

# Bit Error Rate Reduction Using Index Modulation in MIMO OFDM System

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**ABSTRACT:** The frequency spectrum is an expensive resource limiting the bandwidth. To achieve high speed ( $10^6$ ), data rate (1Gbps) and simultaneous increase in range and reliability without consuming extra radio frequency (3 KHz-300GHz) requires enhanced spectral efficiency in order to increase link throughput, to meet QoS, and network capacity. So to fulfil these requirements the MIMO-OFDM system for wireless broadband communication is used.

In wireless transmission, bit error rate deteriorates over wireless transmission, the reduction of a data channel and the corresponding (BER) bit error rate is noise and changes to the propagation path. In OFDM transmission system a term called peak-to-average power ratio (PAPR), arises which results in corresponding distortion when signal gets transmitted through a nonlinear nature device, such as a power amplifier use at transmitter stage.

The limitations of OFDM signals are that, the OFDM signals are more immune to the time-varying channel, which breaks the orthogonality between sub-carriers, causes the generation of inter-channel interference (ICI). It is seen that once the symbols are transmitted in the radio fading channel, then the transmitted signal will suffer deep fades that give rise to loss of signal or outage of signal.

Outage probability is a performance measure of MIMO system. The outage probability is a measure of the quality of the transmission in a mobile radio channel. Outage arises when the received signal goes below a given threshold level. Like (0.1% or 0.5%). There is criteria to increase the BER beyond  $10^{-5}$  using 8X8 MIMO system or higher, to achieve the data rate of 1Gbps. To improve all these parameters, a orthogonal frequency division multiplexing with index modulation (OFDM-IM) technique is used for frequency selective fading channels. The information is conveyed not only by M-ary signal constellations as in classical OFDM, but also by the indices of the subcarriers, which are activated according to the incoming bit stream.

The paper deals with measurement/analysis of parameters such as BER, SNR, outage capacity, for (4X4, 8X8) MIMO system using QPSK, 16-QAM, to improve BER beyond  $10^{-5}$ . It is observed via computer simulations that the proposed MIMO-OFDM-IM scheme achieves significantly better error performance up to  $10^{-5}$  than classical MIMO-OFDM using QPSK, 16-QAM for several (2X2, 4X4, 8X8) system configurations due to the information bits carried in the spatial domain by the indices of OFDM subcarriers.

**KEYWORDS:** BER, ICI, MIMO, OFDM, OFDM-IM, PAPR, QAM, QPSK, SIM, SNR.

## I. INTRODUCTION

MIMO is abbreviated to multiple input multiple output system, uses multiple  $T_x$  and  $R_x$  antenna to multiply the capacity of a radio link. The power efficiency of MIMO system can be increased by maximizing spatial diversity. Such techniques are STBC and STTC. Another technique is V-BLAST used to increase the channel capacity.

There are huge demands of wireless application now days, with better quality of services. Due to restricted bandwidth,

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High BER, low SNR, wireless systems like SISO, SIMO and MISO fails to meet the growing demands of users. Therefore a new technique MIMO is used. The MIMO system is used to improve spectral efficiency, data rate, and transmission coverage, to minimize error, to optimize speed, without wasting the additional frequency spectrum. [1]

Consider a transmitter with  $N$  transmits antennas, and a receiver with  $M$  receives antennas.

The channel can be modelled by the  $N \times M$  matrix  $H$ , where  $H$  is the channel matrix, the  $N \times 1$  received signal  $y$  is given by Eq.1

$$y = Hs + n \tag{1}$$

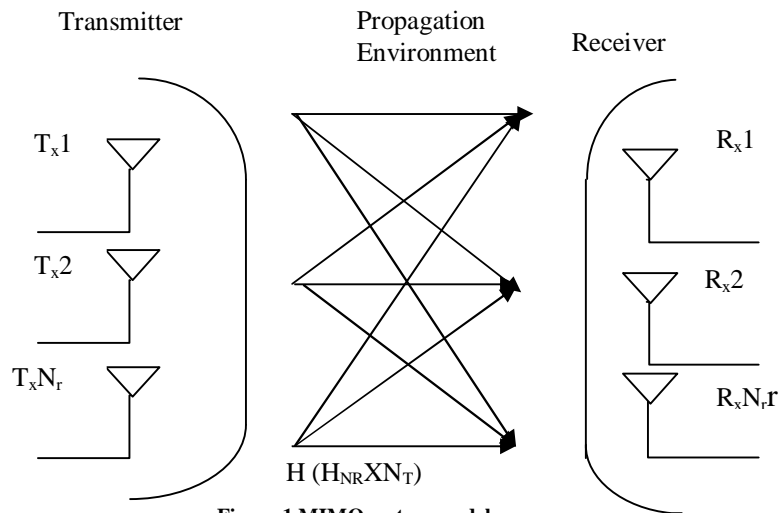
Where  $s$  is the transmitted symbol ( $s_1, s_2, s_3 \dots s_{NT}$ ), and the covariance matrix for this transmitted signal is given by Eq.2

$$R_{ss} = \frac{E_s}{N_t} I_{N_t} \tag{2}$$

Where  $\frac{E_s}{N_t}$  is equal to the power of each antenna. In the formula (1), the  $H$  can be defined as given by Eq.3

$$H = \begin{bmatrix} h_{11} & h_{12} & \dots & h_{1M} \\ h_{21} & h_{22} & \dots & h_{2M} \\ \vdots & \vdots & \ddots & \vdots \\ h_{N1} & h_{N2} & \dots & h_{NM} \end{bmatrix} \tag{3}$$

Here  $h_{ij}$  is a term called complex Gaussian random variable that is used to model fading gain between the  $J_{th}$  transmit antenna and  $I_{th}$  receive antenna in MIMO system.



