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Performance Enhancement of MIMO-MC-CDMA Systems by Employing Various Diversity Combining Techniques

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Abstract--- **Wireless communication is a system of transferring data from single point to other, without using similar wires, cables or any physical medium. In this paper, plain (MC-CDMA) scheme is implemented and the presentation in expressions of (BER) is achieved. The theoretical performance of the MC-CDMA scheme is also calculated and related using the simulated presentation to verify the accuracy of the system. Then, the MIMO systems are implemented and passed through the MCCDMA system with multiple input multiple output (MISO) antenna diversity and SIMO(single input multiple output) in the Rayleigh flat fading channel. The combination of MIMO and MC-CDMA scheme is named as MIMO-MC-CDMA system. By the side of the receiver, the acknowledged signals of MIMO-MC-CDMA system are united in the frequency domain in command to assemble the complete acknowledged signal energy spread on dissimilar subcarriers 7assuming flawless channel state information (CSI). The combining schemes used are the maximum ratio combining (MRC 1X2) with MIMO-MC-CDMA scheme, equal gain combining (8EGC 1X2) with MIMO-MC-CDMA system, (MMSE 2X1) with the MIMO-MC-CDMA system, maximum likely hood combining (MLD 2x1,MLD 2x2) with MIMO-MC-CDMA system then the performance of these combining schemes will be measured with respect to the SISO-MC-CDMA systems at the receiver. The MLD (2x1) is combined with MLD (2x2).**

Keywords--- **CDMA, OFDM, MC-CDMA, SISO, MIMO, MIMO-OFDM, STBC, EGC, MRC, MMSE, MLD, Diversity, BER**

I. INTRODUCTION

The world today is mostly dependent upon the Wireless Technologies due to their flexibility reliability, low cost and much easier way of deployment. Hence, it has become more important and only means of communications in most of the remote areas. Entire globe is dependent upon wireless communications which also includes homes, businesses etc. Satellite Communications which are a part of wireless

Communications provide way to several military, medical and commercial applications. Several Wireless technologies evolved based on the requirement of the speed, robustness and throughput. Various versions like 4g, VOLTE, 5G also evolved. Radio waves are propagated into the air in wireless communications. The signal may undergo reflections, refractions, scattering which may result in fading of the signal quality. Hence, to measure the quality of the signal, certain parameters have to be analysed.

CDMA is a 3G technology. It is multiple access technology in which different users are allocated different codes through the same communication channel simultaneously. Advantage of this technology is that each symbol is multiplied to a code to generate the samples and the Bandwidth of the original signal is spread orthogonally between the codes. If the code length is N, then the bandwidth is spread by a factor of Disadvantages are near-far problem, Limited users, In CDMA, reverse link as users increases, BER (Bit Energy Rate) increases. Performances are worst as the number of users increases.

OFDM is 4G technology. it a frequency division multiplexing scheme in which digital information is encoded on multiple carrier frequency and a enormous figure of narrowly spaced orthogonal sub carrier signals carry information. Operation is a set of symbols loaded on to the sub carriers and s/p converted and IFFT is performed to generate the transmitted samples and converted to p/s (M UX) to generate serial stream. CP is applied and transmitted over the channel and remove C.P (to avoid IBI) and S/p (DeMUX & FFT) detection of symbols. P/s (MUX) to generate serial stream of data. Spatial efficiency decreases as we add C.P. Carrier frequency offset produces ICI in OFDM and thus introduces distortion and PAPR.

MC-CDMA is a mixture of CDMA and OFDM. At this

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time, several duplicates of similar data symbols all multiplied by single chip of user specific spreading code are transferred on dissimilar sub carriers in parallel. Frequency diversity is attained to reject frequency selective fading. FFT converts frequency domain into time domain. Multiple copies are joined by the side of the receiver signal to rise Signal to Noise Ratio (SNR).

Diversity reception reduces the probability of occurrence of communication failures like fading. These techniques are used to associate the signals beginning numerous diversity branches. In wireless communication systems, signal is transferred starting from the transmitter to receiver. As the signal travels through the channel, multipath fading occurs. To avoid this multipath fading effects, diversity combining techniques are used to get the actual transmitted data. By using diversity combining with transmit or receive antenna or both transmit and receive diversity techniques used at the receiver to avoid the multipath fading effects and to improve the BER presentation of the scheme. So, the diversity combining methods are implemented in the MIMO- MC-CDMA system to boost the BER presentation of the system by using various combining techniques like EGC, MRC, MMSE, MLD. The result shows comparison of BER performance for MC-CDMA, SISO-MC-CDMA, EGC, MRC, MMSE, and MLD combining techniques.

