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Implementation of an efficient low complexity method for wireless CE using a BEM for the wireless channel taps.

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Abstract: The matrix representation of the signal model of MIMO-OFDM systems, which clearly describes the relation of signals in frequency domain and time domain and expressing operations like adding CP and removing CP as matrix product. Our channel estimation method differs in its ability to estimate fast time-varying wireless channel since pilot tones are inserted into each OFDM block, and in its explicit relation with space-frequency code design which can benefit the channel estimation in return. Then the simple LS algorithm can be used to solve the estimation problem, provided that the noise term in the quasi-linear form is Gaussian. In this paper, the ML algorithm can be directly utilized to estimate the target location since the probability density function of the observation data is known with our assumption. Finally, the extensive simulation studies have demonstrated the effectiveness of our proposed algorithm. We proposed a low complexity algorithm for equalization, which uses the estimated BEM coefficients directly without creating the channel matrix and equalization method require O (K log K) in operations and O (K) in memory.
Keywords: BEM, OFDM, Algorithm, ML, LS, Channel Estimation.

I. INTRODUCTION

In LTE-A, average spectrum efficiency and the cell-edge user throughput are given a higher priority than the peak spectrum efficiency and Voice over IP (VoIP) capacity. In LTE-A, the DL peak spectrum efficiency is targeted up to 30 bps/Hz while for UL peak spectrum efficiency should be up to 15 bps/Hz for a system employing 8 × 8 or less antenna configurations for DL and 4 × 4 or less antenna configurations for UL [1].The first generation comprises the analog frequency division multiple access (FDMA) systems such as the NMT and AMPS (Advanced Mobile Phone Services) [2]. The second generation consists of the first digital mobile communication systems such as the time division multiple access (TDMA) based GSM (Global System for Mobile Communication), D-AMPS (Digital AMPS), PDC and code division multiple access (CDMA) based systems such as IS-95. The third generation [3]started operations on 1st October 2002 in Japan.

II. ABOUT OFDM

A. OFDM Basics:

To reduce the equipment cost and to require less number of RF radios at the transceiver ends, Discrete Fourier Transform (DFT) is used as an efficient computational tool.

B. OFDM Block Diagram

The key steps carried out in an OFDM communication system are shown in Figure. QAM modulator is used to convert the incoming data into complex valued symbols$X[0], X[1], \dots, X[N-1]$. This sequence contains the samples of the multicarrier signal and each QAM symbol X[i] is transmitted over different carrier frequency, given as$e^{j2\pi i \frac{t}{T_N}}, \;\; i = 0, \dots, N-1$. After modulating over carrier frequency, CP is added to each OFDM symbol. At receiver side the incoming parallel data is passed through parallel to serial converter and then these digital samples are converted into analog data sequence, which gives a baseband OFDM [4] signal $\tilde{x}(t)$ which is again up-converted to the pass band frequency f_0.

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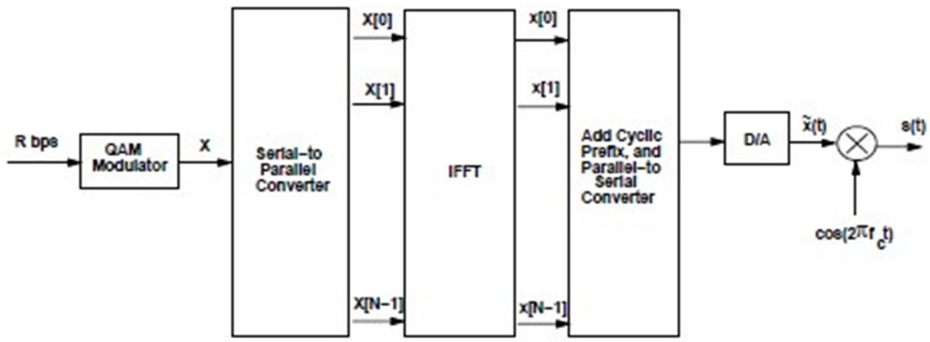