The generalize model of MIMO as shown in fig.1. At first, the incoming data streams travels through serial to parallel converter and then all the streams are modulated by using BPSK, QPSK, 16 QAM modulation technique. etc. At receiver end, the modulated data stream is collected and then demodulated and detected by the V-BLAST detection technique. [2]

MIMO the only efficient way to increase bandwidth, range & will become a core technology in wireless systems. The MIMO channel is constructed with multiple antennas at both ends of the wireless link. [3]

The layout of the paper is as follows. section 1 describes about MIMO, section 2 depicts about the modulation technique, section 3 explains the system model, section 4 describes about implementation of OFDM-IM, section 5 explains principle of index modulation and operation of MIMO OFDM-IM system, section 6 summarizes simulation results and section 7 states the conclusion of the paper.

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## II. MODULATION TECHNIQUES

The process of varying property of carrier signal, with a modulating signal that typically contains information to be transmitted. This alteration is termed modulation, and it's the modulated signal that's transmitted. The receiver then recovers the initial signal through a method known as demodulation. Modulation is the way in which the information is superimposed on the radio carrier. Modulation techniques must have varieties of properties such as. [4]

- Good Bit Error Rate Performance:** BER is the percentage of bits with errors divided by the total number of bits that have been transmitted, received or processed over a given time period. The rate is typically expressed as 10 to the negative power. Low bit error rate is required in the presence of fading, Doppler spread effect in wireless system.
- Power Efficiency:** Power limitation is one of the critical design challenges in mobile applications. Nonlinear amplifiers are usually used to increase power efficiency. However, nonlinearity present at the amplifier output cause degradation to the BER performance of modulation.
- Spectral Efficiency:** It refers to the information rate that can be transmitted over a given bandwidth in a specific communication system. Spectral efficiency density should have a narrow main lobe and fast roll-off of side lobes. It is defined as  $\eta = \text{bitspersec/channel B.W}$  [4]

### A. Quadrature Phase shift Keying

Here, the phase of the carrier signal is divided which is designed by allotting four equally spaced values for the phase angle. QPSK sent twice data that can be sent in the same bandwidth compared to BPSK. QPSK provides twice the spectral efficiency with same energy efficiency. QPSK has four constellation points in the constellation diagram. But the exact phase retrieval is a challenge in the receiver design considerations, failing which can give rise to erroneous detection of the signal. This factor increases the receiver design complexities. To overcome these problems, and to shape up the carrier modulated signal, the root raise cosine pulse shaping is used, which in turn provides demerits that the constant envelope property of the signal is lost. [4]

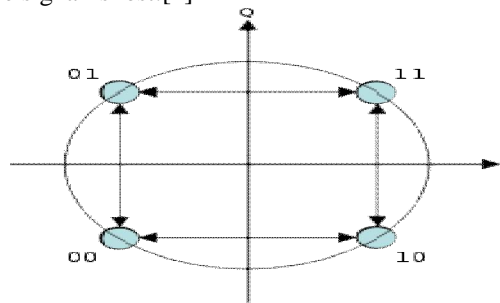


Figure 2 Constellation diagram for QPSK

The implementation of QPSK is more general than that of BPSK as given by Eq.4

$$S_n(t) = \sqrt{\frac{2E_b}{T_b}} \cos(2\pi fct + \pi(2n - 1)), \text{ where } n = 1, 2, 3, 4 \quad (4)$$

This yields the four phase's  $\pi/4, 3\pi/4, 5\pi/4$  and  $7\pi/4$  as needed. This results in a two-dimensional signal space with unit basis function. The first basis function is used as the in-phase component of the signal, is given by Eq.5,

$$\Phi_1(t) = \sqrt{\frac{2}{T_s}} \cos(2\pi fct), \quad (5)$$

And second basis function is used as the quadrature component of the signal, is given by Eq. 6

$$\Phi_2(t) = \sqrt{\frac{2}{T_s}} \sin(2\pi fct), \quad (6)$$

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## B. Quadrature amplitude modulation

Quadrature amplitude modulation (QAM) requires changing the phase and amplitude of a carrier sine wave. 16-QAM is also called 16-state quadrature amplitude modulation. Here four I phase values and four Q phase values are used, which generates four bits per symbol. It has 16 states because  $2^4 = 16$ . Its theoretical bandwidth efficiency is four. Let's look at the time-domain representation of QAM signals. Taking 4-QAM, supposed to transmit the bitstream 100111. Map the to 4-QAM symbols representing 10, 01, 11. The time-domain waveform for this bit stream is shown in

