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PERFORMANCE OF CHANNEL ESTIMATION TECHNIQUE INMIMO-OFDM SYSTEM USING m-PSKMODULATION

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Abstract

Multicarrier modulation technique as Orthogonal Frequency Division Multiplexing (OFDM) is able to vanishIntersymbol Interferences (ISI) caused by multipathchannel. Merging with multi-antenna transmission techniques such asMIMO become MIMO-OFDM system is able to improve (data rate transmission)the transmission of data and capacity of the system. Pilot channel estimation technique with the algorithm Linear Minimum Mean Square Error (LMMSE) with modulation m-PSK is applied in this study. The results obtained in the form of graphs BER against EbNo which shows that the system performance with LMMSEestimator has a different gain for QPSKmodulation better about 0.75 dB, for 8 PSKmodulation is about 1.5 dB and for 16 PSKmodulation around 1 dB compare to LS estimator. Number of the largest antenna both in the transmitter and receiver produce the best system performance. Observation for QPSKmodulation shows a scheme transmitter-receiver antenna 4x2 having gain approximately 9 dB better than the number of the lowest transmitter antenna(1x2). For scheme 4x4 shows gain around 8,5 dB than the number of the lowest receiver antenna.

Keywords:MIMO, OFDM,LS, LMMSE, MPSK.

1. INTRODUCTION

OFDMis a famous technique of multi-carriermodulationand lot of researches about it have been conducted. The OFDMtechnique divides series of high speed information data become parallel series of low speed information data, so that symbol duration becomes larger than duration of delay spread channel so that it is capable of vanishing the effect of ISI [1].The technology of OFDM has hingher spectral efficiencyand is able to minimize bandwidth by arrange bandwidth of some subcarrier in overlapping orthogonally so itcan not produce Inter Carrier Interference (ICI).Process of transmissioncan be conducted by providing more antenna at both receiver and transmitter which is called MIMO to rise transmission rate when the signal through multipath channel.MIMOoffers addition of parallel channel in space domain, so MIMO-OFDM system is a combination technique that can fulfill needs of communication system with high data rate [1].By using space time block coding (STBC), encoder will send some series of replicasdataas a number of receiver antenna, and in the receiver the signals will be summed using Maximum Ratio Combining (MRC) and is being detected using Maximum LikehoodDetector (MLD) to obtain similar signal with that's sent.

MIMO-OFDM system still has problem related to channel characteristic mentioned as Channel state information (CIS)which has not been recognized yet so that it is difficult to do detection process coherently. For problem solving, it is being appliedchannel estimation technique. One of that which has been frequently researched is based on pilot signals insertion. There are two problems for planning channel estimation techniquein wireless system. The first is how to manage the pilot information, where pilot means reference signal used in both transmitter and receiver. The second is design of estimator so it will not be difficult and good ability in searching channel charateristics. Both problems are related to each other. Generally, fading channel of OFDMsystem can be shown as 2 dimensions (2D) signal (time and frequency) based on the complex 2DWiener filter interpolationand structure of 2D estimator is too complex for practical implementation.

OFDM system usually needs the high accurately and low complexity estimator mentioned as one dimension (1D) channel estmation. The two basic of 1Dchannel estimator is estimation are block type and comb type channel estimation, where the pilots are inserted in the direction of time and frequency [2].

That block type can be conducted by put pilot in all subcarriersymbol of OFDMperiodically called type block. It is used for slow fadingchannel [3]. The estimation of this can utilizethe methods of Least Square (LS), Minimum Mean Square Error (MMSE) andmodifiedMMSEnamelyLinier Mean Minimum Square Error(LMMSE). LMMSEhas better performance than LS estimation [4].

Implementation of channel estimation technique with arranging pilot at OFDM system has been done by SinemColeri at all [5]. Otherwise the implementation of channel estimation technique with pilot carriers at MIMO-OFDM system withSTBChas been studied by Kala Praveen BagadiandSusmita Das [6] for modulation of BPSK, QPSKandQAM.

In this research has been conducted the performance analysis of channel estimation technique LMMSE at MIMO-OFDM system with encoder STBCfor m-PSKmodulation (up to16 PSK) with change number of receiver and transmitter antenna

2. MODELING OF CHANNEL ESTIMATION SYSTEM OFMIMO-OFDM

System model of channel estimation in MIMO-OFDMshown at figure 1. Methods explained at testing of MIMO-OFDMsystem using channel estimation at Rayleigh fading channel.

