

BER Performance by Modulation in Fading Channel with MLSE\MMSE Analysis

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ABSTRACT

During the research equalizer is always a matter of strategies. When a signal is transmitted over a radio channel, it is subject to reflection, refraction and diffraction and also the type of modulation technique selected at transmitter. The communication environment changes quickly and thus introduce more complexity and uncertainty to channel response. Ofdm is one of the best multiplexing techniques which compensate intersymbol- interference as well as co-channel- interference. In wireless Communication, scarce resources and hence imposes a high cost on the high data rate transmission. Fortunately, the emergence of multiple antenna system has opened another very resourceful dimension space, for information transmission in the air. OFDM suffers a number of drawbacks; high peak-to-average power ratio (PAPR), a need for an adaptive or coded scheme to overcome spectral nulls in the channel, and high sensitivity to frequency offset. This can result in poor power efficiency, degradation in bit-error-rate (BER) performance, and spectral spreading. For analysis and comparison, two parameters such as BER and PAPR are considered with different modulation techniques with different channels. MMSE equalizer under the multipath fading and MIMO strategy has improved Bit Error Rate Performance in this paper.

Keywords: Mimo, Ofdm, Intersymbol Interference, Minimum Mean Square Error, Rayleigh Random Variable.

1. INTRODUCTION

A balanced linear equalizer is the Minimum Mean-Square Error (MMSE) equalizer, which does not usually eliminate ISI completely but instead minimizes the total power of the noise and ISI components in the output, therefore preferred in Orthogonal Frequency Division Multiplexing (OFDM) [2]. We want to solve the problem of Inter-symbol Interference (ISI) therefore the joint operation of OFDM with MMSE. In statistics and signal processing, MMSE estimator describes the approach, which minimizes the mean square error (MSE)[2], which is a common measure of estimator quality. The term MMSE specifically refers to estimation in a Bayesian setting, since in the alternative frequency setting there does not exist a single estimator having minimal MSE. A somewhat similar concept can be obtained within the frequent point of view if one requires

Unbiasedness, since an estimator may exist that minimizes the variance (and hence the MSE) among unbiased estimators. Such an estimator is then called the minimum-variance unbiased estimator (MVUE).

2. OFDM – BASIC PRINCIPLES

OFDM is a multicarrier transmission technique used in applications catering to both Wired and Wireless Communications. To generate OFDM signals successfully the relationship between all carriers must be carefully controlled in order to maintain orthogonality. Shown below is the frequency spectrum depicting the various carriers/channels (used interchangeably). Rectangular windowing of transmitted pulses results in a sinc-shaped frequency response for each channel. As can be seen, whenever any particular carrier frequency attains peak amplitude, the remaining carriers have a null point.

OFDM Generation

The spectrum required is first chosen based on the input data and the modulation scheme used (typically Differential BPSK,

QPSK or QAM) [6]. Data to be transmitted is assigned to each carrier that is to be produced. Amplitudes and phases of the carriers are calculated based on the chosen scheme of modulation. The required spectrum is then converted back to its time domain signal by employing Inverse Fourier Transform algorithms like the Inverse Fast Fourier Transform (Cooley-Turkey Algorithm). The next step is that of adding a guard period to the symbol to be transmitted. This ensures robustness against multipath delay spread. This step can be achieved by having a long symbol period, which minimizes intersymbol interference. The level of robustness can be further increased by the addition of a guard period between successive symbols.

Benefits of OFDM and Performance Criteria

The four main criteria for evaluating the performance of the OFDM system are tolerance to multipath delay spread, peak power clipping, channel noise and time synchronization errors. The performance of different OFDM systems under varied channel conditions, keeping in mind the above criteria is now discussed.

Peak Power Clipping:

The OFDM signal showed high degrees of tolerance (BER is not affected adversely) even if it was heavily clipped. The clipping distortions mostly arise from the Power Amplifier transmitting the signal.

a. Gaussian Noise Tolerance of OFDM:

Since the transmitted signal is similar to standard FDM, it is found that the SNR performance is similar to standard single carrier digital transmission. The BER is found to be adversely affected, if the SNR drops below 6dB.

b. Time-Synchronization Errors

The Synchronization factor in an OFDM system is the most critical one. When the receiver is initially turned on, it is not in synchronization with the transmitter. For this reason, data transmission in an OFDM [7] system might need data to be sent in frames. At the beginning of each frame a null symbol is transmitted, so that the receiver can detect incoming data using simple envelope detection techniques.

3. MINIMUM MEAN SQUARE ERROR (MMSE)

In statistics and signal processing, a minimum mean square error (MMSE) estimator describes the approach which minimizes the mean square error (MSE), which is a common measure of estimator quality. The term MMSE specifically refers to estimation in a Bayesian setting, since in the alternative frequentist setting there does not exist a single estimator having minimal MSE. A somewhat similar concept can be obtained within the frequentist point of view if one requires unbiasedness, since an estimator may exist that minimizes the variance (and hence the MSE) among unbiased estimators. Such an estimator is then called the minimum-variance unbiased estimator (MVUE).

