Low BER performance using Index Modulation in MIMO OFDM

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Abstract: ***Index modulation in OFDM is a key technology for next generation cellular communications as well as wireless orthogonal frequency division multiplexing (OFDM) is a popular method for high data rate wireless transmission. OFDM may be combined with antenna arrays at the transmitter and receiver to increase the diversity gain and/or to enhance the system capacity on time-variant and frequency-selective channels. The key thought of IM is to utilize the index subcarrier to pass on data to receiver. Therefore index modulation in OFDM with MIMO is proposed as transmission of the multicarrier technique used for 5G system. The principle thought of index modulation is the utilization of the active subcarriers indices in an orthogonal multiplexing system as an extra resource of data. And, it is verified by means of computer simulation that the planned index modulation in OFDM plan accomplishes altogether better performance of bit error rate over established OFDM with multiple antennas for a few distinctive system configuration.***

Keywords—Bit error rate (BER), Index modulation (IM), ***Orthogonal frequency division multiplexing (OFDM), multiple-input multiple-output (MIMO), MIMO-OFDM, 5G networks.***

I.INTRODUCTION

MIMO technology offers a significant increase in data throughput and link range without additional bandwidth or increased transmit power. It achieves this by spreading the same total transmit power over the antennas to achieve an array gain that improves the spectral efficiency (more bits per second per hertz of bandwidth) or to achieve a diversity gain that improves the link reliability (reduced fading). Because of these properties, MIMO is an important part of modern wireless communication standards, such as IEEE 802.11n (Wifi), 4G, 3GPP Long Term Evolution, WiMAX, HSPA+ and – WHDI.

Considering the advantages of OFDM and MIMO transmission techniques, the combination of them unsurprisingly appears as a strong alternative for 5G and beyond wireless networks. MIMO-OFDM IM, which is obtained by the combination of MIMO and OFDM-IM transmission techniques, is a recently proposed high-performance multicarrier transmission technology and can be considered as a possible alternative to classical MIMO-OFDM. In this scheme, each transmit antenna transmits its own OFDM IM frame to boost the data rate and at the receiver side, these frames are separated and demodulated using a novel sequential minimum mean square error (MMSE) detector which considers the statistics of the MMSE filtered received signals. However, since different applications have different error performance and decoding complexity constraints, the design and analysis of different type of detectors remain an open problem for the MIMO-OFDM-IM scheme.

Index modulation in Orthogonal frequency division multiplexing signal is a one of the procedure for carrying multicarrier information which is compared to traditional OFDM. The primary thought of IM is the utilization of the dynamic subcarriers list in multiplexing of orthogonal frequency method as a extra resource of data. Which yield index modulation plan by combining index modulation in OFDM as well as MIMO transmission procedures. The decreased density nature handset structure of the index modulation plan is created and it is demonstrated by means of PC simulation that the proposed plan accomplishes fundamentally better performance of the error execution over earlier methods of different MIMO-OFDM diverse arrangements.

Index modulation is one of the best modulation for the transmission of the multicarrier signals for future generation wireless communication and it can be used in many applications because of its toughness for the selectivity to the frequency .

II.RELATED WORK

In [2], [3], the authors investigated an example of a spatial modulation technique for MIMO systems known as spatial multiplexing (SM). In SM, multiple streams are transmitted simultaneously, each using a dedicated transmit antenna and the received signal is the sum of the transmitted signals propagating the different paths.

In [4], the authors propose a Spatially Adaptive Modulation and Coding (SAMC) scheme which depends on the Post Processing SNR (ppSNR) of the system. The authors have implemented the scheme on a 2X2 MIMO OFDM system. They then use the ppSNR and get the type of AMC to be used. In order to calculate the ppSNR, they require the noise present in the channel. Also they display the number of times a particular modulation scheme is used by the system.

In [5] the authors propose another adaptive modulation scheme. In this paper they have introduced a new coding technique. The algorithm proposed in this paper determines the BER of only redundant bits of every training packet that is transmitted. Thus this algorithm helps to save computational time and system resources.