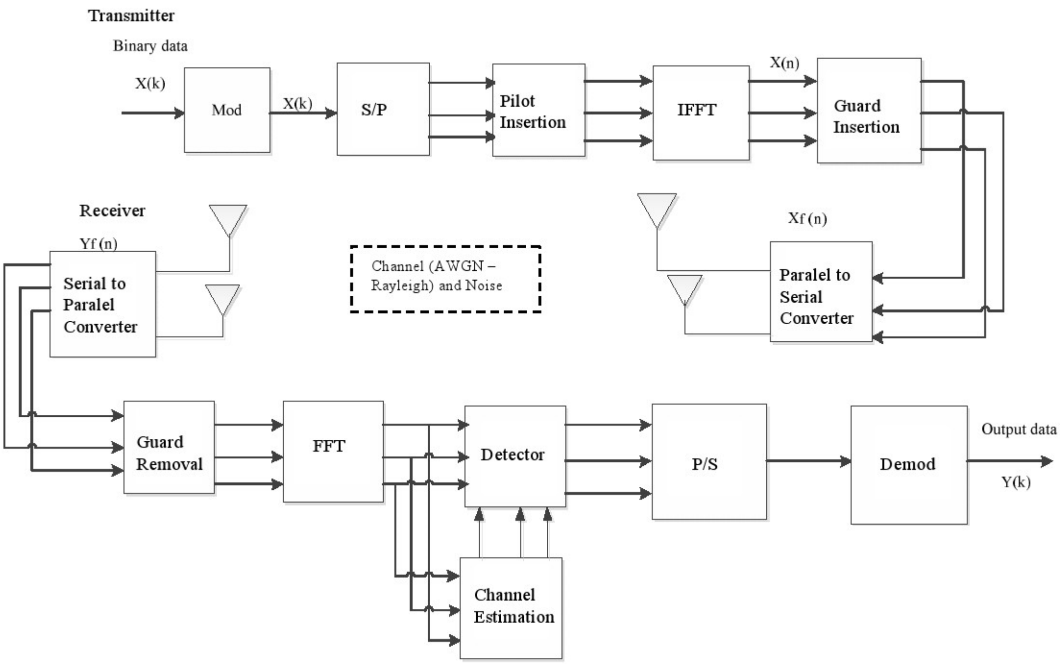

Figure1. System diagram block..

At figure 1, the transmitter generates bits of information X[k], then conducts modulation process, and it is changed to parallel form as number of subcarrier used. The outputs from block Serial to Paralelis inserted pilot signals arranged according to block type channel estimation, pilot signals are initialized based on constellation of m-PSK modulation, pilotis inserted into allsubcarrierfrom OFDM symbol periodically.At figure 2 shows pilot insertion technique of block type channel estimator.

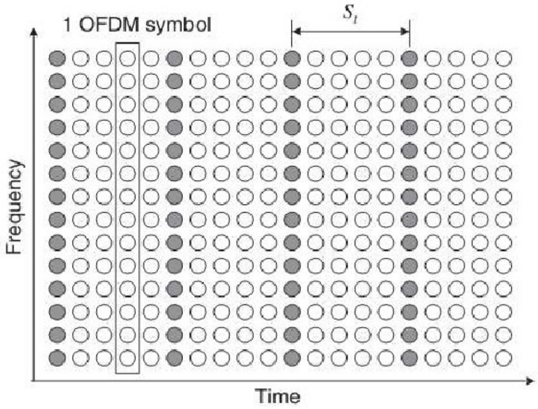

Figure 2. Pilot insertion in block type channel estimator. [3]

As shown in the figure 2 it shows that by inserting pilot signals into all subcarrierperiodically with $S_t$states pilot ratio or distance between one pilot to another.Output of pilot inserting is X[k]. Furthermore, X[k] processedIFFTto changed into time domain refers to formulas(1),(2).

$$x(n)=IFFT\{X(k)\}, \quad n = 1, 2, \ldots\ldots\ldots, N-1 \tag{1}$$

$$x(n) = \sum_{k=0}^{N-1} X(k)e^{j(2\pi kn/N)} \tag{2}$$

where *N is length of* FFT.

After IFFT block, insertedguard timeor cyclic prefixthat has longer duration than delay spreadto vanish Inter-Symbol Interference(ISI), in this research 32 is length of cyclic prefix(cp) with 128 subscarrier. The OFDM symbol which addedcp written as,

$$x_f(n) = \begin{cases} x(N+n), & n = -N_g, -N_g+1, \cdots, -1 \\ x(n), & n = -N_g, -N_g+1, \cdots, -1 \end{cases} \tag{3}$$

where$N_g$is length of cp.

3. PLANNING OF CHANNEL ESTIMATION SYSTEM OF MIMO-OFDM

Channel estimation system of MIMO-OFDM which is planned has block diagram as seen at figure 1, by using STB coding technique and the estimation technique applied is LMMS. It is further explained as follows.

The OFDM symbols$x_f(n)$are going to be transmitted by using multiple antenna in both receiver and transmitter, technique of sending symbol$x_f(n)$adjust as coding matrixSTBC just like a figure 3, if used both 2 receiversand 2antennas.