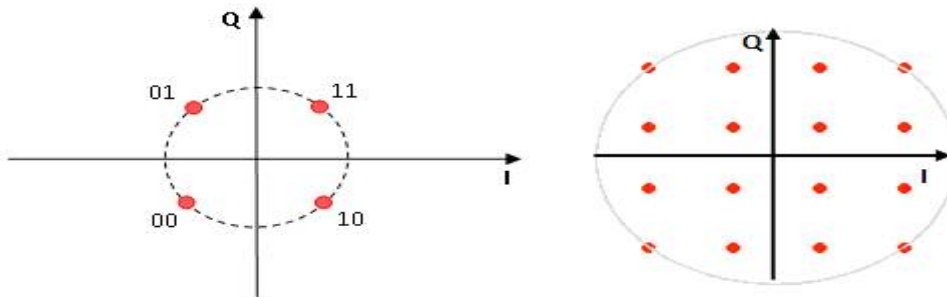


Figure 3 Constellation diagram for QAM

Figure 3. One period of the sine wave has a unique phase shift. In this respect, 4-QAM might be considered a special case of QAM where the amplitude is the same for all symbols. [4]

### a. Bit Error Rate (BER):

The Bit error rate is a ratio of number of bits received in error divided by the number of transmitted bits, measure in dB, as given by Eq.7

$$\text{BER} = \frac{\text{Bits in Error}}{\text{Total bits received}} \quad (7)$$

In wireless transmission, when the number of data bits is received, and if these data bits has modified compare to transmitted data bits, so this happens due quantization, and synchronization error. BER is often expressed as normalized carrier-to-noise ratio measured denoted  $E_b/N_0$  that is energy per bit to noise power spectral density ratio. [4]

### b. Signal to noise to ratio:

The SNR is the ratio of the received signal power over the noise power in the frequency range of the process, and measured in decibel (dB). SNR is inversely related to bit error rate. High BER causes an increase in packet loss, enhance in delay and decrease throughput, and is given by Eq.8. [4]

$$\text{SNR} = 10 \log_{10} (\text{Signal power} / \text{Noise power}) \text{ dB} \quad (8)$$

## III. RELATED WORK

In OFDM-Index modulation system, a frequency-selective Rayleigh fading channel is considered for transmission. A total of  $m$  information bits are entered to the OFDM-IM transmitter for the transmission of each OFDM block. Each group of  $m$  information bits are then split into  $g$  groups, each group contains  $p$  bits. i.e.,  $m = pg$ . Each group of  $p$  bits is mapped to an OFDM sub block of length  $n$  where  $n = N/g$  and  $N$  - number of OFDM subcarriers. This symbols mapping operation is not only performed by means of modulated symbols as in classical MIMO-OFDM but also by the indices of the subcarriers. For each sub-block, only  $k$  out of  $n$  available indices are employed and they are determined by using a selection procedure. For the selection procedure two different mapping methods are used. First, let us use a simple, Look-up table method which indicates active indices for corresponding active bits. In case of having large number of information bits to be transmitted, the use of a look-up table becomes infeasible. Then a simple and effective technique which is based combinatorial number theory to map the  $m$  information bits to the subcarrier indices. The symbols selections corresponding to sub carrier is performed as follows, The symbols are set to zero corresponding to inactive subcarrier, and data is not transmitted with inactive subcarrier. The remaining  $p_2 = k \log_2 M$  bits of this sequence are mapped onto  $M$ -ary signal constellation, so that by Eq.9,

$$p = p_1 + p_2 \quad (9)$$

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So it is observed that the information is conveyed by both of the M-ary signal constellation symbols and the indices of the subcarriers which are modulated by these constellation symbols. The loss in the total number of bits to be transmitted can be compensated by transmitting additional bits in the index domain of the OFDM block. For each OFDM sub block  $\beta$ , the incoming bits are transferred to the index selector, this block chooses  $k$ , active indices out of  $n$  available indices, the selected indices are given by Eq.10,

$$I_{\beta} = \{i_{\beta,1}, \dots, i_{\beta,k}\}, \tag{10}$$

Where  $i_{\beta,\gamma} \in [1, \dots, n]$  for  $\beta=1, \dots, g$  and  $\gamma=1, \dots, k$ .

The vector of the modulated symbols at the output of the M-ary mapper is given by Eq.11

$$S_{\beta} = [S_{\beta}(1), \dots, S_{\beta}(k)], \tag{11}$$

The Block called OFDM block creator generates all of the sub blocks and it then forms  $N \times 1$  main OFDM block, is given by Eq.12,

$$X_F = [x(1)x(2), \dots, x(N)]^T \tag{12}$$

After this, the same procedures of the classical OFDM are applied. The OFDM block is processed by the inverse FFT (IFFT) algorithm, is given by Eq.13

$$X_T = \frac{N}{\sqrt{K}} \text{IFFT} \{ X_F \} = \frac{1}{\sqrt{K}} W_N^H X_F \tag{13}$$

Where  $X_T$  is the time domain OFDM block,  $W_N$  is the discrete fourier transform (DFT) matrix with  $W_N^H W_N = NI_N$  and the term  $\frac{N}{\sqrt{K}}$  is used for the normalization.[5]

## IV. METHODOLOGY

This section particularly deals with development of index selector and index demapper block. The index selector maps the incoming information bits to a group of active indices out of  $C(n; k)$ , possible candidates, whereas the index demapper provides estimates of these bits by processing the detected active indices. Instead of dealing with a single OFDM block with higher dimensions, the OFDM block is estimated into smaller sub-blocks to ease the index selection and detection processes at the transmitter and receiver respectively. ML or LLR detectors are used employed for this purpose.

