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ESTIMATION OF SIGNAL TO NOISE IN MIMO-OFDM SYSTEM

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Abstract- Telecommunications systems require increasing traffic and good signal quality. Multi-input, multi-output and OFDM systems, known as MIMO-OFDM systems, has a significant role in transmitting and receiving signals. This paper evaluates modeling and simulation of different parts of MIMO-OFDM. In this paper investigates serial to parallel, modulation and demodulation by Fourier transform and Inverse Fourier transform FFT, DFT, IFFT and IDFT in continuous and discrete system and the model of system is discussed. All required blocks are coded and simulated in Matlab software. The simulation results include, MRC technique, MMSE and OFDM BASE BAND techniques are explained and comparison of these method are illustrated.

Keywords: MIMO-OFDM, Fourier Transform, Coding, Estimation, Matlab.

1 INTRODUCTION

The original OFDM plan was put forward by Chang in 1966, when Chang published his work on the synthesis of limited-band signals for multi-frequency transmission. The main idea of OFDM is to split the frequency selection channel into parallel flat frequency sub channels. Assuming the bandwidth is narrow, the sub-channels will be almost flat in shape, making the receiver design very easy. In classical parallel data systems, the whole frequency band of the signal is subdivided into non-overlapping frequency channels. FDM or Frequency Overlap avoids inter-channel interference. However, this leads to inefficient use of the existing spectrum. The sub-channels are overlapped and orthogonal to achieve high frequency response efficiency and is named OFDM.

In 2003, Winston and Ebert proposed the idea of using Discrete Fourier Transform (DFT) for baseband modulation and demodulation, which greatly reduced the complexity of OFDM modems, because in Instead of using bank multipliers of oscillators and multiple filters, Discrete Fourier Transform (DFT) and IDFT are used to reduce the complexity of the system. Inter-symbol interference (ISI) was also reduced by using a time shield between symbols and the Cosine-Raised window. Although the proposed system on the scattering channels did not result in complete orthogonality, it was of great assistance to OFDM.

Another important step taken by Pold and Ruiz in 1980 was to introduce the use of prefix CP to solve the orthogonality of carriers, instead of having Zero-Padding they used a periodic expansion of OFDM symbols. . In fact, in this method, the original signal is repeated instead of sending zero at a shield interval. The latter arrangement converts linear convolution into circular convolution, which guarantees the orthogonality between sub-carriers in the multi-channel channel. Although CP reduces effective data rates, zero ISI compensates for this. In recent years, the collaborations of Cult, Simini, Hiroshaki and Salzburg have been significant in the development of OFDM. The most important applications of OFDM techniques in wireless transmission networks are the next generation (4G) of HIPERLAN, MILTIUSER OFDM DAB, IEEE 802.16, IEEE802.11, ADSL, WLAN, WATM, DVB-T, and mobile systems [10, 11, 12, 13].

Review of some studies and study resources:

- A non-iterative algorithm with performance retention over DFT-based iterative algorithms. It is proposed for channel estimation in mobile MIMO-OFDM [1].
- The estimation of training channel investigates by simple method in OFDM system, MIMO system and finally MIMO-OFDM. MMSE is the least squares (LS) algorithm for channel estimation based on training [2].
- The beam shaping techniques to eliminate OFDM interactions, using the Pro-FFT and Post-FFT methods [3].
- The estimation of channel in MIMO-OFDM systems is illustrated and the blind method is selected from the available methods [4].
- MIMO-OFDM systems is performed by maintaining spectral efficiency and estimation of channel [5].

PAPR is of OFDM defects. This paper deals with PAPR reduction methods [6].

- An algorithm is given for simultaneous estimation of frequency and channel offsets [7].
- The optimize the energy in the MIMO-OFDM system by selecting the appropriate antenna, a binary particle optimization algorithm [8].
- Resource allocation in MIMO-OFDM-based multi-sector systems [9].
- Explores the basics and theory of MIMO-OFDM systems [10].