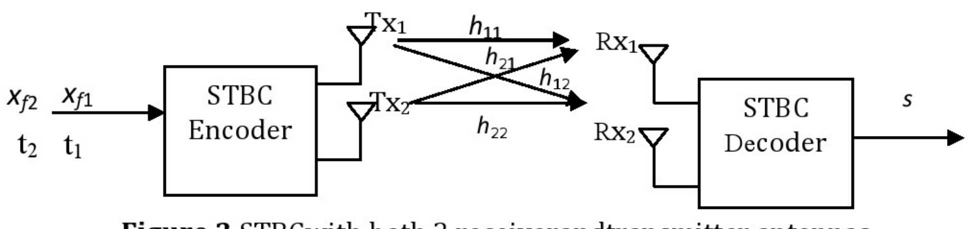

Figure 3.STBCwith both 2 receiverandtransmitter antennas

To simplify the writing of sent symbols, it will be written as following equation:

$$x_f = [x_1 x_2] = \begin{bmatrix} x_1 & -x_2^* \\ x_2 & x_1^* \end{bmatrix} \tag{4}$$

By using antenna 2x2, signals sent are devided in time slot$t_1$and t_2. At the

time $t_1$transmittterantennaTx1 dan Tx2 transmit symbolsx_1 andx_2 while at the time t_2 transmit symbols $-x_2^*$ andx_1^*.
The fadingchannel for each transmitter defined:

$$h_{ij} = \alpha_{ij} e^{j\theta i} \tag{5}$$

where$i$= 1,2 is pathnumberfrom $i$thtransmitter antenna to $j$threceiver antenna. At the time slot $t_1$antennas of Rx1 and Rx2 both accept symbolsr_1^1andr_2^1, at time slot $t_2$antennas of Rx1 and Rx2 both receive symbols of r_1^2danr_2^2, as stated in follow equation:

$$\begin{bmatrix} r_1^1 \\ r_2^1 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} n_1^1 \\ n_2^1 \end{bmatrix}$$
$$\begin{bmatrix} r_1^2 \\ r_2^2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} -x_2^* \\ x_1^* \end{bmatrix} + \begin{bmatrix} n_1^2 \\ n_2^2 \end{bmatrix} \tag{6}$$

where$n$is noiseadditive Gaussian, h_{ij} is channelimpulse responsebetween transmitter and receiver, and$r$is symbol attained by receiver antenna. Equation (6) is able combined and arranged as below.

$$\begin{bmatrix} r_1^1 \\ r_2^1 \\ r_1^{2^*} \\ r_2^{2^*} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \\ h_{12}^* & -h_{11}^* \\ h_{22}^* & -h_{21}^* \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} n_1^1 \\ n_2^1 \\ n_1^{2^*} \\ n_2^{2^*} \end{bmatrix} \tag{7}$$

Further, it is conducted *decoding* STBC process using MRC, obtained series of symbol estimation as [7],

$$\tilde{x}_1 = h_{11}^* r_1^1 + h_{12} r_1^{2^*} + h_{21}^* r_2^1 + h_{22} r_2^{2^*}$$
$$\tilde{x}_2 = h_{12}^* r_1^1 + h_{11} r_1^{2^*} + h_{22}^* r_2^1 + h_{11} r_2^{2^*} \tag{8}$$

With using MLD, symbols received are stated as following equation (9)[7].

$$\left\| \left[\sum_{i=1}^{2} \left(r_i^1 h_{i1}^* + r_i^{2^*} h_{i,2} \right) \right] - x_1 \right|^2 + \psi |x_1|^2$$

$$\left\| \left[\sum_{i=1}^{2} \left(r_i^1 h_{i2}^* + r_i^{2^*} h_{i,1} \right) \right] - x_2 \right|^2 + \psi |x_2|^2$$

$$\psi = \left(-1 + \sum_{i=1}^{2} \sum_{j=1}^{2} \left| h_{ij} \right|^2 \right) \tag{9}$$

If used size of antennatransmitter 2 and 4, transmission matrix using Orthogonal Space Time Block- Codesconcept is shown as,

$$X_3 = \begin{bmatrix} x_1 & -x_2 & -x_3 & -x_4 & x_1^* & -x_2^* & -x_3^* & -x_4^* \\ x_2 & x_1 & x_4 & -x_3 & x_2^* & x_1^* & x_4^* & -x_3^* \\ x_3 & x_4 & x_1 & x_2 & x_3^* & x_4^* & x_1^* & x_2^* \end{bmatrix} \quad (10)$$

$$X_4 = \begin{bmatrix} x_1 & -x_2 & -x_3 & -x_4 & x_1^* & -x_2^* & -x_3^* & -x_4^* \\ x_2 & x_1 & x_4 & -x_3 & x_2^* & x_1^* & x_4^* & -x_3^* \\ x_3 & -x_4 & x_1 & x_2 & x_3^* & -x_4^* & x_1^* & x_2^* \\ x_4 & x_3 & -x_2 & x_1 & x_4^* & x_3^* & -x_2^* & x_1^* \end{bmatrix} \quad (11)$$