Figure 1(a): Transmitter Structure of OFDM

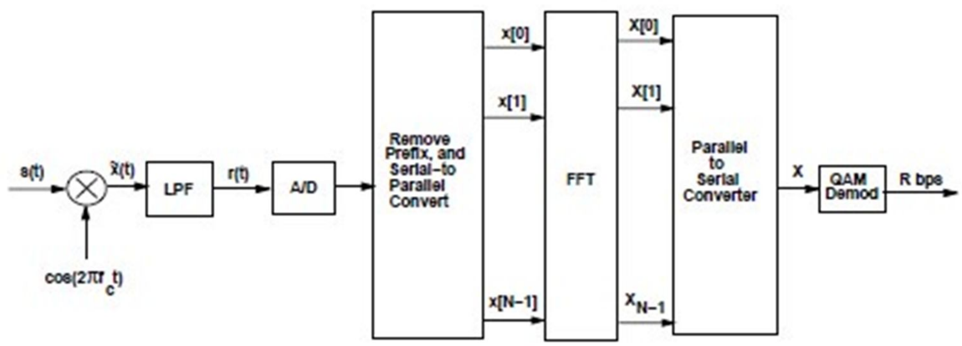

Figure 1(b): Receiver Structure of OFDM

III. LITERATURE

In [1], the pilot arrangement for OFDM system has been investigated. The comb type pilot channel estimation is implemented for the channel interpolation. IDFT (Inverse Discrete Fourier Transform) and zero padding are used to convert frequency domain to time domain. DFT (Discrete Fourier Transform) is used to convert time to frequency domain. For low Doppler frequencies, the decision feedback estimations performance is slightly worse than the low-pass interpolation channel estimation. In [2], a low rank Wiener filter based channel estimator is proposed to reduce the complexity. This optimal estimator avoids large-scale inverse matrix operation, so MMSE estimator complexity is reduced. Moreover this estimator transmits two training blocks instead of one training block of data. This estimator also pre-calculates the singular value decomposition (SVD) of the channel correlation matrix [2]. In [3], a sample spaced approach has been develop for an OFDM system with transmit antenna diversity. This paper analyzes the MSE performance and the leakage effect for sample spaced taps and non sample spaced taps. In [4], the decision-directed MMSE and adaptive channel prediction schemes are proposed for channel estimation. This paper proposes the MMSE predictor which calculates the predicted channel coefficient vector from the current and past received vector. This predictor memory allows exploiting the temporal channel correlations. To exploit the spectral channel correlation, the MIMO approach has been used. To be able to calculate the MMSE channel predictor, the predictor should have presupposes knowledge of channel correlation and variance. In [5], a pilot–aided TD MMSE channel estimator is developed for channel estimation. In this method, pilots are multiplexed with data symbols in different sub-carriers within the OFDM symbol. The TD operation is a simple linear operation. Here the input signal is directly linked to output symbol samples.

IV. PROPOSED WORK

A. Problem Definition

During the past few years, there has been an explosion in wireless technology. This growth has opened a new dimension to future wireless communications whose ultimate goal is to provide universal personal and multimedia communication without regard to mobility or location with high data rates. To achieve such an objective, the next generation personal communication [5] networks will need to be support a wide range of services which will include high quality voice, data, facsimile, still pictures and streaming video. In an OFDM signal the bandwidth is divided into many narrow sub channels which are transmitted in parallel. By combining OFDM with Turbo Coding and antenna diversity, the link budget and dispersive-fading limitations of the cellular mobile radio environment can be overcome and the effects of co-channel interference can be reduced.

B. Objectives

1) Study and implementation of OFDM system.
2) Implement OFDM system using different channel schemes
3) Proposed our system to compare bit error rate of different modulation schemes, channels and channel equalization.

We consider rapidly varying doubly selective channels, such that the channel coherence time is less than one OFDM symbol duration.