II. METHODOLOGY

1. Maximal Ratio Combining Scheme

Maximum ratio combining Scheme may be a linear uniting scheme. During a common linear uniting procedure, a variety of signal responses are independently weighted and added combinedly to urge an output. The weighting factors are regularly selected in numerous methods.

The output may be a linear mixture [1]of a weighted model of completely of the receiving signals. It's assumed ri is the receiving signal at receiving antenna i, and αi are the weighting factor used for receiving antenna i. In maximum ratio combining, the weighting factor of every receiving antenna is selected to be in proportion to its own signal voltage to noise power ratio. Assuming Ai and φi are the amplitude and phase of the receiving signal ri, in that order. Supposing that every receiving antenna takes an equivalent average noise power, the weighting factor αi and receive antenna is given an average noise power are often represented as

$$r = \sum_{i=1}^{nR} \alpha_i \cdot r_i \qquad (1)$$

$$\alpha_i = A_i e^{-j\phi} i \qquad (2)$$

This scheme is named optimum combining scheme since it can improve the output SNR. It's seen that the utmost output SNR is adequate to the addition of the immediate SNRs of the individual signals this method performs better than the equal gain combining method and each individual signal must be co-phased, weighted with its corresponding amplitude then summed. This scheme requires the knowledge of channel fading amplitude and signal phases. So, it is frequently utilized in conjunction with coherent detection, but it's not practical for non-coherent detection.

2. Equal Gain Combining Scheme

EGC Scheme may be a suboptimal then simple linear combining technique. It doesn't want assessment of the fading [2] amplitude designed for every separate branch. As an alternative, the receiver groups the amplitudes of the weighting factors to be unity the equation can be given as

$$\alpha_i = e^{-j\phi} i \qquad (3)$$

Entirely the established signals are co-phased at that time added alongside equal gain. The presentation of EGC is purely slightly poorer to MRC. The performance difficulty designed for EGC is considerably but the utmost ratio combining scheme.

3. MMSE

It is mainly designed for multi user detection. It is the detection technique of the transmitted byte in the presence of Multiple Access Interface (MAI). The main aim of this method is to minimize the mean square error among the transferred symbol vector a^k and its estimated symbol vector $a\^{}^k$. Hence, it is more accurate detection scheme.

Adaptive receivers are generally categorized into chip-rate linear receivers and fractionally spaced receivers. The fractionally spaced receivers require a structure comparable to fractionally spaced equalizers and stand of binary types whichever linear receivers consuming time dependent adaptive filters or non-linear receivers with decision feedback filters. In adding together, the fractionally spaced linear filters moreover use difficult coefficients or real coefficients. There are a variety of structures for adaptive receivers.

Assume that the arriving sequence be r(m) with m=1,2,..,M and the assessed autocorrelation R^ is given by

$$\hat{R} = (1 / M) \cdot \sum_{m=1}^{M} \mathrm{r}(m) . \mathrm{r}^*(m) \qquad (4)$$

A number of systems can be used to improve the filter coefficients W. The greatest important of these schemes is constructed on the minimum mean square measure and estimated w^ is

$$\hat{w} = \hat{R}^{-1} \cdot \hat{P} \quad (5)$$

Anywhere the correlation matrix R^ is as well-defined on top which is given as

$$\hat{P} = E[d_1(m)\mathrm{r}(m)] \quad (6)$$

objective user transfers the data symbol D1(m)

4. MLD combining technique using double Transmitting antennas with single Receiving antenna of MC-CDMA system

The main method of STC is space-time (ST) organization. This arrangement is practical at each carrier by mapping over the transmit intervals. ST coding explains the spatial diversity and time diversity[6]. The data mapping in ST is Alamouti scheme. The Alamouti transmission scheme for ST diversity is shown below.