After coding and detectionprocess, symbols$y_f(n)$are obtained then began to eliminate cpand changed to time domain by DFT process,

$Y(k)$=DFT {$y(n)$}, n = 1, 2, ..., N - 1

$$Y(k) = \frac{1}{N}\sum_{k=0}^{N-1} y(n)e^{-j(2\pi kn/N)} \quad (12)$$

Supposed to ISI not happened, relation between $Y(k)$ and $H(k)$ = DFT {$h(n)$} is

$$Y(k) = X(k)H(k) + W(k) \quad (13)$$

After through DFT block, signal (k)is processed by creating channel estimatorand also detect that signal. The estimator utilizesLMMSE algorithm which formulated as,

$$H_{lmmse}(k) = R_{hh}\left(R_{hh} + \frac{\beta}{SNR}I\right)^{-1} H_{ls} \quad (14)$$

Where$R_{hh}$is matrix auto-correlation of channel, I is matrix identity, SNR is noise power generation and H_{ls} is estimator of LS, then βbased on modulation type m-PSK used, at this research takenβvalue is one, creating R_{hh}conducted according to equation (14), subcarrier$k1$and$k2$, which is given by equation (15)

$$R_h(k1,k2) = \frac{1-e^{-L[\frac{1}{\tau(rms)}+2\pi j(k1-k2)/N]}}{\tau_{(rms)}(1-e^{-\frac{L}{\tau(rms)}})(\frac{1}{\tau_{(rms)}}+j2\pi(k1-k2)/N)} \quad (15)$$

with$L$is length of cyclic prefixand$\tau(rms)$is RMS factor delay spreadassumed ¼ of length cylic prefixand calculation of R_{hh}applied as number of subscarrierto form LMMSEestimator.Otherwise for LSestimatorwritten as follow:

$$H_{ls} = \frac{Y(k)}{X} \quad (16)$$

Where$Y(k)$is received pilot and X ispilot sequencethat's sent.

After achieving value of H_{lmmse} from equation (14),then signal$Y(k)$ *is* detected *using* detector Zero Forcing (ZF). In this simulation, detector ZFis formulated as equation (17).

$$X_e(k) = \frac{Y(k)}{H_{lmmse}(k)} \quad (17)$$

Where$Y(k)$is a symbol ofOFDM without pilot signal and $H_{lmmse}$is estimator LMMSE. Output of diagram block is a complex signal $X(k)$,then it will be demodulated to reobtained signal$x(k)$.

Simulation Parameter

Parametersused to build OFDM system with channel estimation base on pilot arranging block type are in the Table 1.

Table 1. Simulation Parameter

Parameter	Specification
Number of Bit	153600
Pilot ratio	1/6
Number of*subcarier*	128
Length of*cyclic prefix*	32
Channel estimation technique	Ttpe block
Channel Model	Rayleigh and AWGN
Estimator	*Linier Minimum Mean Square Error*
Modulation type	M-PSK (QPSK, 8PSK and 16 PSK)
Number of Antenna	1x2, 2x2, 3x2, 4x2, 4x1, 4x3, 4x4

4. SIMULATION RESULT

For testing channel estimation system MIMO-OFDM it is conducted by changing size of transmitter-receiver antenna2x2, 3x2, 4x2 andreceiverantenna 4x1, 4x2, 4x3, 4x4with applying m-PSK modulation. The testing is being conducted by using QPSK, 8PSK and 16 PSK modulation. The observation presented in graphBit Error Rate (BER) toSignal To Noise Ratio(SNR) orEbNofor observing the performance of system, BER valued observed is 10^{-5}.

4.1 Simulasi result of channel estimation technique at MIMO-OFDM system with the changing of receiver antenna number, QPSK modulation.