### A. Lookup table method:

A look-up table is created having size  $c$  to be used at both transmitter and receiver side. At the transmitter stage, the look-up table gives the indices for corresponding incoming  $p_1$  bits for each sub block, and it performs the opposite operation at the receiver. A look-up table for  $n = 4$ ,  $k = 2$ , and  $c = 4$  is shown in table 1. Where  $S_{\gamma}, S_{\zeta} \in s$ . Since  $C(4, 2) = 6$ , two combinations out of six are discarded. This method is efficient and simple for smaller  $c$  values; this mapping method is not feasible for higher values of  $n$  and  $k$  due to the size of the table. Generally this method is used with the ML detector at receiver, since the receiver has to know the set of possible indices for ML decoding, i.e., it requires a look-up table.

**Table 1 Reference look-up table for  $N=4, K=2, p_1=2$**

Bits	Indices	Sub blocks
[0 0]	{1,2}	$[s_{\gamma} s_{\zeta} 0 0]^T$
[0 1]	{2,3}	$[0 s_{\gamma} s_{\zeta} 0]^T$
[1 0]	{3,4}	$[0 0 s_{\gamma} s_{\zeta}]^T$
[1 1]	{1,4}	$[s_{\gamma} 0 0 s_{\zeta}]^T$

On the other hand, a look-up table does not use with the LLR detector at receiver since the receiver cannot decide on active indices if the detected indices do not exist in the table 1.[5]

### B. Combinational method:

The combinational number system actually performs a one-to-one mapping between natural numbers and  $k$  combinations, for all  $n$  and  $k$ . (i.e.) it maps a natural number to a strictly decreasing sequence, as given by Eq. 14

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$$J = \{c_k, \dots, c_1\}, c_k > \dots, c_1 \geq 0, \tag{14}$$

In other words, for fixed  $n$  and  $k$ , all  $Z$  can be presented by a sequence  $J$  of length  $k$ , which takes elements from the set  $\{0, \dots, n-1\}$ , in accordance with the following Eq.15

$$Z = C(c_k, k) + \dots + C(c_2, 2) + C(c_1, 1) \tag{15}$$

An example for  $n = 8, k = 4, C(8, 4) = 70$ , the following  $J$  sequences can be calculated as, shown in table 2.

The algorithm, which finds the lexicographic ordered  $J$  sequences for all  $n$ , can be explained as follows: start by choosing the maximal  $c_k$  that satisfies  $C(c_k, k) \leq Z$ , and then choose the maximal  $c_{k-1}$  that satisfies Eq.16

$$C(c_{k-1}, k-1) \leq Z - C(c_k, k) \tag{16}$$

In this scheme, for each symbols sub block, the  $p_1$  bits entering the index selector are converted to a decimal number  $Z$ , and then feed this decimal number to the combinatorial algorithm to select the active indices as  $J + 1$ . At the receiver

side, after determining active indices, we can easily get back to the decimal number  $Z$  using (15). We then apply this number to a  $p_1$ -bit decimal-to-binary converter. This method is used with the LLR detector for higher  $c$  values to avoid