	At an antenna 1	At an Antenna 2
Frequency slot 1/at a Time slot 1	S1	S2
Frequency slot 1/at a Time slot 2	-S2*	S1*

Table 1: Alamouti scheme

Alamouti arrangement of successive symbol blocks in the input data stream is transmitted as $s_1$ands_2. STBC encoding, in place of the first time slot is the antenna1 transmits symbol $s_1$and second antenna transmits symbol s_2. In the following time slot is antenna 1 transmits symbol $-s_2*$and antenna 2 transmits symbol s_1*. The scattering of the block data is shown in below figure. The signals go through single track are currently being generated to become 4 tracks using two antennas and two time slots. Therefore enhancing the BER using appropriate diversity reception combiner.

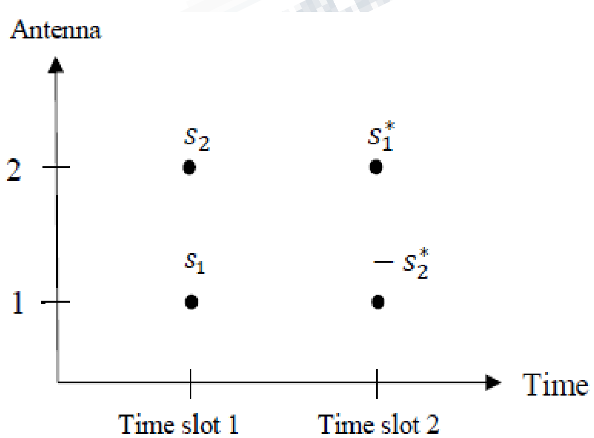

Fig 1: STBC encoding with Alamouti Scheme

The signal will pass through multiplication of channel distribution, H:

$$\mathrm{H} = [\mathrm{h}_1\mathrm{h}_2] \quad (7)$$

Then the receiving signal with noise is given by

$$\mathrm{r} = \mathrm{H} * \mathrm{s} + \mathrm{n} \quad (8)$$

For this diversity technique , the receiving signal of one received antenna after FFT modulation is given below

$$\mathrm{r}_1 = \mathrm{r(t)} = \mathrm{h1s1} + \mathrm{h2s2} + \mathrm{n1} \quad (9)$$

$$\mathrm{r}_2 = \mathrm{r(t+T)} = -\mathrm{h1s2}^* + \mathrm{h2s1}^* + \mathrm{n2} \quad (10)$$

Where, $\mathrm{r}_1$is the receiving signal next to the time slots one t, and $\mathrm{r}_2$is the receiving signal to the next the time slot t + T. Data can be retrieved by maximum Likely Hood combiner (MLD) technique is shown below

$$\tilde{s_1} = \mathrm{h_1}^*\mathrm{r1} + \mathrm{h2r_2}^* \quad (11)$$

$$\tilde{s_2} = \mathrm{h_2}^*\mathrm{r1} - \mathrm{h1r_2}^* \quad (12)$$

Where s1 and s2 are signals after decoding process.

Figure 2 describes the two branch transmitting diversity scheme with single receiving antenna.

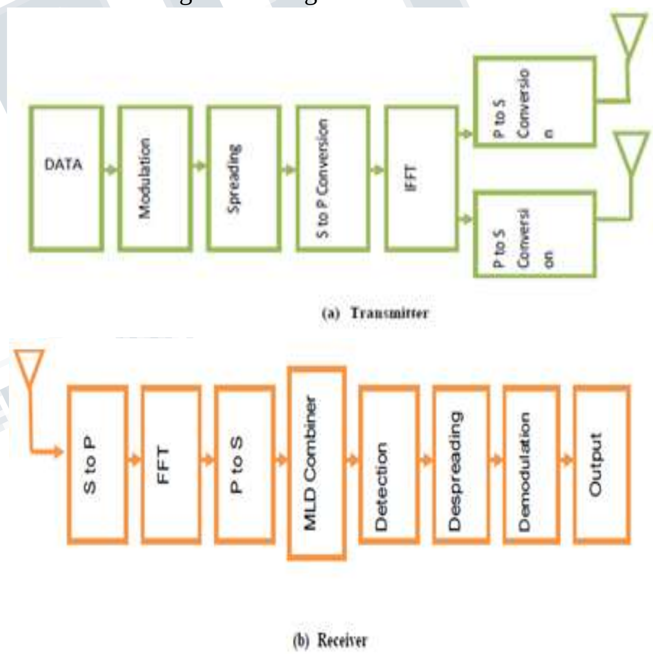

Fig 2: Block Diagram of MLD (2x1) combiner with MIMO-MC-CDMA system

The MLD combining arrangement usages double transmitting antennas and single receiving antenna which is well-defined by the succeeding purposes.