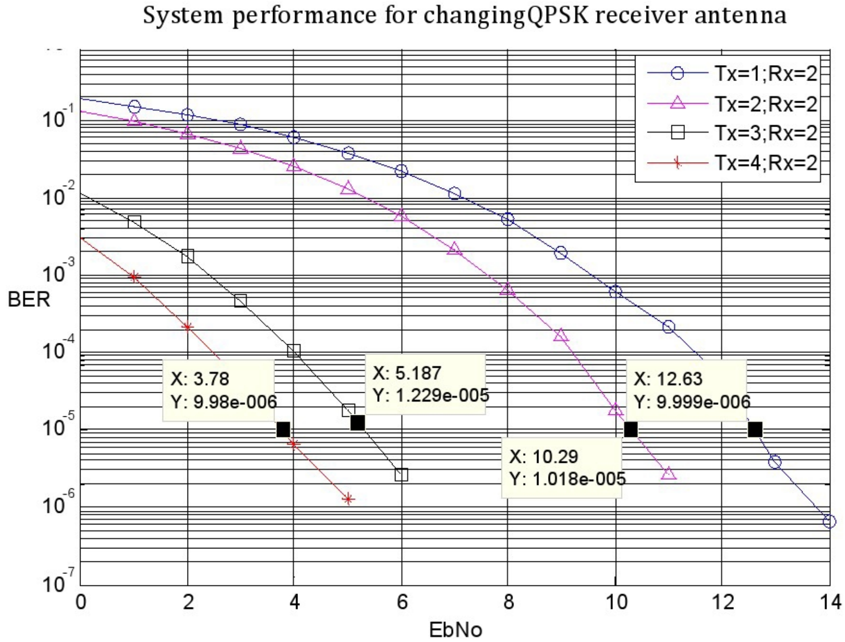

Figure 4. System performance for changing transmitter antenna and 2 receivers antenna with QPSK modulation

At figure 4 obtained performance for scheme transmitter-receiver antenna4x2 reaches BER = 10^{-5} at value EbNo =±4 dB and scheme of performance 3x2 at valueEbNo =±5 dB, scheme 2x2 BER = 10^{-5} atEbNo =±10 dB andscheme1x2 reaching BER = 10^{-5} at value EbNo= ± 13 dB.

At figure 5 attained system performance for scheme transmitter-receiver antenna 4x1 reachesBER= 10^{-5} at value EbNo =±8 dB and performance of shceme4x2 atEbNo =±4 dB, performance of scheme 4x3 atEbNo =±1 dB and performance 4x4 up toBER= 10^{-5} at value EbNo =± 0,5 dB.

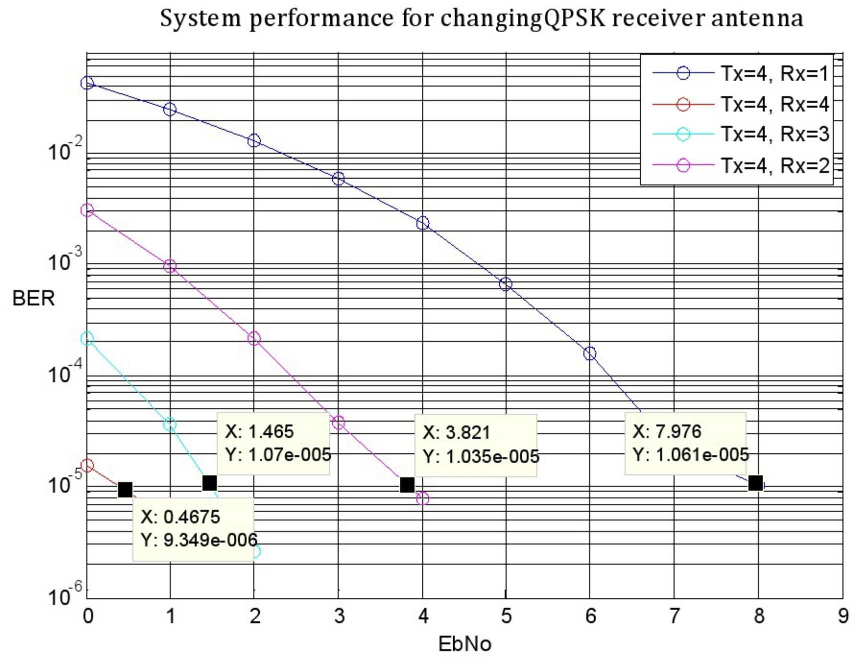

Figure5. System performance for changing receiver antenna and 4 transmitter antennas with QPSK modulation

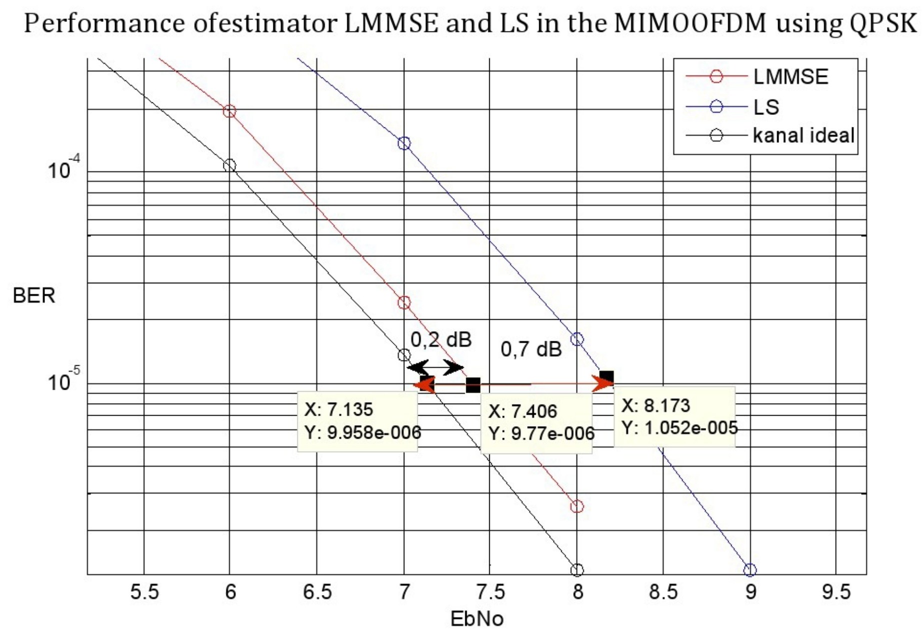

Figure6. Performanceofestimator LMMSE and LS in the MIMO OFDM system using QPSK modulation