III.PROPOSED SYSTEM

Figure 1 shows the architecture of proposed system. Our proposed system combined the importance of MIMO with OFDM. It includes following steps:

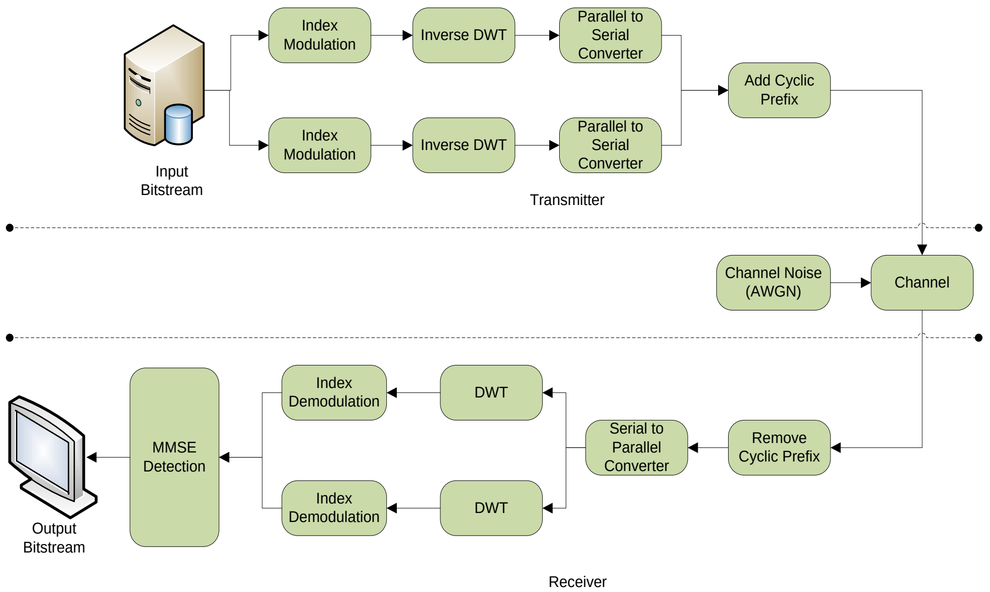

Figure1: Proposed Architecture

a) The program is started and then the input bits are generated randomly

b) The input signals are modulated using index modulation.

The first step in OFDM modulation is subcarrier modulation. One or more bits from the channel coding step are assigned to each subcarrier then modulated using a simple technique such as phase shift keying (PSK) or quadrature amplitude modulation (QAM). The number of bits used for each subcarrier depends on the modulation technique being used

c) Then it is space time block encoded and after that the serial data is converted into parallel data. The Differential Space time codes are ways of transmitting data in wireless communications.

d) The mapped sequences are computed using

- *Discrete Wavelet transmitter and Receiver:*
  In wireless communication interference between the channel and symbol is more in order to avoid such disadvantages and achieve good performance and capacity of the channel high without expanding the bandwidth and get a both time and frequency domain information in detail compared to FFT and DFT, wavelet transform gives better coefficient values of the transmitted signal.
- Once it receives a random signal which carries the information, it adds a pilot signal for synchronization and interleaving of orthogonal frequency division multiplexing of modulation index avoids interference between the symbols so that we can reduce the inter symbol interference as well as inter channel interference. By using this wavelet which has ability to determine frequency component as well as simultaneously location of time. And the implementation of this has two process as decomposition and synthesis process ,uses a filters to obtain a detailed coefficients of the transmitted information to achieve a better data rate.

e) The guard time interval is added and then the parallel data is converted into serial data

f) Add cyclic prefix

ISI in OFDM system can be reduced by using guard intervals of null value but that will disrupt the orthogonality of the subcarriers. So guard space filled with cyclic prefix is used where the last few samples are added to the front of the signal. The symbol period increases from T to T+dT, dT is the guard interval kept less than or equal to T/4, increasing further reduces the frequency spectrum utilization. Information rate reduces and power is lost when CP is inserted as

$$v = 10\log(\frac{T_g}{T} + 1)....(1)$$

Where , T_g is the cyclic guard interval and T data symbol time duration. Addition of cyclic bits leads to the information rate loss as these bits do not carry any information regarding the transmitting message. So as more is the information rate this limits the length of cyclic prefix.

g) AWGN Channel

An Additive White Gaussian Noise (AWGN) channel adds White Gaussian noise to the signal when it is passed through the channel. In the case of white Gaussian noise the values at any pair of times are identically distributed and statistically independent on each other. AWGN channel is not associated with either fading or any other system parameters. It is just the noise that is added to the OFDM modulated signal when it is travelling through the channel. The channel capacity of AWGN Channel is given by

$$C = \frac{1}{2} log\left(1 + \frac{p}{n}\right).....(2)$$

Where C is the channel capacity Performance criteria: minimum mean-square error.