Mathematical Representation Let X be an unknown random variable, and let Y be a known random variable (the measurement). An estimator $\hat{X}(y)$ is any function of the measurement Y , and its MSE is given by

$$i. \quad \text{MSE} = E \left\{ (\hat{X} - X)^2 \right\}$$

where the expectation is taken over both X and Y . The MMSE estimator is then defined as the estimator achieving minimal MSE.

Mmse Estimator

In many cases, it is not possible to determine a closed form for the MMSE estimator. In these cases, one possibility is to seek the technique minimizing the MSE within a particular class, such as the class of linear estimators. The linear MMSE estimator is the estimator achieving minimum MSE among all estimators of the form $AY + b$. If the measurement Y is a random vector, A is a matrix and b is a vector. (Such an estimator would more correctly be termed an affine MMSE estimator, but the term linear estimator is widely used.)

a.) Under some weak regularity assumptions, the MMSE estimator is uniquely defined, and is given by [5]

$$\hat{X}_{\text{MMSE}}(y) = E\{X|Y=y\}, \quad \text{ii}$$

In other words, the MMSE estimator is the conditional expectation of X given the observed value of the measurements.

b. if X and Y are jointly Gaussian, then the MMSE estimator is linear, i.e., it has the form $aX + b$ for constants a and b. As a consequence, to find the MMSE estimator, it is sufficient to find the linear MMSE estimator. Such a situation occurs in the example presented in the next section.

The orthogonality principle: An estimator $\hat{X}$ is MMSE if and only if [8]

$$E\{(\hat{X} - X)f(Y)\} = 0 \quad \text{iii}$$

for all functions f(Y) of the measurements. A different version of the orthogonality principle exists for linear MMSE estimators.

Fading Analysis:

For simulation purposes, it is sufficient to consider baseband but it might not be sufficient for hardware implementation purposes. Therefore, the channel simulation was not made at carrier frequency which is 3.4 GHz, if that was done then spectrum would be considerably trivial as most information would contain zeros instead of doppler spectrum.

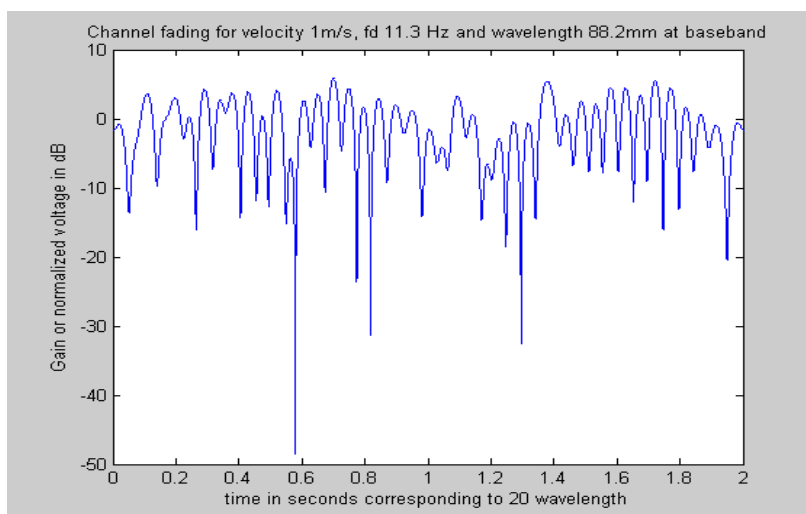


Fig 1: (Channel fading for velocity 1 m/s and wavelength 88.2 mm at baseband) [4]

Bit error rate (BER) Analysis:

A bit error rate is defined as the rate at which errors occur in a transmission system. This can be directly translated into the number of errors that occur in a string of a stated number of bits. The definition of bit error rate can be translated into a simple formula:[3]

$$\text{BER} = \frac{\text{number of errors}}{\text{total number of bits sent}}$$

ANALYZED RESULT

MATLAB provide a simple and easy way to demonstrate fading taking place. MATLAB (short for Matrix Laboratory) is a special purpose computer program optimized to perform engineering and scientific calculations. The

MATLAB language and provides a very extensive library of predefined functions to make technical programming tasks easier to solve technical problem in MATLAB than in other language. Now let us think about the other results of different MIMO strategies with MMSE receiver.

