IJDACR
ISSN: 2319-4863

IJDACR
International Journal Of Digital Application & Contemporary Research

International Journal of Digital Application & Contemporary Research
Website: www.ijdacr.com (Volume 5, Issue 10, May 2017)

BER Evaluation of OFDM under Multipath Fading using SVD and MMSE

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Abstract –**This paper presents a simulation model based on 802.16 OFDM-PHY baseband and demonstrated in different simulation scenarios with different modulation techniques; BPSK and QPSK to find out the best performance of physical layer for WiMAX Mobile. The relay multipath fading and AWGN channel model under varying parameters are taken for the wireless channel in the simulation. The performance is recorded based on BER, and SNR output through MATLAB simulation.**

Keywords **–802.16 OFDM-PHY, AWGN, BER, BPSK, QPSK, SNR.**

I. INTRODUCTION

Some decades ago, we were purely dependent on analog system. Both the sources and transmission schemes were on analog format, but the innovation of technology made it possible to convey information in digital form. Besides those, the computer was getting faster to the fastest, the data payload ability and transmission rate increased from kilobit to megabit and megabit to gigabit. From wire to wireless conception emerged and after researching and investing so much money, engineers became successful to discover wireless transmitter to transmit data. Applications similar to Internet access, voice, SMS, instant messaging, file transferring, paging, video conferencing, entertainment and gaming etc. became a part of life.

Cellular phone systems, wide-area wireless data systems, WLAN, ad-hoc wireless networks and satellite systems etc are wireless communication. The vision extended a bit more by the engineers to provide smooth transmission of multimedia anywhere on the globe through variety of applications and devices leading a new concept of wireless communication which is cheap and flexible to implement even in odd environment [1].

This is a fact that, Wireless Broadband Access (WBA) via DSL, T1-line or cable infrastructure is not accessible particularly in rural areas. Near about 18,000 feet (3 miles) area is covered by the DSL, this means that several urban, suburban, and rural areas may not functioned. The Wi-Fi broadband connection may solve this problem a bit, but not possible in everywhere due to coverage limits. But the Metropolitan-Area Wireless standard, which is called WiMAX can solve these restrictions [2]. The wireless broadband connection is much easier to install, easier to access and more flexible and have a long range of coverage. This connectivity is surely important for developing countries and IEEE 802.16 family are helping to solve the last mile connectivity problems with BWA connectivity [3].

IEEE 802.16e can operate in both Line-Of-Sight (LOS) and Non-Line-Of-Sight (NLOS) environments. In NLOS, the PHY specification is extended to 211 GHz frequency band which aim is to fight with fading and multipath propagation. The OFDM physical layer based IEEE 802.16 standard is almost identical to European Telecommunications Standard Institute's (ETSI) High performance Metropolitan Area Network (HiperMAN) as they cooperate with each other [4].

The main objective of this paper is to implement and simulate the OFDM physical layer specification of IEEE 802.16. Performance analysis of higher data rate is anlyzed with changing the different modulation techniques. Forward error correction codes (Convolution code) are implemented to improve the BER under higher data rate. The performance analysis is recoreded based on the simulation results of Bit-Error-Rate (BER) and Signal-to-Noise Ratio (SNR). The simulation of above metioned system is done by MATLAB.

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II. Proposed Methodology

As per the flow diagram (Figure 1), it is clear that there are three sections namely; transmitter section, channel section and receiver section.
Mathematically the demodulation process (assuming no CP and no channel impairments) using the FFT is equation (1),

$$Y_{m,k} = FFT\{x_{m,n}\}$$

$$= \frac{1}{N}\sum_{n=0}^{N-1} x_{m,n} e^{-j2\pi nk/N}$$
$$= \frac{1}{N}\sum_{n=0}^{N-1}\sum_{d=0}^{N-1} X_{m,d} e^{j2\pi n(d-k)/N}$$
$$= \frac{1}{N}\sum_{d=0}^{N-1} X_{m,d}\sum_{n=0}^{N-1} e^{j2\pi n(d-k)/N}$$
$$= \frac{1}{N}\sum_{d=0}^{N-1} X_{m,d}\, N\delta[d-k]$$
$$= X_{m,k} \quad (1)$$