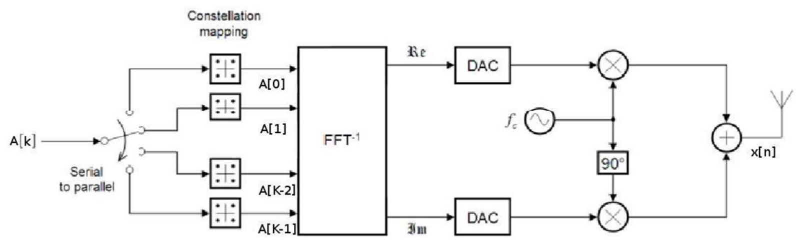

Figure 2: Typical example of an OFDM transmitter.

Fig.3 demonstrates a typical OFDM receiver with the ideal channel. The time domain receive signal is first demodulated from the carrier frequency f_c, the cyclic-prefix is removed, and then the signal is changed to a digital equivalent for further signal processing.

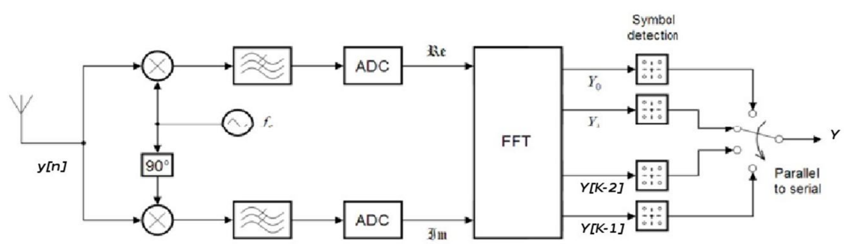

Figure 3: Typical example of an OFDM receiver.

C. Pros and Cons of OFDM

1) Advantage of OFDM systems are

a) High spectral efficiency;
b) Simple implementation by FFT (fast Fourier transform);
c) Low receiver complexity;
d) Robustability for high-data-rate transmission over multipath fading channel
e) High flexibility in terms of link adaptation;
f) Low complexity multiple access schemes such as orthogonal frequency division multiple access.

2) Disadvantages of OFDM systems are

a) Sensitive to frequency offsets, timing errors and phase noise;

b) Relatively higher peak-to-average power ratio compared to single carrier system, which tends to reduce the power efficiency of the RF amplifier.

D. OFDM System Model

The OFDM technology is widely used in two types of working environments, i.e., a wired environment and a wireless environment. When used to transmit signals through wires like twisted wire pairs and coaxial cables, it is usually called as DMT (digital multi-tone). For instance, DMT is the core technology for all the xDSL (digital subscriber lines) systems which provide high-speed data service via existing telephone networks. The principle of OFDM [6] is to divide a single high-data-rate stream into a number of lower rate streams that are transmitted simultaneously over some narrower sub channels. The time duration of the IDFT time signal is equal to *NT*. In essence, IDFT and DFT is a reversible pair. It is not necessary to require that IDFT be used in the transmitter side. It is perfectly valid to use DFT at transmitter and then to use IDFT at receiver side.