**Table 2 J's sequence calculations**

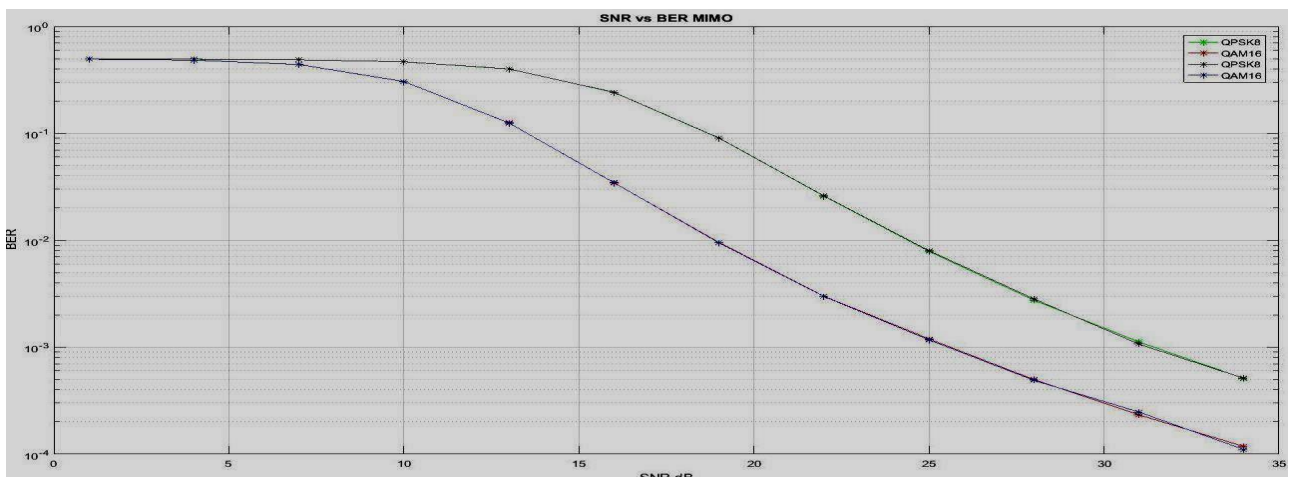
$69 = C(7, 4) + C(6, 3) + C(5, 2) + C(4, 1) \rightarrow J = \{7, 6, 5, 4\}$
$68 = C(7, 4) + C(6, 3) + C(5, 2) + C(3, 1) \rightarrow J = \{7, 6, 5, 3\}$
$32 = C(6, 4) + C(5, 3) + C(4, 2) + C(1, 1) \rightarrow J = \{6, 5, 4, 1\}$
$31 = C(6, 4) + C(5, 3) + C(4, 2) + C(0, 1) \rightarrow J = \{6, 5, 4, 0\}$
$1 = C(4, 4) + C(2, 3) + C(1, 2) + C(0, 1) \rightarrow J = \{4, 2, 1, 0\}$
$0 = C(3, 4) + C(2, 3) + C(1, 2) + C(0, 1) \rightarrow J = \{3, 2, 1, 0\}$

look-up table. However, it can give a catastrophic result at the exit of the decimal-to-binary converter if  $Z \geq C$  we use this detector for the increased bit-rate. In order to improve the data rate beyond the  $10^{-6}$ , the new technique called MIMO OFDM with index modulation can be adopted.[5]

## V. EXPERIMENTAL RESULTS

### A. MIMO-OFDM using higher modulation techniques:

In this section, the analysis of MIMO OFDM 8X8, 16X16 MIMO system using QPSK and 16-QAM modulation under Rayleigh fading channel is considered. This system is built with the following parameters. convolution encoding and ML detection is used at receiver.



**Figure 4 BER vs. SNR graph for 16X16,32X32 MIMO using QPSK,16-QAM**

Considering 8X8 MIMO system the BER difference of 6.8dB is obtained between QPSK, 16-QAM modulation. Considering the 16X16 MIMO BER difference of 7.8 dB is obtained between QPSK, 16-QAM modulation. The BER vs. SNR graph for

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08X08,16X16 MIMO using QPSK,16-QAM is shown in fig.4.The graph shows that16-QAM provide improvement in the bit error rate compare to the QPSK technique. Here data rate can beincreased beyond 10-6 using higher order M-QAM such as 256-QAM and using the MIMO OFDM with IM.

### B. MIMO-OFDM with Index modulation:

#### a. Case1:

The implementation of MIMO-OFDM-IM is done here, the following parameters are considered while implementation. N=64(one OFDM symbol),(n-available symbols=16),(K-selected symbols=8),2X2,4X4, 8X8, 16X16, 32X32 MIMO configurations.No. of symbols=64000, Here, the OFDM-IM system is built with the SIM modulation and demodulation concept to transmit the information symbols. The BER vs.SNR graph for2, 4, 8, 16, 32 MIMO configurations is shown in fig.5.The table 3 shows the BER performance analysis resultfor2, 4, 8, 16, 32MIMO configuration using SIM modulation and demodulation.[5],[6]

