrect demodulation of all subsequent QAM symbols. It creates the biggest impact on BER performance. That's why it becomes necessary, not only to detect it's carrier as active but also to have detected any previous carriers- active or inactive correctly & as the total number of carriers N increases this issue becomes worse. The main contribution to this paper is a solution to these problems [1].

III. ADVANCED INDEX MODULATION

In order to limit these effects a slight modification has been done in the way of Book. It can be encoded in the States of two consecutive carriers -a carrier pair, instead of each bit from Book being encoded in single carrier state. Figure 2 shows the principle of new encoding scheme. For 1, the first carrier of the pair is set to active and second one as passive and for "0" in Book, the first carrier of pair is set as passive and second one as active. Thus the size for Book, which can be represented by carrier states, is N/2 that is half the size than in original IM-OFDM scheme.

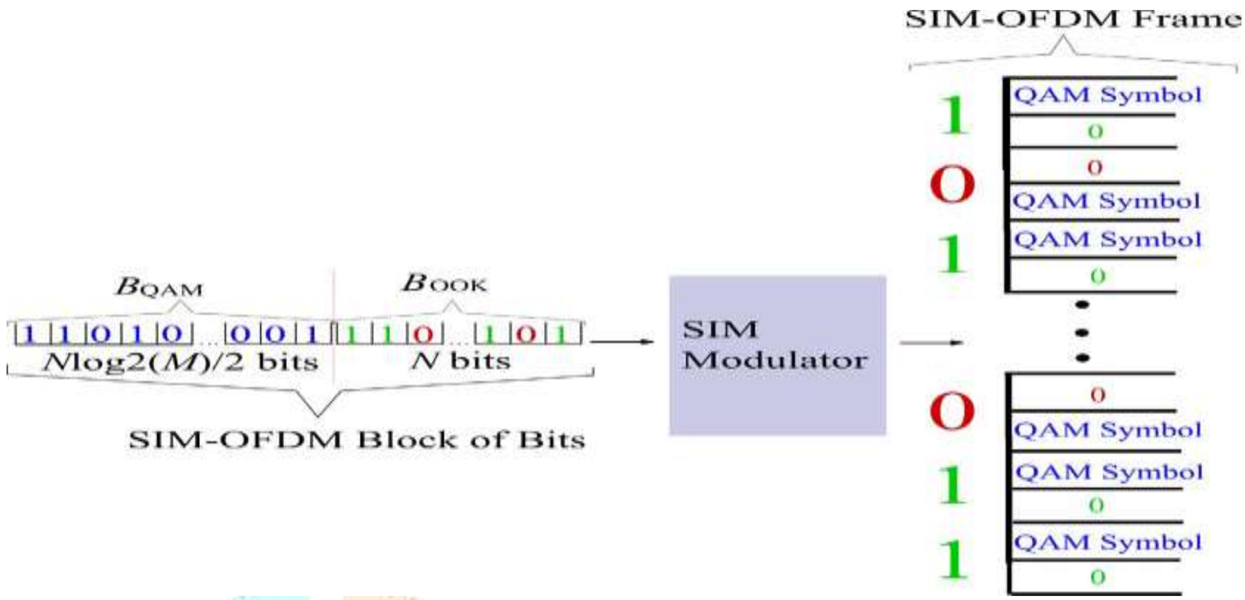

Fig2: Modified SIM-OFDM modulation approach.

The benefit is that for each pair it is certain that exactly one of the carriers is active. It means that no longer misplaced of bits due to wrong detection of previous subcarrier states. And no need to define a majority bit in Book and total no of active carriers is always the same. As we know the number of active carriers within each pair is known and it is always 1.so there is no need to use threshold for OOK.

Instead the carrier with higher power can be recognized as active which would lead to better performance in the carrier state detection. The disadvantage of modified scheme is that, it has slightly reduced spectral efficiency of IM-OFDM measured in bits/carrier is

$$\eta_{AIM-OFDM}^{old} = \frac{log_2(M)}{2} + 1 \qquad (3.1)$$

While spectral efficiency of modified IM-OFDM is

$$\eta_{AIM-OFDM}^{new} = \frac{log_2(M)}{2} + \frac{1}{2} \qquad (3.2)$$

If number of sub carriers in the block is L and the no. of active carriers within the block in La, a general expression for the spectral efficiency becomes

$$\eta_{AIM-OFDM}^{genral} = \frac{La*log_2(M)}{L} + \frac{log_2\left|\frac{L!}{La!(L-La)!}\right|}{L} \qquad (3.3)$$

If La is chosen to be close to L, the system gets closer to conventional OFDM. If L is chosen to close to N and La approaches 1 the system starts to resemble PPM. As L approaches N/2, the system gets closer to original IM-OFDM. The BER performance of the system can be calculated based on detection probabilities. The bit from Book which they encode is in error when the carrier states are incorrectly determined. That bit amounts to $\frac{1}{log_2(m)+1}$ part of all the bits encoded in a carrier pair. Hence the BER contribution of Book is expressed as

$$BER_{Book} = p_0 \frac{1}{log_2(M)+1} \qquad (3.4)$$

IV. . PEAK TO AVERAGE POWER RATIO

Conventional OFDM modulation suffers from high PAPR. The structure of modified IM-OFDM frame leads to reduction of PAPR, which is highly beneficial especially in the context of optical wireless systems where power is limited by eye safety regulations. PAPR is defined as the ratio of the maximum achievable power at any point in time Pmax and average power of the signal Pavg.

$$\text{PAPR} = \frac{P_{MAX}}{P_{AVG}} \qquad (4.1)$$

$$\text{PAPR} = \frac{P_{MAX}}{P_{AVG}} = \frac{3Na\,(\sqrt{M}-1)^2}{M-1} = \frac{3Na(\sqrt{M}-1)}{\sqrt{M}+1} \qquad (4.2)$$

The above equation is generalization for an arbitrary number of active carriers. On both number of active carriers the PAPR depends. And which is expressed as Na and the way they are modulated expressed by the ratio $\frac{3(\sqrt{M}-1)}{\sqrt{M}+1}$. The best PAPR is achieved in FSK because Na=1 & there is no carrier modulation.

The main advantage of advanced index modulation over conventional OFDM comes from the fact that it has less active carriers. For example M-QAM advanced index modulation OFDM has half PAPR when compared to M-QAM OFDM for any number of carriers.

V. CONCLUSION

This brief survey on MIMO OFDM with advanced index modulation attempts to illustrate the recent research work that has been done in field. The new scheme demonstrate improvement over conventional OFDM in terms of energy requirement, low PAPR, reduced complexity, increases speed , reduces bandwidth requirements so the more no of users can access the bandwidth. In overall it improves the performance of overall system.

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