(i). The STBC encoding and transmission order of information symbols is done at the transmitter side.

(ii). The MLD combining is done at a receiver side.

(iii). The conclusion is taken by using maximum likelihood decoder at the receiver.

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(i) The Encoding and Transmission of information symbols

In a specific symbol duration, two signals are at the same time transferred through the two antennas. The signal transferred after antenna zero is denoted by s_0 and from antenna one by s_1 . Through the following symbol period signal ($-s_1^*$) is transmitted from antenna zero, and signal $s_0^*$is transferred after antenna one where * is the complex conjugate process. series is exposed in below table 1.

In the below table 1, the encoding is finished in space and time (space–time coding). Encoding, on the other hand, is finished in space and frequency. As an alternative of two neighboring symbol periods, two neighboring carriers might be used (space–frequency coding)

	At an Antenna 0	At Antenna 1
At aTime t	s_0	s_1
At a Time t + T	$-s_1^*$	s_0^*

Table 2: Alamouti scheme

The station by time may be designed by a composite multiplicative distortion $h_0(t)$ for transmitting antenna zero and $h_1(t)$ for transmitting antenna one. Taking that disappearing is steady across two consecutive symbols, we can write

$$h_0(t) = h_0(t+T) = h_0 = \alpha_0 e^{j\theta}{}_0 \quad (13)$$

$$h_1(t) = h_1(t+T) = h_1(10) = \alpha_1 e^{j\theta}{}_1 \quad (14)$$

anywhere is the symbol time. The acknowledged signals can be written as

$$r_0 = r(t) = h_0s_0+h_1s_1+n_0 \quad (15)$$

$$r_1 = r(t+T) = -h_0s_1+h_1s_0^*+n_1 \quad (16)$$

anywhere $r_0$and r_1 are the acknowledged signals at the assumed time t , t+T where n_0 and $n_1$are complex random variables shows the receiver noise and receiver interference.

(ii) The Uniting Scheme

It develops two united signals which are directed to the maximum likelihood detector:

$$s_0^1 = h_0^* r_0+h_1r_1^* \quad (17)$$

$$s_1^1 = h_1^* r_0-h_0r_1^* \quad (18)$$

It is significant to reminder that the MLD combining scheme is dissimilar from the MRC

(iii) The Maximum Likelihood Decision Rule

After the combining is done these united signals which are transmitted to the maximum likelihood detector where signals $s_0$and s_1, uses the decision rule conveyed. The resultant united signals are equivalent to that attained after the MRC. The major change is phase rotations going on the noise components don't destroy the active SNR. Consequently, the ensuing diversity after the original two-branch transmitter diversity scheme through unique receiver is better than that of the MRC with receive diversity.

5. MLD combining technique with Two Transmit antennas with two Receiver antennas of MC-CDMA system

Here might probably be requests a advanced order of diversity required and numerous receiver antennas at the distant units are potential. In that situation, it is likely to there a diversity order of 2 with two transmitters and receivers . For implementing purpose, we have a discussion about the particular case of two transmitter and two receiver antennas in identify.The report of channels among the transmitters and receivers is regarding the two transmit antennas at the transmitter and two receiving antennas at the receiver as exposed in below figure.

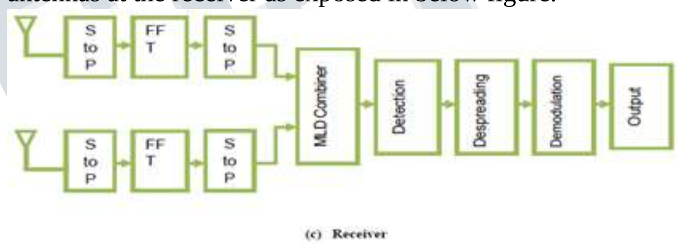

Fig 3: Block Diagram of MLD combiner (2x2) with MIMO-MC-CDMA system

	Receiver antenna 0	Receiver antenna 1
At a transmitter antenna 0	h_0	h_2
At aTransmitter antenna 1	h_1	h_3