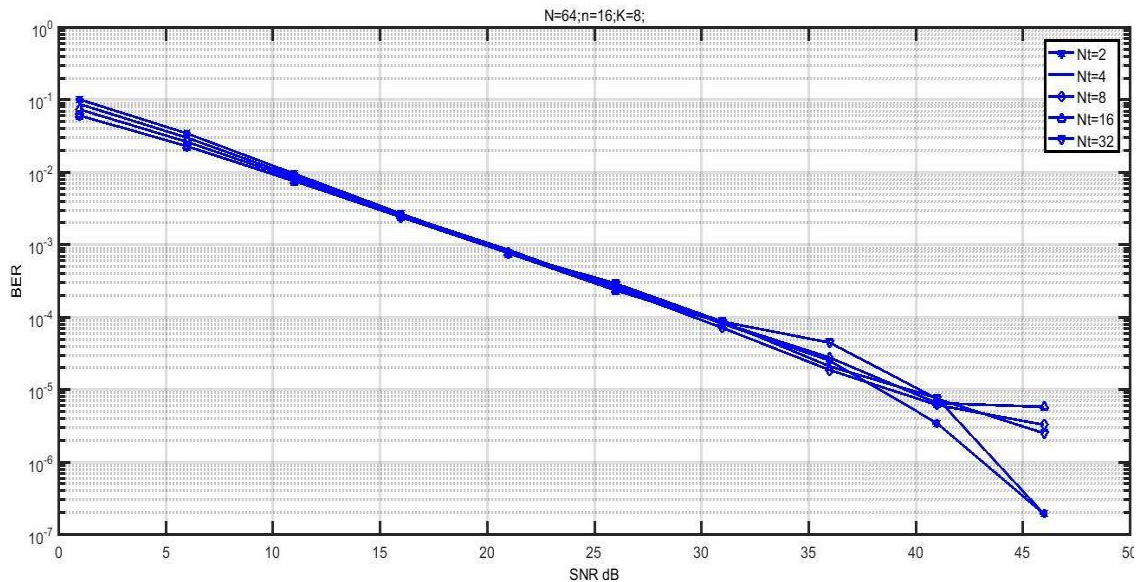


Figure 5 BER vs. SNR analysis for various MIMO systems using index modulation

Table 3 BER vs. SNR analysis for various MIMO systems using index modulation

Reported results			Obtained results			
Order of MIMO	BER	SNR (dB)	Order of MIMO	BER	SNR (dB)	SNR Difference (dB)
$N_T=2$	$10^{-5}$	42	$N_T=2$	$10^{-5}$	37.8	4.2
	$10^{-6}$	47		$10^{-6}$	41	6
$N_T=4$	$10^{-5}$	45.4	$N_T=4$	$10^{-5}$	38.2	7.2
	$10^{-6}$	45.7		$10^{-6}$	42.5	3.2
$N_T=8$	$10^{-5}$	45.8	$N_T=8$	$10^{-5}$	38.7	7.1
	$10^{-6}$	49.2		$10^{-6}$	46.5	3.7
$N_T=16$	$10^{-5}$	-	$N_T=16$	$10^{-5}$	39.2	-
	$10^{-6}$	-		$10^{-6}$	46.9	-
$N_T=32$	$10^{-5}$	-	$N_T=32$	$10^{-5}$	39.	-
	$10^{-6}$	-		$10^{-6}$	47	-

From table 3, the improved SNR differences(i.e. 4.2, 6, 7.2, 3.2, 7.1, 3.7)between OFDM and OFDM-IM with

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QPSK is obtained with respect to results in reported papers.

**b. Case 2:**

The implementation of MIMO-OFDM-IM is done here. The main focus here is to use the constant value of (n-available subcarrier=16) and variable values for the 'k' (k-selected subcarrier=8,12,16) to implement the BER vs. SNR graph for MIMO system implemented using the index modulation as shown in fig. 6. The following parameters are considered while implementation. (N-one OFDM symbol)=64, (n-available subcarrier)=16, (k-selected subcarrier=8, 12, 16),  $N_T=16, N_R=N_T, M1=QPSK=4, M2=16\text{-}16\text{-}QAM$ , no. of symbol=40000, modulation=16-QAM. The table 4 shows the BER vs. SNR result for different number of active subcarrier (k=8, 12, 16) with  $N_T=16, 16\text{-}QAM$ . [5], [6]

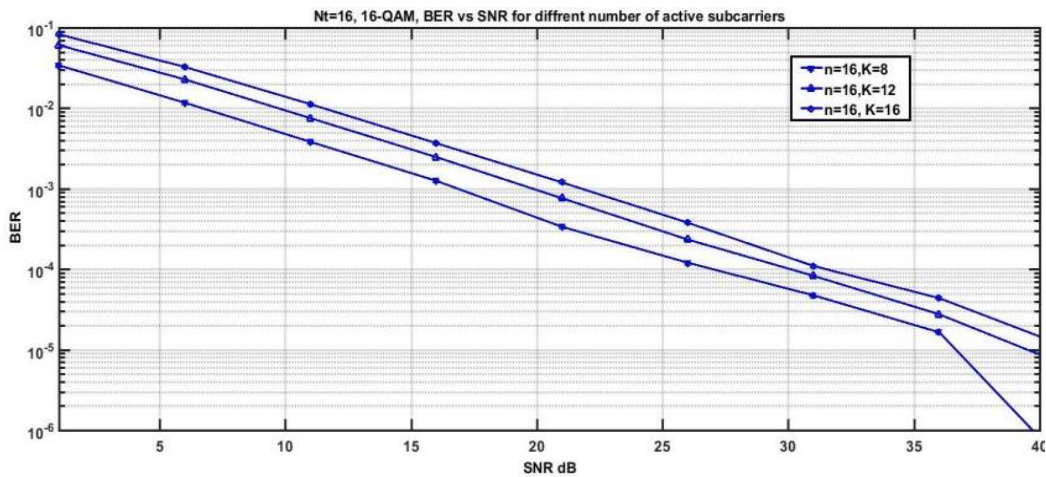


Figure 6 BER vs. SNR Graph for  $N_T=16, 16\text{-}QAM$ , for different number of active subcarrier

Table 4  $N_T=16, 16\text{-}QAM$ , BER vs. SNR for different number of active subcarrier

Reported results			Obtained results			
MIMO parameters	BER	SNR (dB)	MIMO parameters	BER	SNR (dB)	SNR Difference (dB)
(n=16, k=8)	$10^{-4}$	31	(n=16, k=8)	$10^{-4}$	26	5
	$10^{-5}$	41		$10^{-5}$	37	4
(n=16, k=12)	$10^{-4}$	33.6	(n=16, k=12)	$10^{-4}$	30	3.6
	$10^{-5}$	43.5		$10^{-5}$	40	3.5
(n=16, k=16)	$10^{-4}$	32.3	(n=16, k=16)	$10^{-4}$	31.5	0.8
	$10^{-5}$	37.4		$10^{-5}$	42	4.6



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**c. Case 3:**

The implementation of MIMO-OFDM-IM is done here.