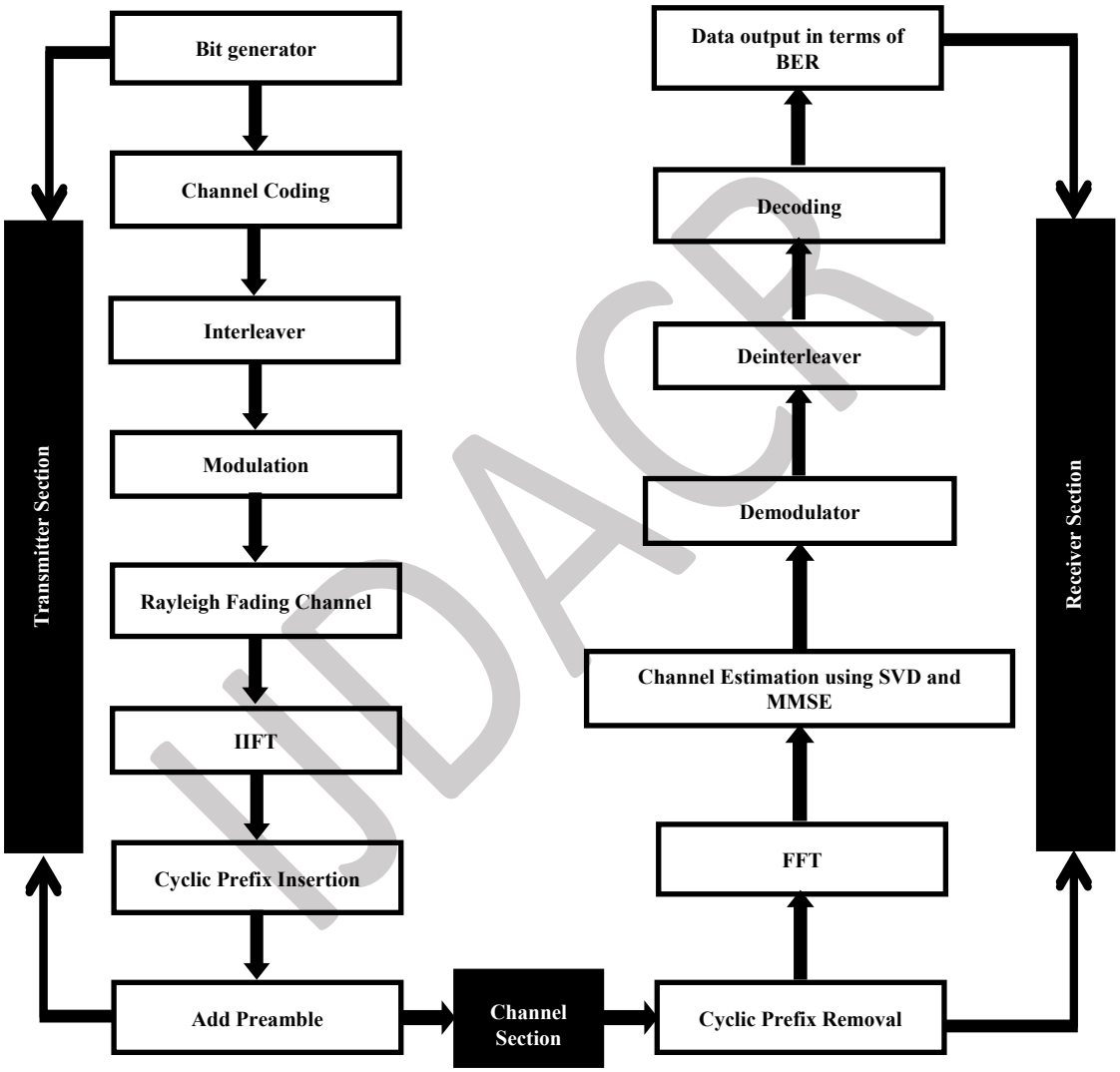

Figure 1: Flow diagram for proposed work

1. Transmitter Section:

Channel Coding
Channel coding is done by:

- Randomization
- Forward Error Correction (FEC)
- Interleaving

Modulation
Modulation is the technique by which the signal wave is transformed in order to send it over the communication channel in order to minimize the effect of noise. This is done in order to ensure that the received data can be demodulated to give back

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the original data. In an OFDM system, the high data rate information is divided into small packets of data which are placed orthogonal to each other. This is achieved by modulating the data by a desirable modulation technique. After this, IFFT is performed on the modulated signal which is further processed by passing through a parallel to serial converter. In order to avoid ISI we provide a cyclic prefix to the signal. Furthermore, this research work uses BPSK, QPSK and QAM modulation schemes.

Cyclic Prefix

The Cyclic Prefix or Guard Interval is a periodic extension of the last part of an OFDM symbol that is added to the front of the symbol in the transmitter, and is evacuated at the receiver before demodulation.