h) Remove the cyclic prefix

i) Then it is obtained at the receiver and the serial data is converted into parallel data

j) The Guard interval is removed and then the DWT is applied to the time domain .

k) Once again the Parallel data is converted into serial data and then it is passed into the Space Time Block Decoder.

l) Index Demodulation process takes place.

m) MMSE detection at receiver end

- *Algorithms on the Receiving Side*

The receive signal consists of the linear overlapping of the transmitted layers. The transmitted information can no longer be directly evaluated. In particular, it is apparent that optimal detection methods are accompanied by rather high computing costs and the number of calculation steps increases significantly with the number of sending and receiving antennas. To reduce these huge computing costs, that is, to be able to implement SM-MIMO systems more efficiently, a sub-optimal detection method has been and is being sought for and worked on. The complexity of the Maximum Likelihood (ML) detector grows exponentially with the size of the signal constellation, and this motivates the use of simpler suboptimum detectors in practical applications.

n)Minimum mean-square error (MMSE) detectors:

Which reduce the combined effect of interference between the parallel channels and additive noise. The MMSE receiver slightly improves the performance of the ZF receiver, but it requires knowledge of the SNR, which can be impractical. Besides, it does not exploit completely the channel diversity either. Decision-feedback receivers, which make a decision on one of the symbols and subtract its interference on the other symbol based on that decision. Sphere detectors, which reduce the number of symbol values used in the ML detector.

Thus, in case signal conditions are excellent, the data rate is doubled, tripled or quadrupled depending on the number of antennas used in both the transmitter and receiver. In practice, spatial multiplexing is often implemented using more receive antennas than transmit antennas (WiFi 11n). In that case, the channel matrix is better conditioned and the performance degradation of suboptimal detectors (ZF, MMSE and Decision-Feedback) is reduced. The first practical realizations of OFDM-based WLAN technique show that MIMO can now be made available to the mass market. It reduces the mean square error of the information as well as reduces ISI ,reduces the noise of the total power .Suppose X be the unknown variable and Y be the known and X^(Y) measurement function of y variable ,then MSE is given by MSE=E {[X^X²]}. As shown in architecture when it receives information of the data stream at the receiver from the index demodulation, and we get the original information which has low rate of the error performance.

IV.RESULTS

In index modulation every active subcarrier carry extra resource of information stream for getting a better error rate of data as well as receives additional energy from subset states. Therefore multi carrier information is efficient using this method for futute generation communication system. As well as compared to earlier methods it requires less energy, power, for transferring data which leads to complexity structure of transceiver is better. From the overall graph it is observed that M-QAM for M=64 bit it provides a better BER performance.

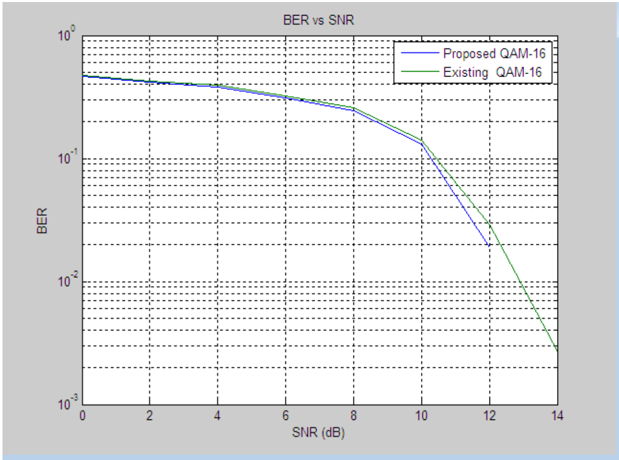

Figure 2: comparison graph of BER vs SNR for proposed OFDM-IM with existing M-QAM where M=16.

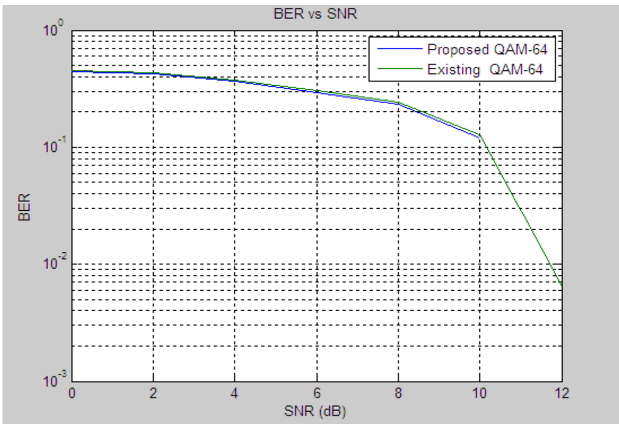

Figure 3: BER vs SNR for proposed OFDM-IM with existing M-QAM where M=64.