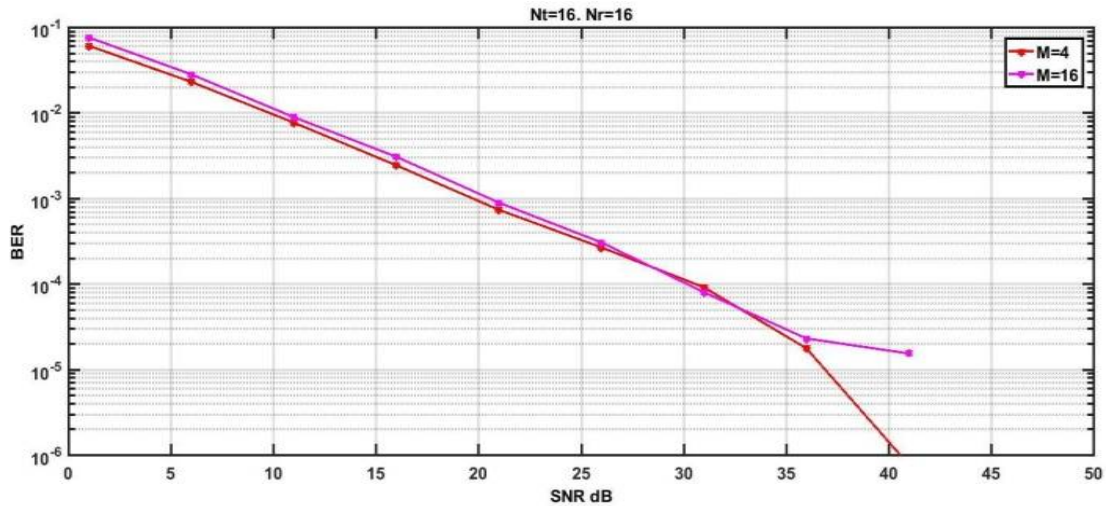


Figure 7 BER vs. SNR Graph for BER vs. SNR for variable values of 'M(QPSK)=4, 16(16-QAM)'

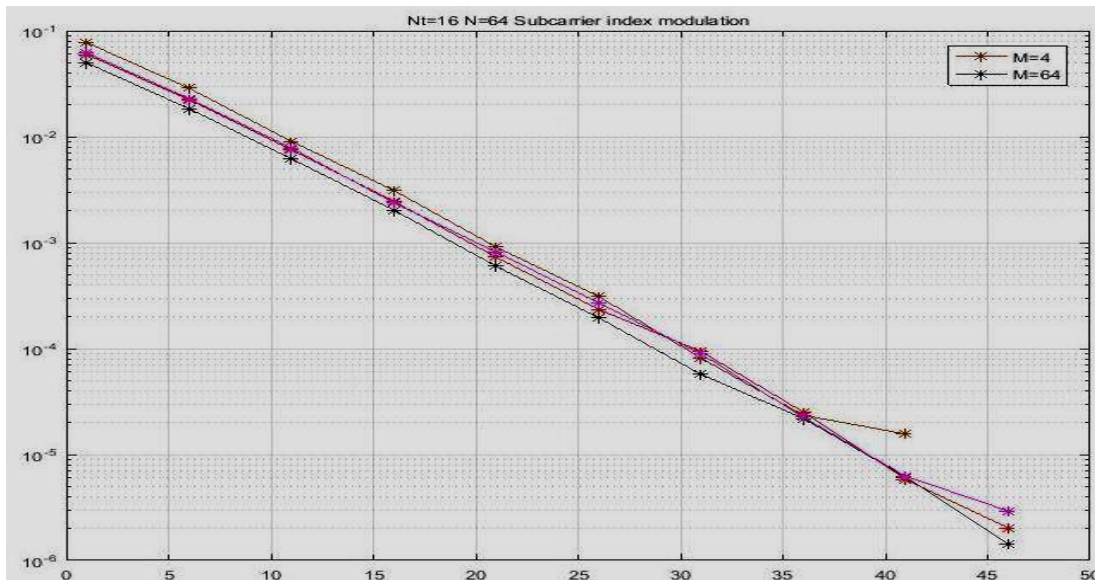


Figure 8 BER vs. SNR Graph for variable values of 'M(QPSK)=4, 64(64-QAM)'

Table 5 BER vs. SNR Graph for BER vs. SNR for variable values of 'M(QPSK)=4, 16(16-QAM)'