Table 3: Channel representation of transmitting and receiving antennas

	Receiver antenna 0	Receiver antenna 1
At a time t	r_0	r_2
At a time t+T	r_1	r_3

Table 4: receiving antenna representation at different time slots

Where, receiving signals by the double receiving antennas can be represented below

$$r_0 = h_0s_0+h_1s_1+n_0 \quad (19)$$

$$r_1 = -h_0s_1^*+h_1s_0^*+n_1 \quad (20)$$

$$r_2 = h_2s_0+h_3s_1+n_2 \quad (21)$$

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$r_3 = h_0 s_1^* + h_3 s_0^* + n_3$ (22)

n_0, n_1, n_2 and n_3 denotes complex random variables. The combining techniques build the following two signals which are directed to the maximum likelihood detector:

$s_0^1 = h_0^* r_0 + h_1 r_1^* + h_2^* r_2 + h_3 r_3^*$ (23)

$S_1^1 = h_1^* r_0 - h_0 r_1^* + h_3^* r_2 - h_2 r_3^*$ (24)

$s_0^1 = (\alpha_0^2 + \alpha_1^2 + \alpha_2^2 + \alpha_3^2) s_0 + h_0^* n_0 + h_1 n_1^* + h_2^* n_2 + h_3 n_3^*$ (25)

$S_1^1 = (\alpha_0^2 + \alpha_1^2 + \alpha_2^2 + \alpha_3^2) s_1 - h_0 n_1^* + h_1^* n_0 - h_2 n_3^* + h_3^* n_2$ (26)

The joined signals are transmitted through the maximum likelihood decoder uses signal s_0 usages the assessment criterion

$(\alpha_0^2 + \alpha_1^2 + \alpha_2^2 + \alpha_3^2 - 1)|s_i|^2 + d^2(\tilde{s}_0, s_i) \leq (\alpha_0^2 + \alpha_1^2 + \alpha_2^2 + \alpha_3^2 - 1)|s_k|^2 + d^2(\tilde{s}_0, s_k)$ (27)

$d^2(\tilde{s}_0, s_i) \leq d^2(\tilde{s}_0, s_k)$, $\forall\ i \neq k$ (28)

$(\alpha_0^2 + \alpha_1^2 + \alpha_2^2 + \alpha_3^2 - 1)|s_i|^2 + d^2(\tilde{s}_1, s_i) \leq (\alpha_0^2 + \alpha_1^2 + \alpha_2^2 + \alpha_3^2 - 1)|s_k|^2 + d^2(\tilde{s}_1, s_k)$ (29)

$d^2(\tilde{s}_1, s_i) \leq d^2(\tilde{s}_1, s_k)$, $\forall\ i \neq k$ (30)

The data uses the receiving signals by the double receiving antennas through double transmit and double receiving antennas. The encoding and transmission arrangement of the information symbols and this agreement is the same to the that of a single receiver, shown in Table 4 and Table 3 describes the channels among the transmitting and receiving antennas, and Table 4 explains the representation designed for the receiving signal by the two receiving antennas.

III. RESULTS AND DISCUSSION

The outputs of the current and the projected system simulation using MATLAB is presented here. The working of the system can be analysed from resulting graphs and can be easily understood. Here the graph 4 describes the assessment (BER) of the proposed system using the current system.

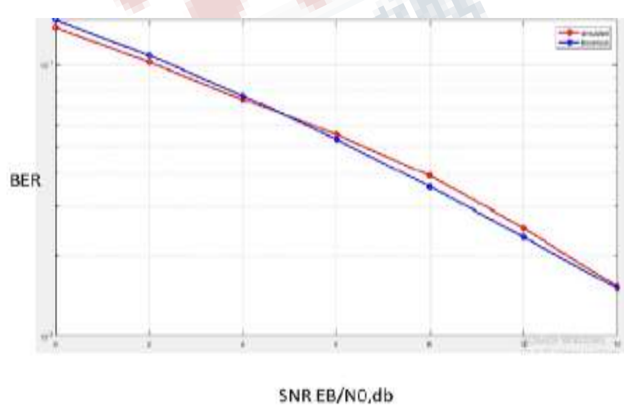

Fig 4: shows the comparison of and Theoretical and the Simulated BER of MC-CDMA system

The situation is seen, the simulated performance of MC-CDMA system is in close approximation using the theoretical performance of MC-CDMA system which shows that the accuracy of the implementation of MC-CDMA system as shown in table 4.