The performance of both estimator LS and LMMSE at figure6shows that LMMSE has performance ± 0,7dB that is better than performance of estimator LS using QPSK modulation.

4.2.Simulation resultchannel estimation technique at MIMO-OFDM system with changing number of receiver antenna, 8 PSK modulation.

At figure 7 it is shown that system performance of scheme transmitter-receiver4x2 reachesBER = 10^{-5} at value EbNo= $\pm$13 dB and performance of scheme 3x2 at EbNo= $\pm$ 15 dB, scheme 2x2 atEbNo =$\pm$20 dB and scheme 1x2 up to BER 10^{-5} at EbNo= $\pm$ 23 dB.

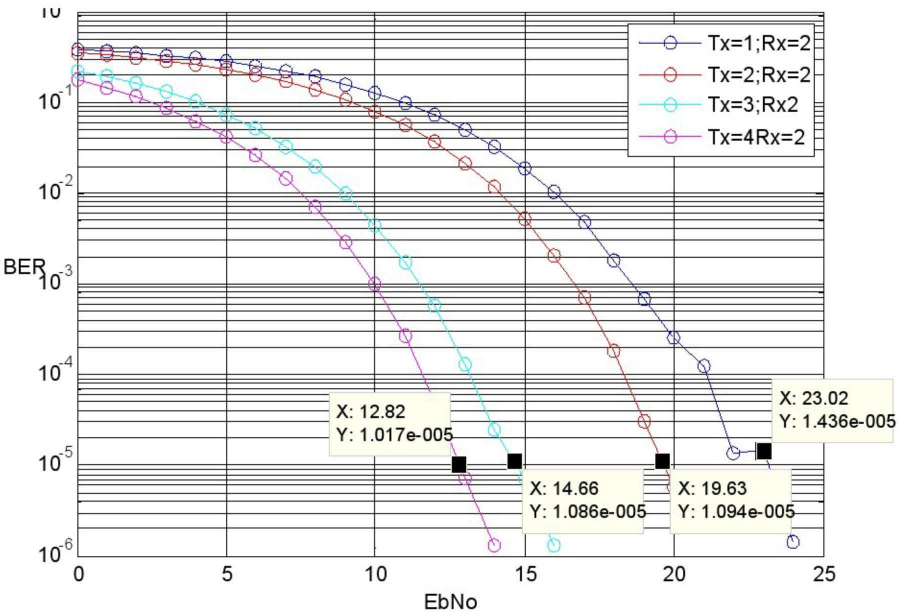

Figure7. System performance for changing transmitter antenna and 2 receiver antenna with 8PSK modulation

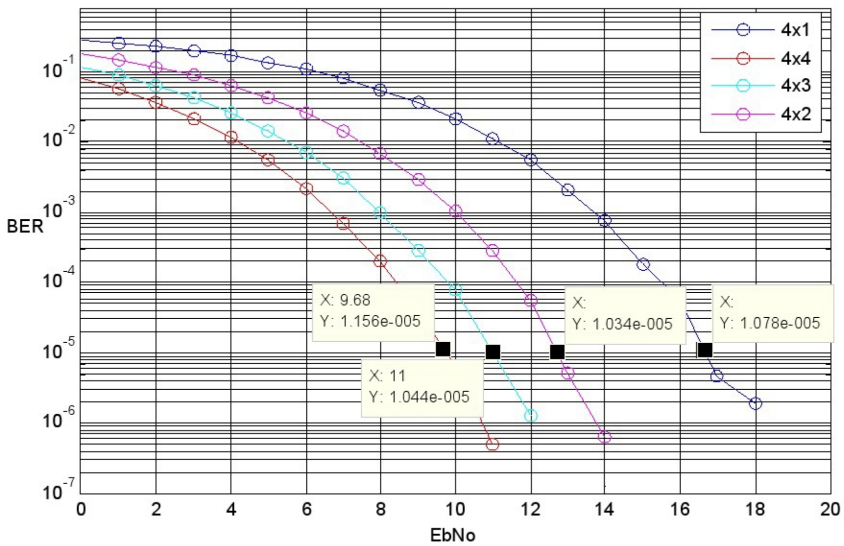

Figure8. System performance for changing transmitter antenna, and 4 transmitter antennas with 8 PSK modulation

At Figure 8, for changing receiver antennait was obtained performance of scheme 4x1 reaches BER = 10^{-5} atvalue EbNo =±17 dB and performance of scheme 4x2 atEbNo = ±13 dB, scheme 4x3 atEbNo = ±11 dB and scheme 4x4 up to BER 10^{-5} at EbNo = ± 13 dB.