- An overview of OFDM for optical telecommunications [11].
-The issue of mobile telecommunications generations [13].
- The content software is part of OFDM system s[14].
- The bit error rate in the OFDM system [15].

2. MIMO FUNDAMENTAL PRINCIPLE

As mentioned, MIMOs is multiple output and multiple input (Figure 1). In environments with independent multiplexing feeds between each pair of transmitter and receiver antenna, MIMO telecommunication systems obtained significantly higher gains than conventional systems. In addition, offer enormous advantage systems by exploiting both transmitter and receiver using different time-space coding. Two features are related to two different batches of MIMOs called space-time coding and space-sharing, in short, the first batch can improve reliability and the transmission rate of wireless systems [2, 17, 18].

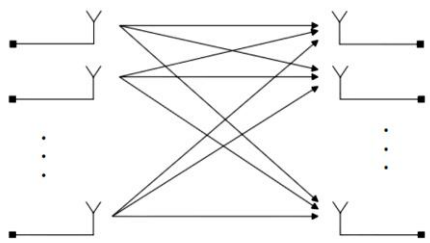

Figure 1. MIMO channel [2]

Consider a MIMO system with M transmit antenna and N receiver antenna. The signal sent by column matrix s is displayed in M×1. The total transmitting power is limited regardless of the number of transmitted M antennas to P. Assume that the signals sent from each dedicated antenna have the potential of P/M. The bandwidth of signal is narrow, so its frequency response is flat. The noise in the receiver is described by a column matrix N×1 denoted by n. The received antennas have the same noise power of σ^2. The received signal is represented by the matrix N×1, denoted by r, where each complex component points to a receiver antenna.

The channel is characterized by a complex M M N matrix denoted by H. For normalization it is assumed that the power received for each N branch is equal to the total transmitted power. Therefore, we obtain the normalization condition for H elements in a channel with constant coefficients as follows:

It is assumed that the channel matrix is known to the receiver, which can be obtained for example by sending a training preamble. Matrix H has different scenarios:

$$\sum_{j=1}^{M} \left| h_{ij} \right|^2 = M \qquad i = 1, 2, ..., N \tag{1}$$

where, the matrix H is definitive.

The random H matrix is fast feed. The channel matrix elements change randomly at the beginning of the interval of each symbol T and remain constant throughout the interval of a symbol. This channel is called fast feed channel. The H matrix is a random block feeder. Its elements change randomly and remain constant over a certain number of time intervals (shorter than a sending block). Such a channel is called a block feed channel.

The H-matrix is pseudo-static random. Matrix elements are random, but they are at the start of a specified sending block and remain constant throughout the sending block, meaning that the symbol time is smaller than the channel coherence time. Equation (2) is shown relationship between parameters.

$$r_t^j = \sum_{i=1}^{M} h^{ji}(t).s^i(t) + \nu^j(t) \quad (j = 1, 2, ..., N) \tag{2}$$

$$\begin{pmatrix} r_t^1 \\ r_t^2 \\ \vdots \\ r_t^N \end{pmatrix} = \begin{pmatrix} h^{11}(t) & h^{12}(t) & & h^{1M}(t) \\ h^{21}(t) & h^{22}(t) & \dots & h^{2M}(t) \\ h^{N1}(t) & \cdots & & h^{NM}(t) \end{pmatrix} \times \begin{pmatrix} s_t^1 \\ s_t^2 \\ \vdots \\ s_t^M \end{pmatrix} + \begin{pmatrix} \nu_t^1 \\ \nu_t^2 \\ \vdots \\ \nu_t^N \end{pmatrix} \tag{3}$$

where, $s_t = [s_t^1, s_t^2, ..., s_t^M]^T$ specifies the transmitted symbol vector with the transmitted power uniformly distributed. Here is the transcript T transcript and $\nu^j(t)$ is the noise signal [1, 2, 3].

2.1. OFDM Generation

In recent years, the need to send and receive high-speed data in 4G wireless telecommunications has been considered. However, there are challenges in the development of wireless telecommunications, one of the most important of which is the destructive effects of the wireless channel on the signal, so it is impossible to transmit high-rate data without addressing these effects. One of the methods that effectively counteract channel effects is OFDM.