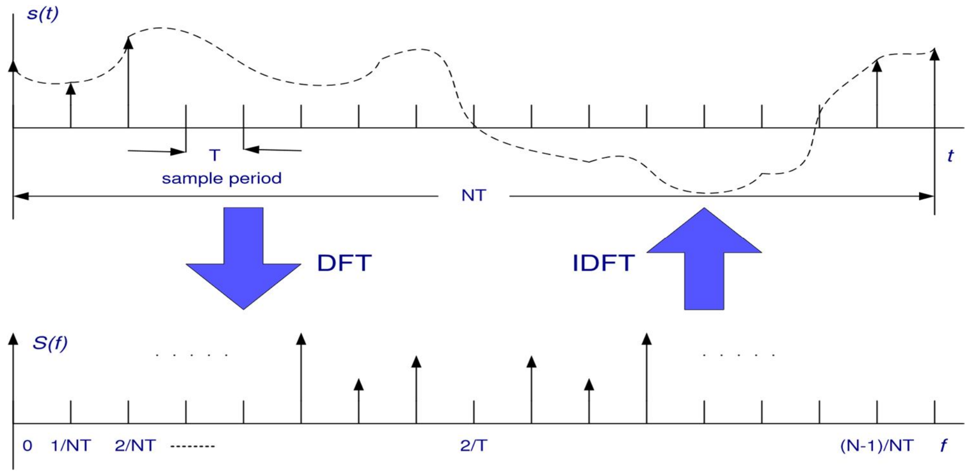

Figure 4: Preliminary concept of DFT

Figure shows a block diagram of a baseband OFDM modem which is based on PHY (physical layer) of IEEE standard 802.11a [7].Before describing the mathematical model, we define the symbols and notations used in this paper. Capital and lower-case letters denote signals in frequency domain and in time domain respectively. Arrow bar indicates a vector and boldface letter without an arrow bar represents a matrix. It is packed into a table as follows. As shown in Figure 5, the input serial binary data will be processed by a data scrambler first and then channel coding is applied to the input data to improve the BER (bit error rate) performance of the system.

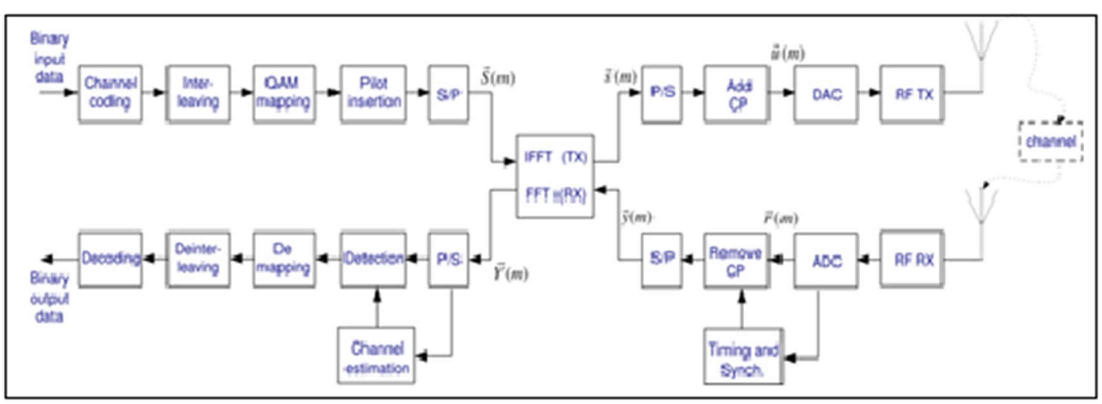

Figure 5: Block diagram of a baseband OFDM transceiver

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V. SIMULATION RESULT

A. Performance Analysis

Orthogonal frequency-division multiplexing (OFDM), essentially identical to Coded OFDM (COFDM) and Discrete multi-tone modulation (DMT), is a frequency-division multiplexing (FDM) scheme utilized as a digital multi-carrier modulation method. The results show the superiority of our proposed channel estimation and equalization methods over existing methods used in OFDM based systems.

B. Simulation Environment

1) We have used MATLAB Editor for implementation.
2) The result will be shown in the command window of MATLAB.