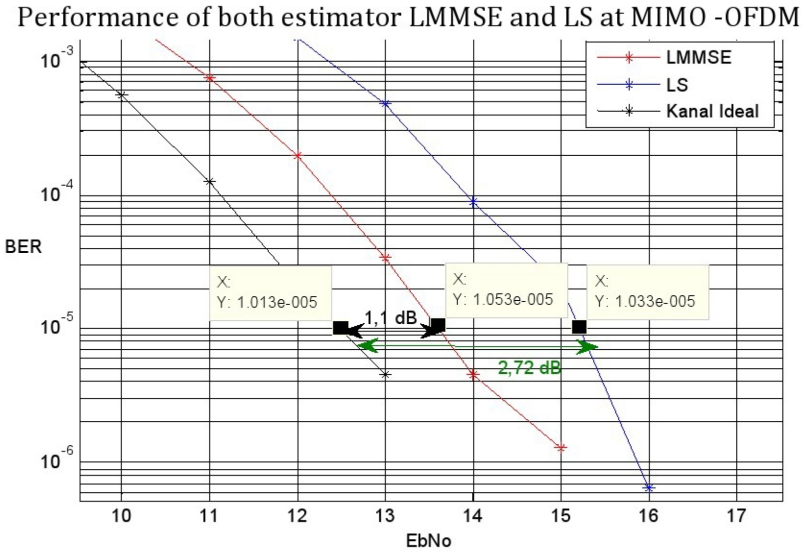

Figure 9. Performanceof bothestimator LMMSE and LS at MIMO -OFDM system using 8 PSK modulation

The performance of both estimator LS and LMMSE pointed at Figure 9, it is shown that performance LMMSE has gain value ±2,3 dB better than performance LSwith 8 PSK modulation.

4.3. Testing at channel estimation technique MIMO-OFDM using 16 PSK modulation.

At figure 10 it is interpreted that performance of scheme transmitter-receiver 4x2 reaches BER = 10^{-5}at value EbNo= ±23 dB and performance of scheme 3x2 at rate EbNo =± 24 dB, scheme2x2 atEbNo = ±29 dB and scheme 1x2 up to BER 10^{-5}at EbNo =± 31dB.

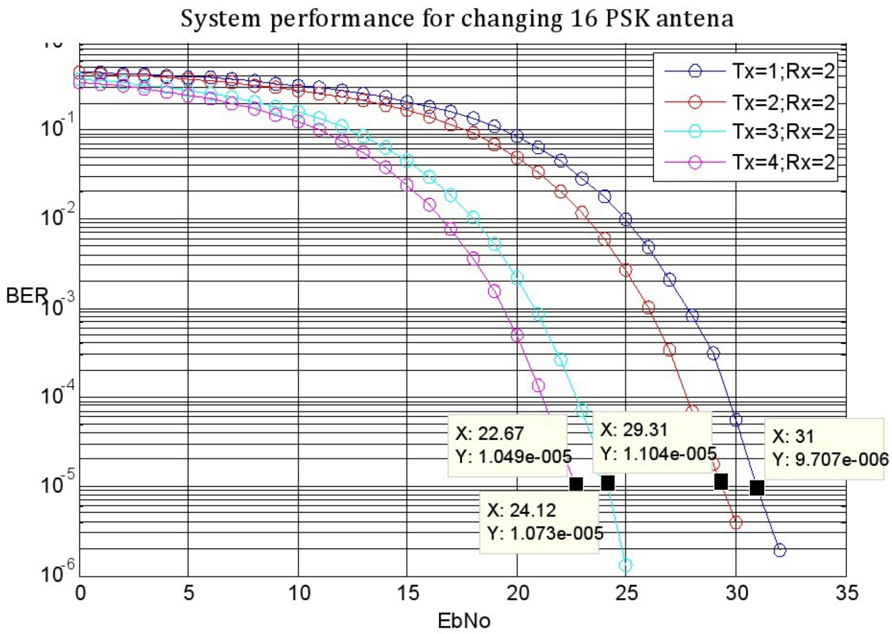

Figure10. System performance for changing transmitter antenna and 2 receiver antennas with 16 PSK modulation