Technique	BER
MC-CDMA system theoritical performance	0.1085
MC-CDMA system simulated performance	0.1025

Table 5: Theoretical and simulated presentation of the SISO-MC-CDMA system

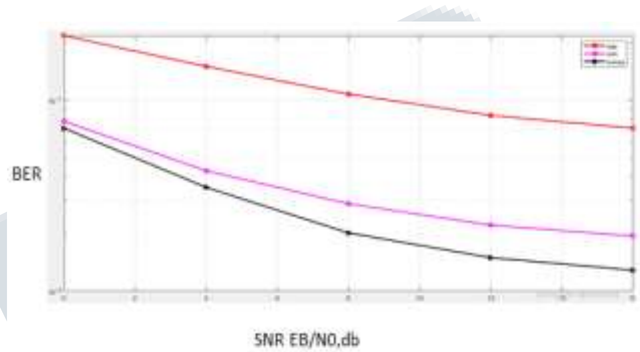

Fig 5: displays the comparison of BER and SNR of MIMO-MC-CDMA system with the combining techniques like EGC, MRC and MMSE

The above graph 5 shows the BER performance of EGC (1x2) receives antenna diversity , MRC (1x2) receive antenna diversity and MMSE (2x1) which is a transmit antenna diversity. The Maximal Ratio Combining performance is enhanced compared with the Equal Gain combining. The MMSE combining performs better than the Maximal Ratio Combining. The worst performance is for EGC which is a receive antenna diversity.

SNR	MLD(2X2)	MLD(2X1)	MMSE(2X1)	MRC(1X2)	EGC(1X2)
4	0.0018	0.0261	0.0349	0.0427	0.1502
8	0.0003	0.0102	0.0202	0.0287	0.1076
12	0.000	0.0032	0.0150	0.0222	0.0833
16	0	0.0010	0.0129	0.0197	0.0714

Table 6: comparison of BER and SNR values of MIMO-MC-CDMA system by the other combining techniques

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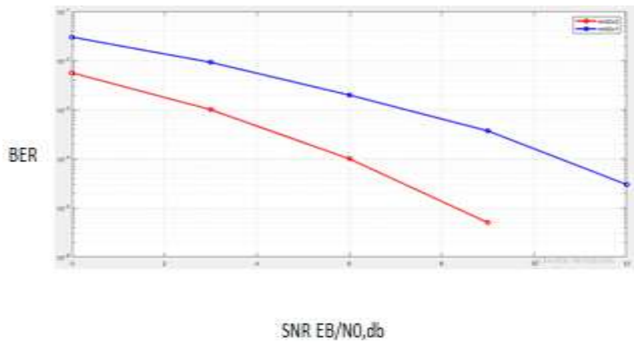

Fig 6: displays the assessment of BER and SNR of MIMO-MC-CDMA system by means of the combining techniques like MLD (2x1) and MLD (2x2)

The above graph 6 displays the BER of MLD (2x2) receives antenna diversity, MRC (2x1) transmit antenna diversity. The Maximal Ratio Combining with 2x2 performs better than the Maximal Ratio combining (2x1). As the diversity order improves the system performance better than the other system. The MLD (2x2) which is having the both transmit and receive antenna diversity which is having a diversity order of 2 so, it is performing better than the (2x1) MLD system.

Technique	MLD(2X1)	MLD(2X2)	MMSE(2X1)	MRC(1X2)	EGC(1X2)
Spreading factor	8	8	8	8	8
channel	Rayleigh channel	Rayleigh channel	Rayleigh channel	Rayleigh channel	Rayleigh channel
modulation	BPSK	BPSK	BPSK	BPSK	BPSK
Data size	4000	4000	4000	4000	4000
Number of antennas	2(tr)and1(r)	2(tr)and2(r)	2(tr)and1(r)	1(tr)and2(r)	1(tr)and2(r