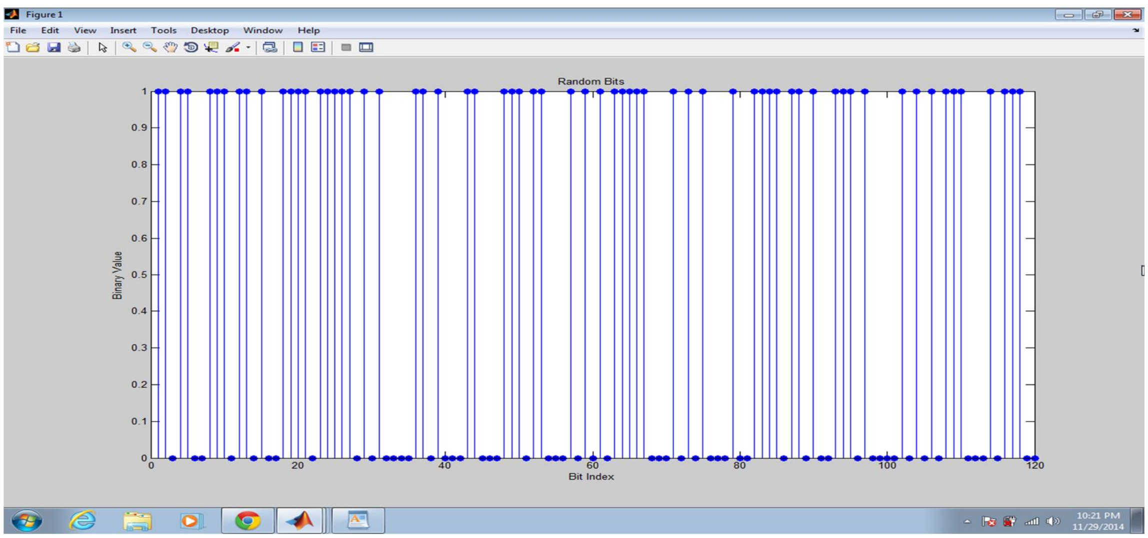

Fig 6.Input Stream of Channel

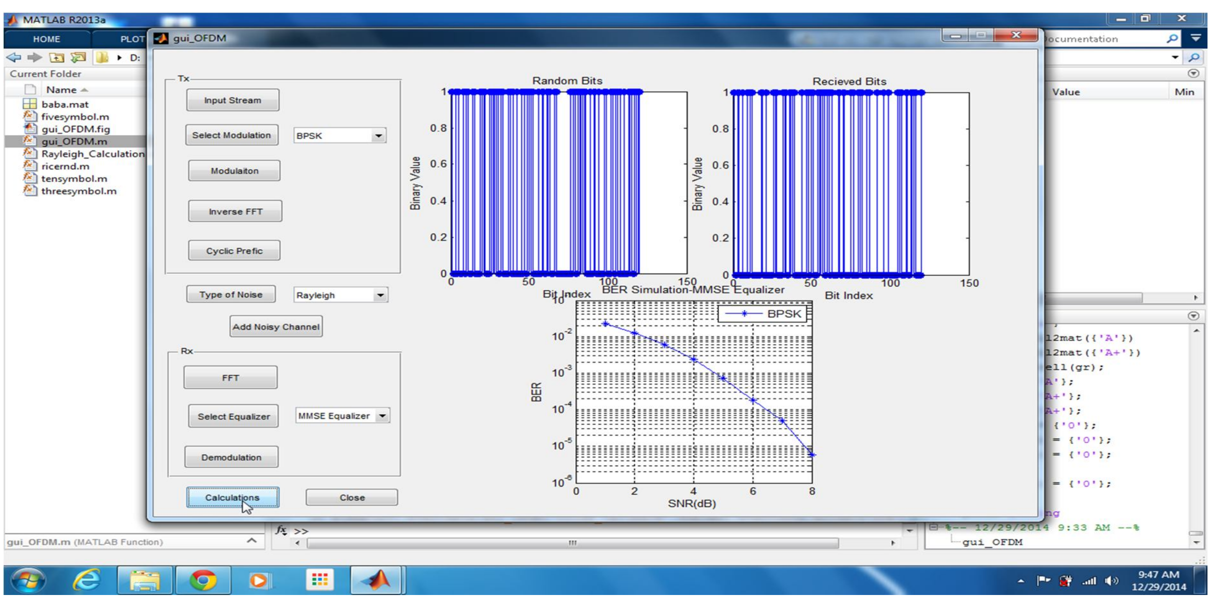

Fig 7. Result of BPSK modulation with Rayleigh noise and MMSE equalizer

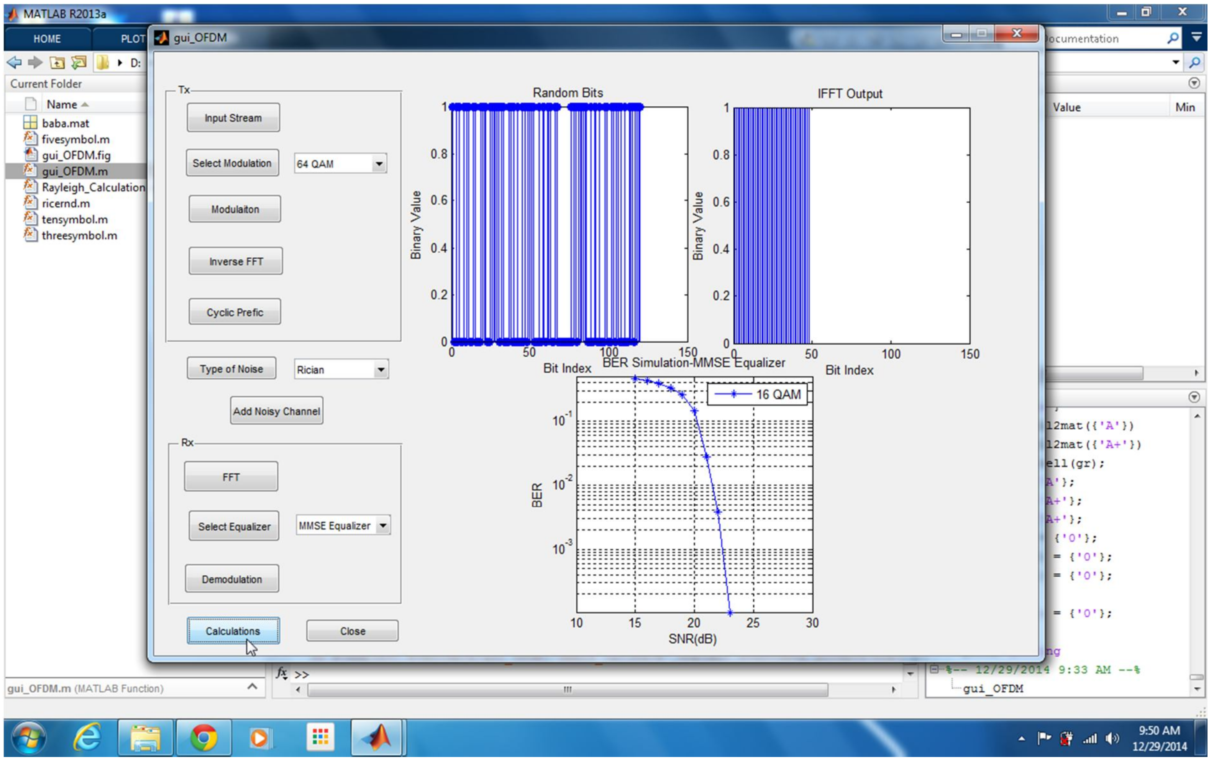

Fig 8. Result of 64 QAM modulation with Rician noise and MMSE equalizer

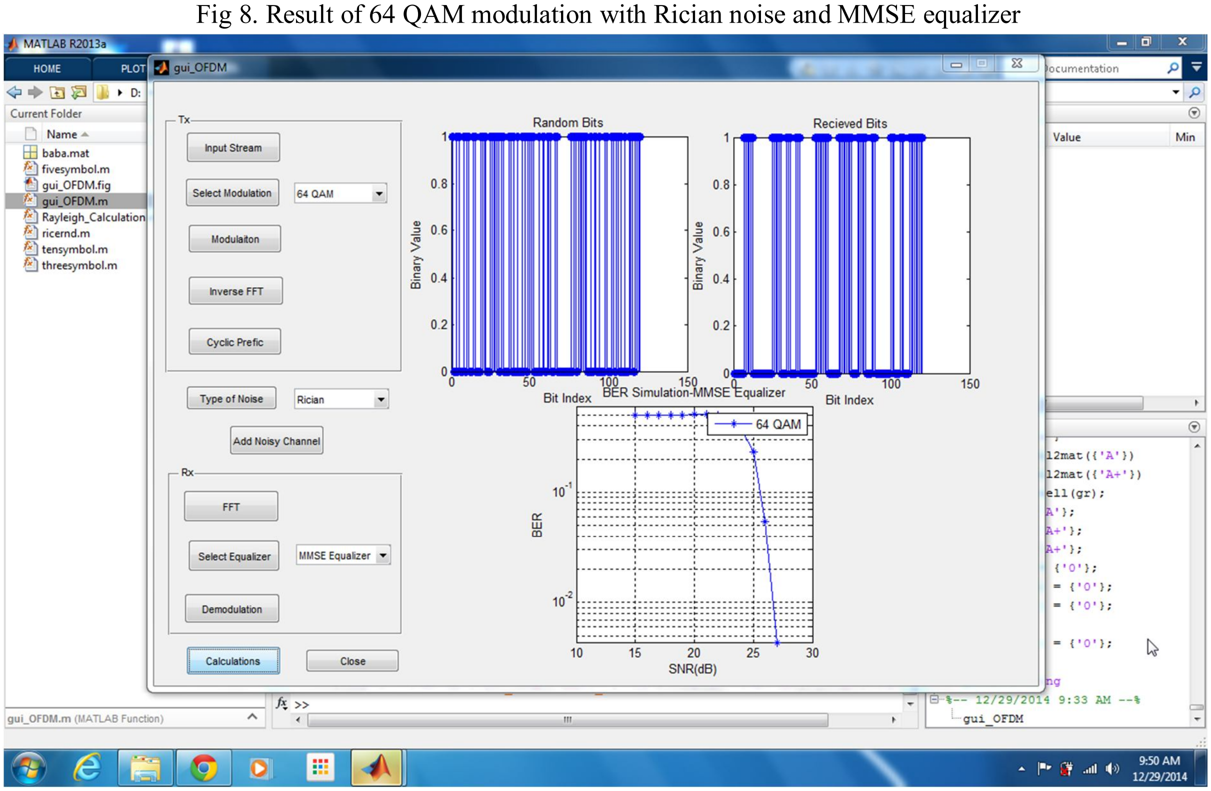

Fig 9.Result of 64 QAM modulation with Rician noise and MMSE equalizer

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VI. CONCLUSION

In this paper, first part addresses the problem of channel estimation of MIMO-OFDM systems. It starts from the matrix representation of the signal model of MIMO-OFDM systems, which clearly describes the relation of signals in frequency domain and time domain and expressing operations like adding CP and removing CP as matrix product. Our channel estimation method differs in its ability to estimate fast time-varying wireless channel since pilot tones are inserted into each OFDM block, and in its explicit relation with space-frequency code design which can benefit the channel estimation in return. Here, we address problems of wireless channel estimation and equalization, for transmission using OFDM setup through rapidly varying wireless channels, and proposed an efficient low complexity method for wireless channel estimation using a Basis Expansion Model for the wireless channel taps. Furthermore, we propose a low complexity algorithm for equalization, which uses the estimated BEM coefficients directly without creating the channel matrix. With L discrete channel taps, the proposed estimation method requires O ($L\log L$) in operations, and O(L) in memory, Whereas previously published methods requires O(L^2) in complexity and memory. With K OFDM subcarriers, the proposed equalization method require O (K log K) in operations and O(K) in memory. Computer simulation based on the standard IEEE 802.16e shows the effectiveness of the proposed methods.