OFDM, a special mode of multi-band modulation and frequency sharing, has achieved good performance in frequency-selective wireless channels and has a spectral gain due to the overlap of the sub-channels in the frequency domain. Multi-carrier data transmission fits well with the inter-symbol interference effect caused by channel delay propagation. If the symbol period is longer than the maximum channel delay extension, there is no interference between the symbol and we encounter a non-frequency channel. By dividing the signal bandwidth into a number of narrow band signals, the signal period to expand the channel delay is increased and the channel effects on the signal can be largely eliminated. In other words, OFDM converts the frequency channel into a set of flat frequency sub channels. To get into the discussion, we first need to have a definition and review of the OFDM processes and show how the signal is generated. The block diagram in Figure 2 shows the overall performance of the system as follows.

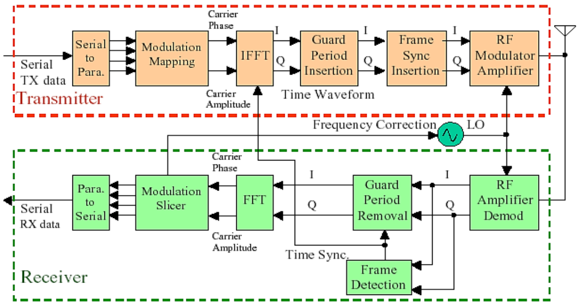

Figure 2. OFDM [1]

For discussion of the difference between FDM and OFDM and more specific bandwidth usage as Figure 3 The modulation and peak points in OFDM and the orthogonality of the signals.

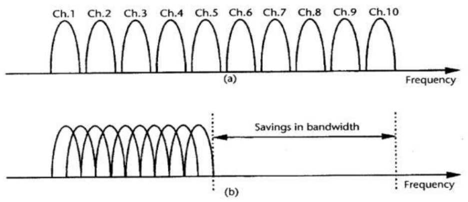

Figure 3. FDM & OFDM modulation [5]

2.2. OFDM Generation by FFT and DFT

FFT of OFDM is given bellow:

$$X(t)=\frac{1}{N_c}\sum_{n=0}^{N_c-1} S_n e^{j2\pi f_n t} e^{j\omega_c t} \qquad 0\le t\le T_s$$

$$X_b(t)=\frac{1}{N_c}\sum_{n=0}^{N_c-1} S_n e^{j2\pi f_n t} \qquad 0\le t\le T_s$$

$$f_n=\frac{n}{T_s} \tag{4}$$

$$X_b(t)=\frac{1}{N_c}\sum_{n=0}^{N_c-1} S_n e^{\frac{j2\pi nt}{T_s}} \qquad 0\le t\le T_s$$

$$f_n=\frac{n}{T_s}$$

In relation (4), N_c denotes the number of frequency channels, S_n denotes the complex symbols sent on the n channel, T_d the signal timing of the signal sent in serial mode, and T_s the signal timing of the message after serial conversion. They are parallel to $T_s=N_cT_d$.

If we sampled an OFDM symbol at times T_d, we would have relationship (5), [5].

$$T=vT_d\,,\ v=0,1,...,N_c-1$$

$$X_b(t)=\frac{1}{N_c}\sum_{n=0}^{N_c-1} S_n e^{\frac{j2\pi nt}{T_s}}\,,\quad 0\le t\le T_s \tag{5}$$

$$X_v(t)=\frac{1}{N_c}\sum_{n=0}^{N_c-1} S_n e^{\frac{j2\pi nvT_d}{T_s}}=\frac{1}{N_c}\sum_{n=0}^{N_c-1} S_n e^{\frac{j2\pi nv}{N_c}}$$

Obviously, Equation (5) shows the same IFFT relation and therefore in the OFDM method, instead of using multiple oscillators, FFT / IFFT signal processing techniques can be used, which is one of the important advantages of this method. Figure 4 shows an OFDM transmission system [1, 2, 3, 7, 8, 9].