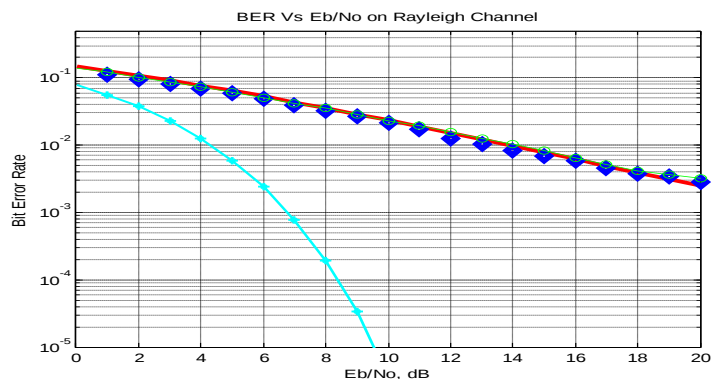


Fig 2 (Bit Error Rate with E_b/N_0 on Rayleigh Channel)

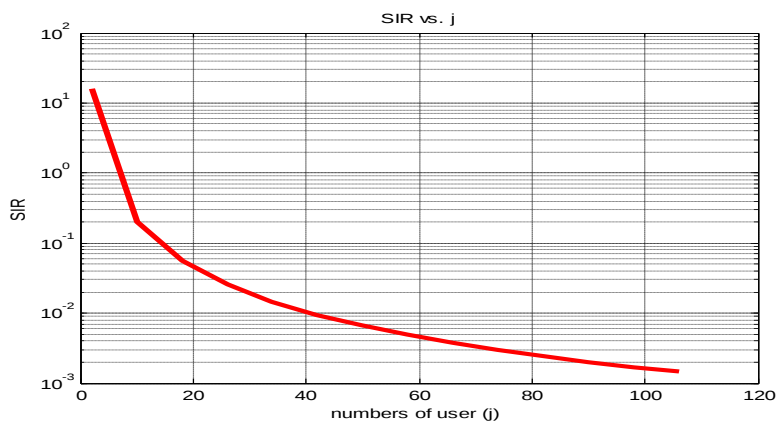


Fig3: (SIR-vs.-.j)

Parameter used for Calculation: T=298

B=100

$K=1.38 \times 10^{-23}$

Alpha=1

N1=4

alpha=1

nl=4

$ps=1 \times 10^{-3}$

Here we can see the plot between the numbers of user (j) vs. the signal to interference ratio (SIR). If we increase the numbers of user (j), the signal to interference ratio will decrease.

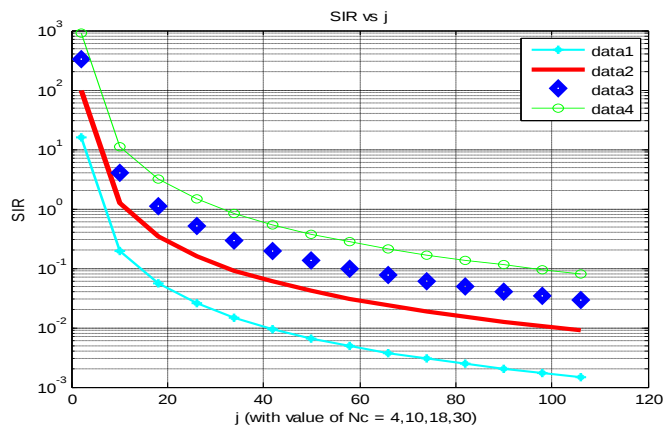


Fig 4 (SIR vs. j (with value of N_c))

Analysis for Minimum Mean Square Error (MMSE):

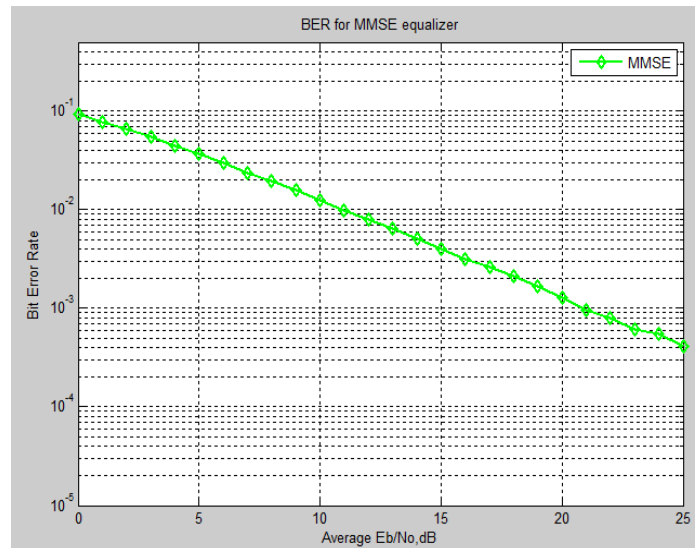


Fig 5 (BER Error Rate)

CONCLUSION

We realized that the MIMO capacity plays very important role in closing the BER performance with the vertical axis. And also the power of OFDM we realized in our equalizer. From the simulation results obtained in our case with MIMO and OFDM based MMSE equalizer, we find that the MRC may be powerful receiver technique, but due to the combination of OFDM and MMSE. By the help of simulation and mathematical calculation we have determine the The Response of the BER in Rayleigh Fading Domain, The array response of number of user increase at a desired frequency range, Consider a particular data parameter alpha on which we have calculated the different parameters like signal to noise ratio, signal frequency Range.

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