Table 7: Parameters of the MIMO-MC-CDMA system Combining techniques

Combining technique	SNR	BER
EGC 1X2 with MIMO-MC-CDMA system having receive diversity	4	0.1502
EGC 1X2 with MIMO-MC-CDMA system having receive diversity	4	0.0349
MMSE 2X1 with STBC MIMO-MC-CDMA system having transmit diversity	4	0.0370
MLD 2X1 with STBC MIMO-MC-CDMA system having transmit diversity	4	0.0261
MLD 2X2 with STBC MIMO-MC-CDMA system having transmit and receive diversity	4	0.0018

Table 8: MIMO-MC-CDMA system by the Combining techniques on a particular SNR value

The below graph 7 describes the BER performance of MLD (2x2) receives antenna diversity, MRC (2x1) transmit antenna diversity and the MMSE. The Maximal Ratio Combining with 2x2 performs which is a space Time Block Coded system better than the Maximal Ratio combining (2x1) which is a Space Time Block Coded system and MMSE (2x1) which is a block coded system. As the diversity order improves the system performance is enhanced compared with the other system. The MLD (2x2) which is having the both transmit and receive antenna diversity which is having a diversity order of 2 so, it is performing better than the (2x1) MLD system. The MLD (2x1) is having binary transmitting antennas and unique receiving antenna and the MMSE 2x1 is having the two transmitting antennas and one receiving antenna .The MLD (2x1) performs better than the MMSE (2X1) because MMSE is non linear because linear system performance is enhanced compared with the Non-Linear system.

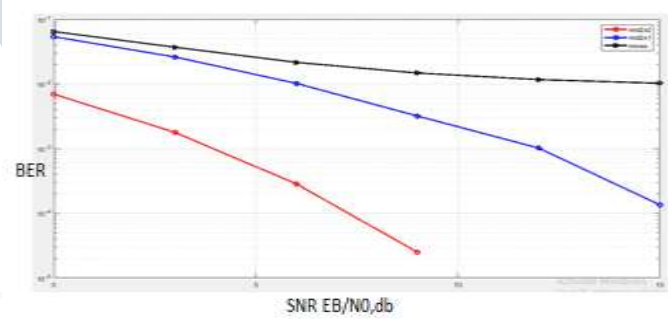

Fig 7: shows the comparison of BER and SNR of MIMO-MC-CDMA system with the combining techniques like MLD (2x1), MLD (2X2)

Algorithm of Proposed System

Algorithm for implementation of MLD combining Technique in Space Time Block Coded MIMO-MC-CDMA is explained below [9].

a) Generate the binary data bits from the data generator block.
b) Data modulation can be done by using BPSK modulation.
c) Transmit the data into space time block coded using Alamouti scheme.
d) Then the data is spreaded using Walsh Hadamard spreading code.
e) Formerly the spreaded signals are united then serial to parallel conversion then IFFT and parallel to serial changed and transferred through the Rayleigh flat

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fading channel using two transmitting antennas at the transmitter.

f) The signal is received with one and two receiving antennas at the receiving side.
g) Then data converts into serial to parallel conversion, FFT and parallel to serial .
h) The data is data combined using MLD combiner and detected.
i) Then dispreading and data demodulation is done.
j) Finally, Bit Error Rate is plotted.

IV. CONCLUSION

The existing system mainly focuses on MC-CDMA technology and BER performance. By using Diversity Combining techniques in MC-CDMA system at receiver there is possibility of getting errors because in MC-CDMA as the quantity of users rises interference increases. Through this the original data is corrupted and BER performance will be degraded.

So in proposed work to avoid multipath fading effects by allocating more number of users MIMO technology is added MC-CDMA technology. As result the MIMO-MC-CDMA technology used for transmitting large amount of data with high data rates at a time. But In order to avoid increasing BER Equal Gain Combining (EGC1x2) and Maximal Ratio Combining(MRC1x2) which is receive antenna diversity combining techniques are compared with the MMSE(2x1) which is transmit antenna diversity combining .By using these methods the BER performance is improved . MMSE and MLD (2x1 and 2x2) in MIMO-MC-CDMA system using the diversity scheme Space Time Block Coding (STBC) are proposed. The results shows that potential among these techniques to reduce BER in STBC MIMO-OFDM can be achieved using MLD (2x1) and MLD (2x2) in a better way. The BER performance of SISO- MC-CDMA also compared to Space Time Coded MIMO-MC-CDMA system which is enhanced compared with the SISO-MC-CDMA system.

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