2. Communication Channel

This is the channel through which the data is transferred. Presence of noise in this medium affects the signal and causes distortion in its data content. Rayleigh Fading Channel and AWGN Channel are used in this research work.

3. Receiver Section

Demodulation is the technique by which the original data (or a part of it) is recovered from the modulated signal which is received at the receiver end. In this case, the received data is first made to pass through a low pass filter and the cyclic prefix is removed. FFT of the signal is done after it is made to pass through a channel estimation using SVD and MMSE.

Singular Value Decomposition (SVD)

In linear algebra, the singular value decomposition (SVD) is a factorization of a real or complex matrix, with many useful applications in signal processing and statistics. Formally, the singular value decomposition of a $m \times n$ real or complex matrix M is a factorization of the form

$$M = U\Sigma V^* \qquad (2)$$

Where U is a $m \times m$ real or complex unitary matrix, Σ is a $m \times n$ rectangular diagonal matrix with nonnegative real numbers on the diagonal, and V^* (the conjugate transpose of V) is a $n \times n$ real or complex unitary matrix.

Minimum Mean Square Error Equalizer

Minimum Mean Square Error equalizer otherwise stated as MMSE equalizer throughout this thesis lessens the problem of noise amplification by taking Noise power into consideration while designing filtering matrix through MMSE criterion. The estimated symbol vector from MMSE equalizer can be given as:

$$\tilde{x} = [[(H^H H + (\sigma^2 I))^{-1}] H^H] r \qquad (3)$$

Where H represents H channel matrix, σ^2 is noise variance.

A demodulator is used to get back the original signal. The Bit Error Rate and the signal–to–noise ratio is calculated by taking into consideration the unmodulated signal data and the data at the receiving end (Sink).

III. Simulation Resuls

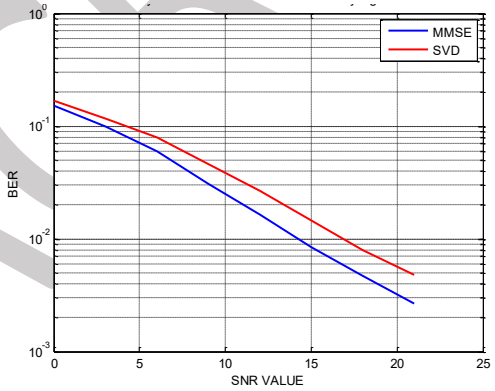

Figure 2: BER analysis of BPSK modulation under Rayleigh fading channel

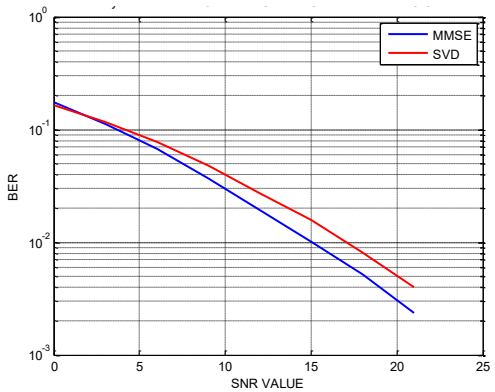

Figure 3: BER analysis of BPSK modulation under multipath fading channel

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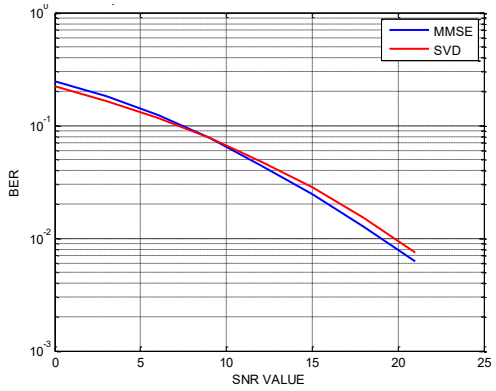

Figure 4: BER analysis of QPSK modulation under multipath fading channel

IV. Conclusion

The work is undertaken in this paper firstly discusses the WiMAX IEEE 802.16.e-2005 system. The implementation of IEEE 802.16.e model is presented with the analysis of the capabilities of WiMAX in different communication channels. The simulation uses MATLAB and the effect of different modulation schemes has been evaluated over OFDM system. Forward error correction code (Reed Solomon and Convolution codes) with different modulation techniques is analyzed and its performance evaluation is done with BER. On comparing the variations of the BER for different SNR in the MATLAB simulation, it is observed that the BER performance of BPSK is better than QPSK modulation scheme.

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