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The main focus here is to use the constant value of ( $N_T$ -transmit antenna=16) and variable values for the 'M'(M-QPSK=4, 16-16-QAM, 64-64-QAM), to implement the BER vs. SNR graph for MIMO system implemented using the index modulation as shown in fig.7 and fig. 8. The following parameters are considered while implementation. (N-one OFDM symbol=64,)(N-available carrier=16), (k-selected carrier)=8,  $N_T=16$ ,  $N_R=NT$ , M= (04,16,64), no.of symbols=64000, modulation=16-QAM. The table 5 shows the BER vs. SNR result for different size of M (M=4, 16) with  $N_T=16$ , 16-QAM. From the above results tabulated in table 5, the SNR difference (OFDM-IM, QPSK= (5.2, 1 dB), and (OFDM-IM, 16-QAM= (0.4,-2 dB). [5],[6]

## VI. CONCLUSION

The recently proposed MIMO-OFDM-IM scheme has been investigated for next generation 5G wireless networks. A novel OFDM scheme, which uses the indices of the active subcarriers to transmit data, has been analysed in this paper using series of MATLAB simulation. In this this scheme, the coming information bits are transmitted in a unique fashion to improve the bit error rate performance as well as to increase spectral efficiency.

The considered OFDM system parameters are given as follows:  $N_F = 512$ , subcarrier spacing  $\Delta f = 15$  kHz, sampling frequency  $f_s = 7.68$  MHz,  $C_p = 36$  and  $L = 10$ .

Thus the theoretical as well as MATLAB simulation results for the MIMO-OFDM-IM scheme have been analysed and its comparisons are made with the classical MIMO OFDM scheme for different type of detectors and system configurations. Thus from this analysis it has been concluded that the MIMO-OFDM-IM scheme outperform better compare to the classical OFDM system in terms of bit error rate performance, outage capacity, ergodic capacity.

Size of M	Modulation technique	BER	SNR (dB)	Size of M	Modulation technique	BER	SNR (dB)	SNR Difference (dB)
4	QPSK (4x4)	$10^{-4}$	25	4	16-QAM	$10^{-4}$	30.2	SNR diff1=5.2
		$10^{-5}$	35			$10^{-5}$	36	SNR diff2=1
16	16-QAM	$10^{-4}$	30	16	16-QAM	$10^{-4}$	29.6	SNR diff1=-0.4
		$10^{-5}$	40			$10^{-5}$	38	SNR diff2=-2
64	16-QAM	$10^{-4}$	--	64	16-QAM	$10^{-4}$	27	----
		$10^{-5}$	--			$10^{-5}$	37.6	-----

Using 2X2 MIMO the BER difference of 4.5dB is obtained between QPSK, 16-QAM modulation. Considering the 4X4 MIMO BER difference of 5.2dB is obtained between QPSK, 16-QAM modulation. Considering 8X8 MIMO the BER difference of 6.8dB is obtained between QPSK, 16-QAM modulation. Considering the 16X16 MIMO BER difference of 7.8dB is obtained between QPSK, 16-QAM modulation.

Secondly when the MIMO-OFDM-IM system is built with the subcarrier index modulation. So the difference in BER of 1dB is obtained by employing the 16x16 MIMO, QPSK, 16-QAM technique modulation. It is seen that the OFDM-IM system has achieved better BER compared to classical MIMO-OFDM system.

It is seen that the proposed scheme achieves significantly better BER (i.e.  $10^{-5}$  at SNR=30dB) performance than classical MIMO-OFDM system using QPSK, and 16-QAM under different MIMO configuration.

For the MIMO-OFDM-IM scheme, ML detector has been used. To improve performance parameters such as BER, new detectors such as near-ML, simple MMSE, MMSE-LLR-OSIC detectors can be used. As future research, can be done on OFDM-IM system with the implementation of different transceiver structures to increase the data rate as well as to improve the error performance. The proposed scheme should also be investigated in real world conditions such as mobility. (i.e. zero mobility, high mobility).

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## REFERENCES

- [1] R. Bansode, P.Sarode, B. K. Mishra, "Design, simulation and Performance Evaluation of 4 x 4 MIMO Transceiver System using 16 QAM," *International Journal of Applied Information Systems (IJ AIS)*, ISSN: 2249-0868, pp.28-38, 2013.
- [2] R.ahmad, D.P.singh, M.singh, "Ergodic Capacity of MIMO Channel in Multipath Fading Environment," *I.J. Information Engineering and Electronic Business*, vol.3,pp.41-48,march,2013.
- [3] E. Başar, "Multiple-Input Multiple-Output OFDM with Index Modulation," *International IEEE Signal Processing Letters*, ISSN: 1070-9908, vol.22, no12, pp. 2259 - 2263, Oct. 2015.
- [4] S.Kumari, R.Bera, S.Dhar, "Modeling and Analyzing the BER Performance of MIMO System using different Modulation Technique," *International Journal of Engineering Research & Technology (IJERT)*, ISSN: 2278-0181, pp.505-510, vol. 4 issue 05, May-2015.
- [5] [5] E.Başar, "Orthogonal frequency division multiplexing with index modulation," *International Global Communications Conference (GLOBECOM)*, ISSN: 1930-529X, pp.4741-4746, Dec. 2012.
- [6] [6] E. Başar, "Multiple-Input Multiple-Output OFDM with Index Modulation," *International IEEE Signal Processing Letters*, ISSN: 1070-9908, vol.22, no12, pp. 2259 - 2263, Oct. 2015