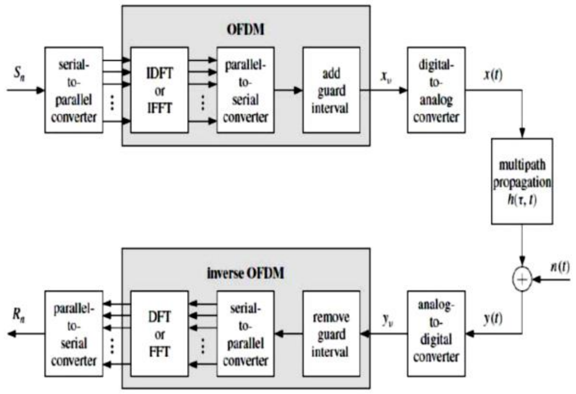

Figure 4. Transmission of OFDM modulation [5]

IDFT of OFDM is given bellow [5]:

$$w(t)=\sum_{k=0}^{k-1} X_k(t)e^{j2\pi f_k t}$$

$$w(t)\to w(nT_s)\to w(n)$$

$$w(t)\to w(nT_s)=\sum_{k=0}^{k-1} X_k(n)e^{j2\pi f_k nT_s}$$

$$n=0,1,...,K-1$$

$$f_k=k\left(\frac{W}{K}\right) \tag{6}$$

$$W=\frac{1}{T_s}$$

$$w(nT_s)=\sum_{k=1}^{k-1} X_k e^{j2\pi k\left(\frac{W}{K}\right)nT_s}$$

$$\Rightarrow w(n)=\sum_{k=0}^{k-1} X_k e^{\frac{j2\pi kn}{K}} \qquad n=0,1,...,K-1$$

$$w(n)=IDFT[X_k(n)]$$

3. OFDM ESTIMATION

One of the simple estimators is Least Square LS estimation which has been studied. The following equations show that in the domain of frequency the signal carrier. Estimation of channel can be obtained after the FFT block. The received signal is modeled with the following relation [2, 6]:

$$Y=XH+W \tag{7}$$

where, Y of the vector of signal, if X is the signal in the frequency domain $N\times 1$, X is the matrix of the transmitted signal $\tilde{X}$, H is response of frequency of vector and W is the noise vector. The received signal in relation (7) has the same structure as the general linear data model described in relation (8).

Using the LS estimator results in section for an OFDM system is described by the following relation [2, 6]:

$$\hat{H}_{LS} = (X^H X)^{-1} X^H Y \quad (8)$$

Since X is a diagonal matrix, the estimation is reduced to the following relation:

$$\hat{H}_{LS} = X^{-1} Y \quad (9)$$

This relationship implies that the least squares estimation of LS is the frequency response of the channel simply dividing the received signal by the transmitted signal. Of course, the LS female estimate for each carrier is as follows [2, 6]:

$$\hat{H}_{LS} = \tilde{y}[k] / \tilde{x}[k] \quad (10)$$

That is, the estimated channel on each sub-carrier is simply obtained by dividing the received signal on each sub-carrier by the signal transmitted on that sub-carrier which gives the same result as before.

In Figure (5) is shown where x_k are the sent symbols, $g(t)$ the channel impulse response, $\tilde{n}$ the Gaussian mixed channel white noise, and y_k are the received symbols. The QAM-16 modulation is used to generate the x_k symbols. converters include ideal low-pass filters with bandwidth of $1/T_s$ with T_s sampling interval. A rotational extension along the T_G) was used to eliminate the ISI as well as to establish interaction between the tones.