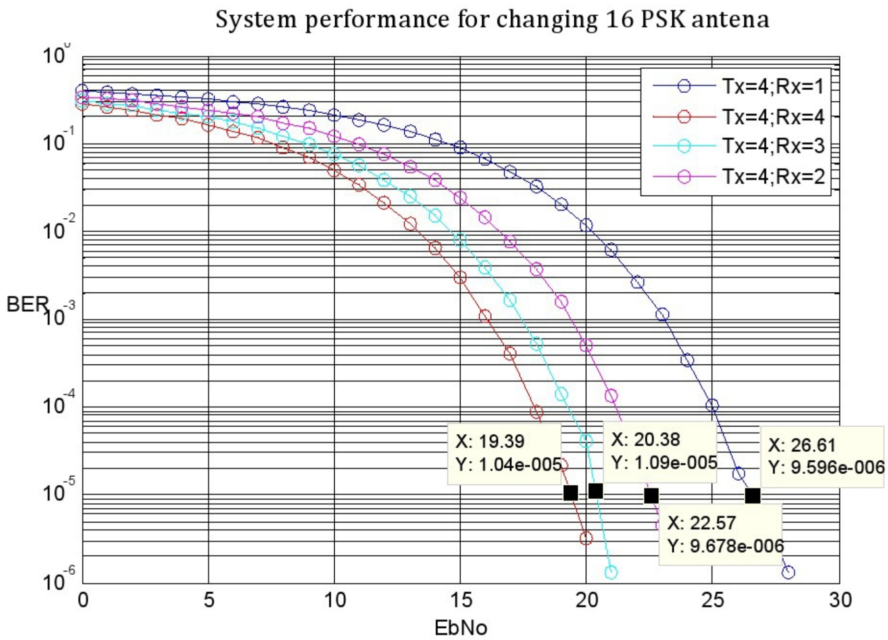

Figure 11. System performance for changing receiver antenna and 2 transmitter antenna with 16 PSK modulation

At figure 11 is shown that changing receiver antennaobtained performance outcomes scheme4x1reaches BER = 10^{-5}atvalue EbNo= ±27 dB, performance of scheme4x2 at EbNo =± 23 dB, scheme 4x3 atEbNo =± 20 dB andperformance of scheme4x4 up to BER 10^{-5} at EbNo =± 19 dB.

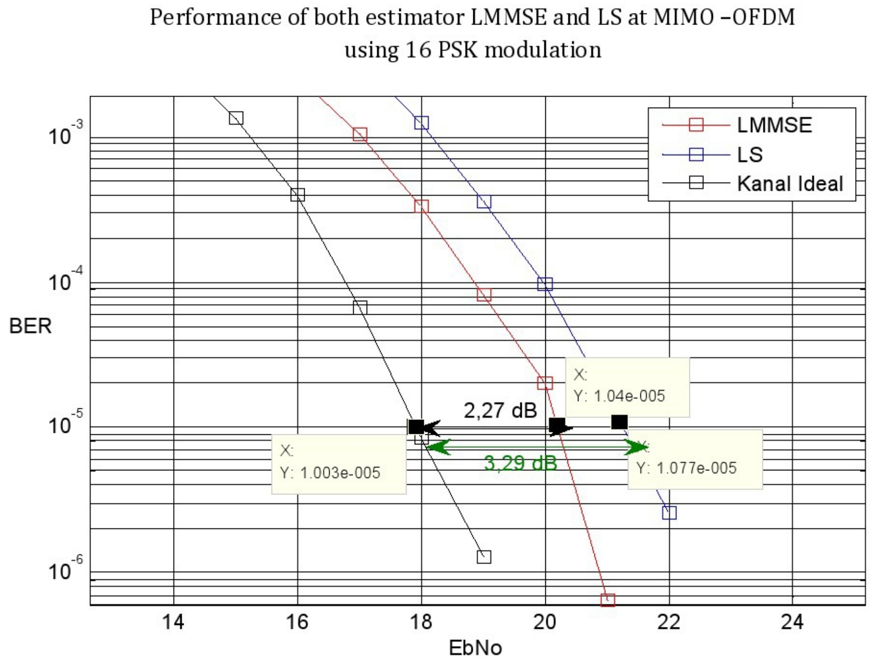

Figure 12. Performanceofboth estimator LMMSE and LS at MIMO –OFDM system using 16 PSK modulation

Performanceofboth estimator LMMSE and LS which shown at Figure 12 proves that performanceof estimator LMMSE has gain 1 dB better than estimator LSat 16 PSK modulation.

5. CONCLUSION

Based on the result of testing system using simulation, it can be concluded as follow:

- Performance of channel estimation technique LMMSE at MIMO OFDM system with M-PSK modulationfor the largest receiver antenna, scheme 4x2 has the best performance, approximately 9 dB compared with number of lowest transmitter antenna(one piece), for QPSKmodulation.
- For changing receiver antenna, scheme with the largest receiver antenna namely 4x4 also show the best performance, about 8,5 dB compared with number of the lowest receiver (one piece), for QPSKmodulation.
- Estimator LMMSE produce better performance thatestimator LS for all scheme transmitter-receiver antenna. For QPSKmodulation is better around 0,75 dB, for 8 PSK modulationapproximately1,5 dB and for 16 PSK modulationround 1 dB.

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