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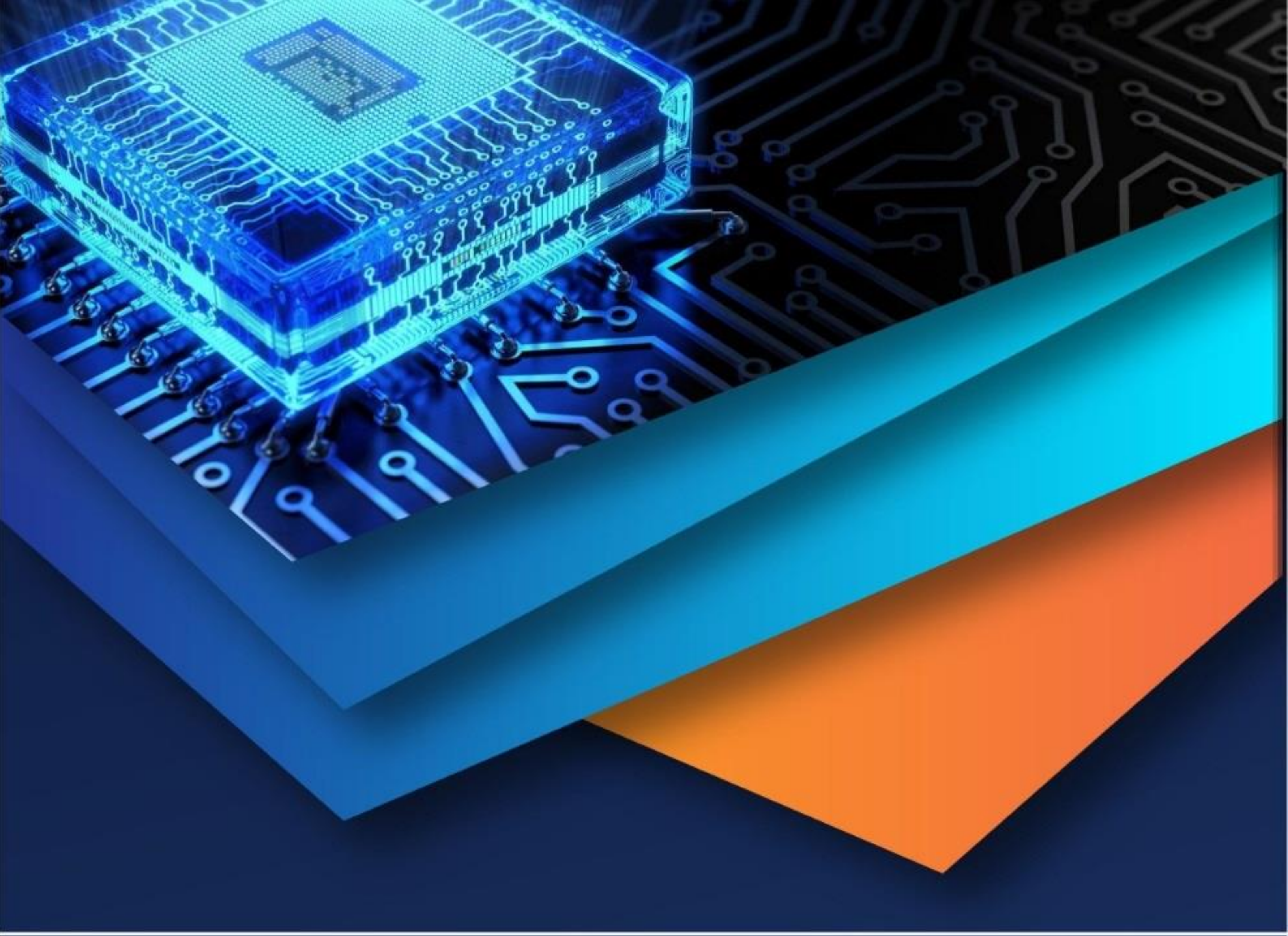

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