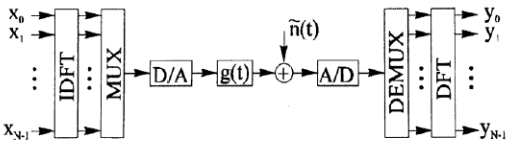

Figure 5. OFDM Base [2]

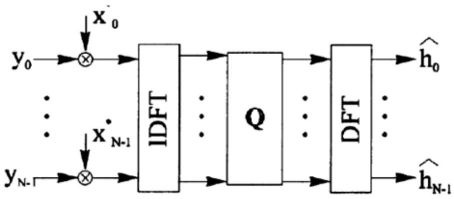

Figure 6. Estimator of OFDM [2, 6]

Notice that $\hat{h}_{LS}$ corresponds to the structure of the estimation in Figure 6. Hence (11) is as follows:

$$\hat{h}_{LS} = X^{-1} y \quad (11)$$

The LS female estimate is equivalent to the female estimate called Zero-Forcing. In the next section, we examine the modified type of LS estimation.

Other estimations may include the MRC (Maximum Ratio Combining) or LMMSE (Linear Minimum Mean Square Error) channel, which has not been addressed due to the many mathematical calculations and the high similarity of relationships [2, 17, 18].

4. BIT ERROR RATE (*BER*)

In OFDM system *BER* is the most important parameter. So that in Matlab, it is defined a special Toolbox for *BER* calculation for signal.

BER Toolkit is designed to analyze bit error rates, not the Symbol Error Rate (*SER*). For example, if your simulation calculates the Symbol Error Rate (*SER*), you would have to convert *SER* to *BER* and in the toolbox.

• Start simulating BER

The next section deals with analysis through the *BER* toolkit. Run the *BER* Toolkit. BER toolbox environment, Calculate *BER*s of theory [14, 15, 16].

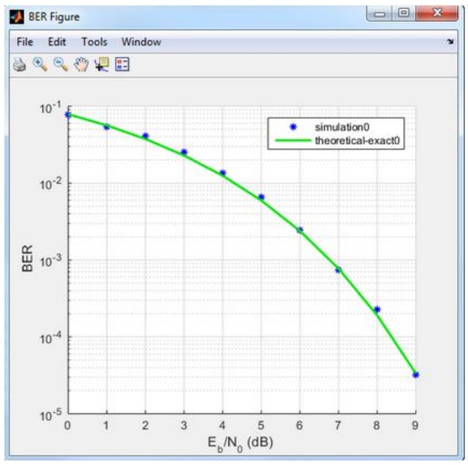

Figure 7. BER

5. SIMULATION AND ESTIMATION

• Maximal Ratio Combining MRC Channel Estimation

In MRC systems there is a way in which the signals from each channel are combined. Different Proportional Constants Used for Each Channel MRC is an optimized synthesizer for retractable Gaussian noise channels. MRC can restore the signal to its original form. The following example is about coding in MATLAB environment for optimizing MRC.

• Simulation Condition

Three methods are used in this simulation. In this below is defined condition of simulation.

- MRC Method: *NS*(Number of sending antenna)=1, *NR*(Number of Receiving antenna=2), *QPSK* Symbol and Number of subcarriers=128
- OFDM BASE Method: *NS*(Number of sending antenna)=1, *NR*(Number of Receiving antenna=2), *QPSK* Symbol and Number of subcarriers=128
- LMMSE Method: *NS*(Number of sending antenna)=2, *NR*(Number of Receiving antenna=2), *QPSK* Symbol and Number of subcarriers=125

After the simulation run, the result is in the form of 1. When the signal-to-noise ratio is 12.598, the red dots indicate the received signals (Figure 8).

Estimation of the base band OFDM channel process is as the following:

- Import text data
- Convert text to binary
- Convert binary to symbol
- February conversion of OFDM discrete image

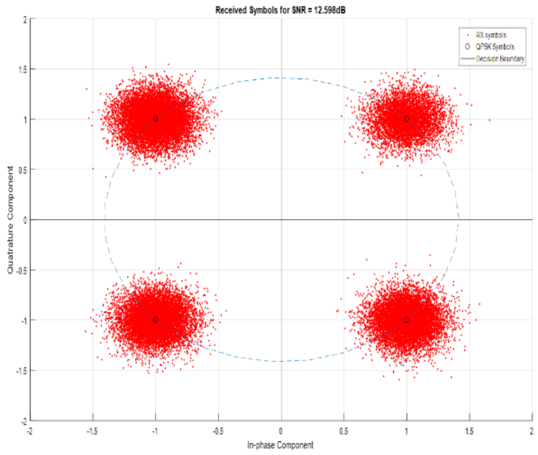

Figure 8. MRC Simulation

Figure 9 shows the OFDM in the baseband with the signal-to-noise ratio of 12.598 in the Rayleigh fading channel with Absolute Gaussian White Noise (AWGN).