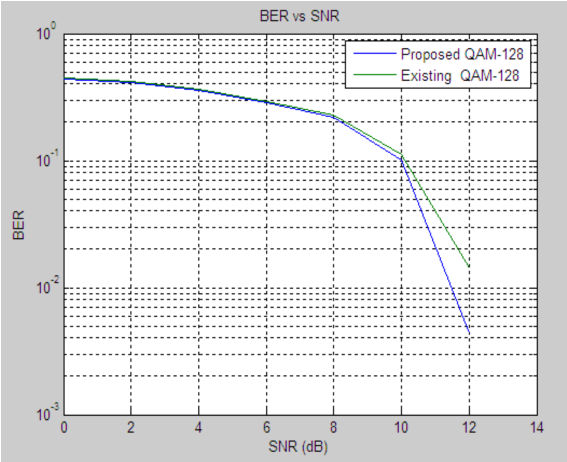

Figure 4:BER vs SNR for proposed OFDM-IM with existing M-QAM where M=128

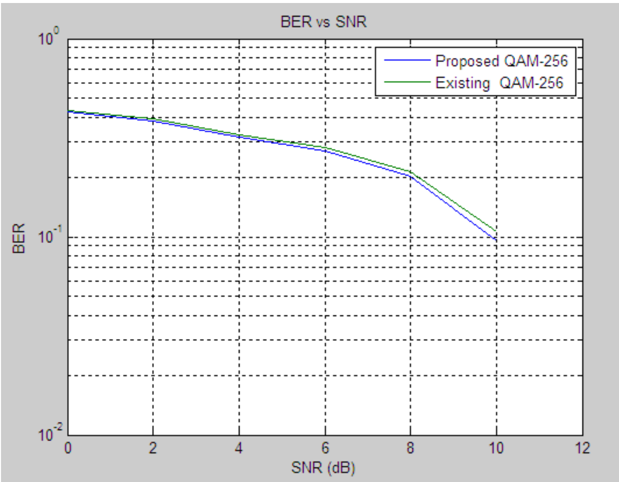

Figure 5:BER vs SNR for proposed OFDM-IM with existing M-QAM where M=256.

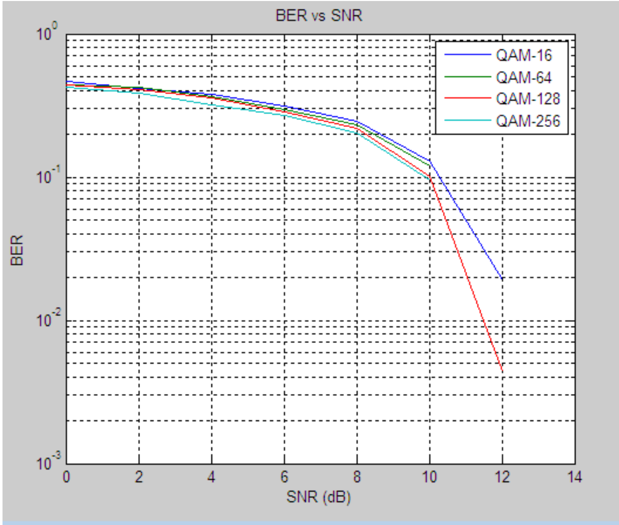

Figure 6*: BER vs SNR plot for all 16, 64, 128 and 256 bit QAM.*

V.CONCLUSION

From the simulation results it can be concluded that, the advancing DWT based index modulation with multiple antenna system will be demonstrating the best performance of BER ,using DWT we can reduce the complexity structure of transceiver and increase the rate of transmission as well as provides a both time and frequency domain information at a time. From simulation result it is observed that using index modulation in a multicarrier data achieve a better performance of BER and graph is compared with proposed and existing methods of BER v/s SNR for different M-QAM.

In this study we implemented a wavelet transform based multicarrier system .The main features of MIMO-OFDM-IM can be summarized as follows: i) better BER performance, ii) flexible system design with variable number of active OFDM subcarriers and iii) better compatibility to higher MIMO setups. Simulations clearly showed that the performance is superior to non-adaptive symbol modulation.

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