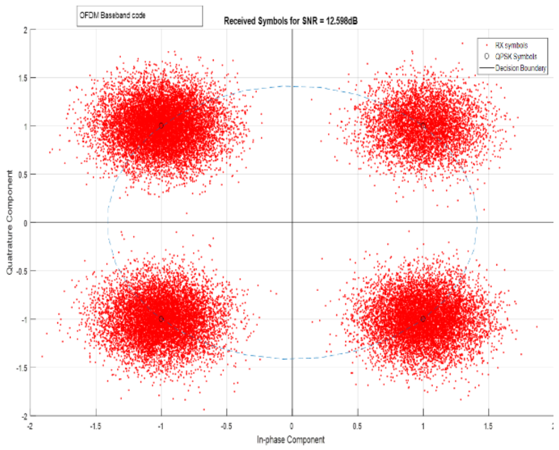

Figure 9. OFDM Base with AWGN

The LMMSE-based technique, which utilizes channel spatial correlation knowledge, performs better than LS (Least square) techniques as Figure 10. The LMMSE estimate minimizes the mean square of the error.

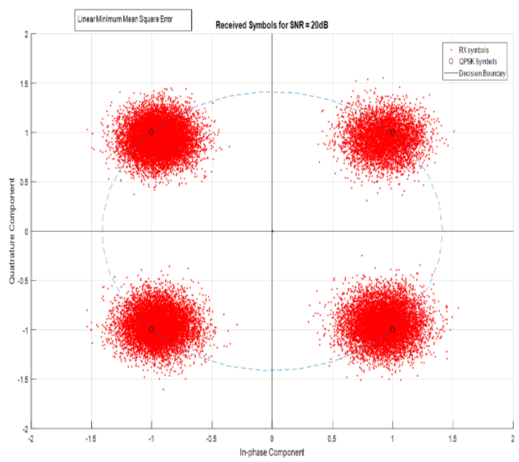

Figure 10. Linear Minimum Mean Square Error (LMMSE)

6. CONCLUSIONS

The first deals with the basics and background of the topic then the model of MIMO-OFDM systems was investigated. Continuous and discrete Fourier transforms, serial-parallel and vice versa, modulation and demodulation ports, were investigated.

Finally, coding in the field of study was considered in the light of what was said and software outputs and coding were examined according to the number of carriers, the number of antennas, the type of symbols, and the ratio. The signal was calculated in noise. The results show that the MIMO-OFDM system has the capability to improve the spectrum received. By comparing the above three figures we can see that MRC technique performs better than MMSE and OFDM BASE BAND techniques because the scatter of received signals around QPSK symbol is less than other methods.

The signal-to-noise ratio is given for different cases. The new generation of mobile telecommunications can be improved in the Matlab software environment and the use of suitable processors as well as analogue to digital converters. What is clear is that while developing hardware systems, the use of software and mathematical models is highly effective. This tool enables fast estimation of the received signal from a good quality signal transmitter with three outputs described.

After simulating the system in Matlab and comparing the three methods used to estimate the signal, it can be seen that MRC technique performs better than MMSE and OFDM BASE BAND techniques because the scatter of received signals around QPSK symbol is less than other method. Also, the results show that OFDM is significant technical method for transmission system.

NOMENCLATURES

CP	Cyclic Prefix
FFT	Fast Fourier Transform
IDFT	Inverse Discrete Fourier Transform
OFDM	Orthogonal Frequency Division Multiplexing

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BIOGRAPHIES

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