ASEE 2014 Zone I Conference, April 3-5, 2014, University of Bridgeport, Bridgpeort, CT, USA.

A Study on the Performance of IEEE 802.16-2004 Includes STBC

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Abstract— **The era of entirely wireless, mobile communication is rapidly approaching. Increasingly, consumers are demanding versatile and convenient modes of communication that are available whenever they want, wherever they are; all of this without losing performance and efficiency. On the other hand, the demand for high-speed broadband and technology with less energy costs are growing side-by-side. The challenge is to give consumers high-speed, high-performance, mobile, and Earth-friendly alternatives to what is currently available. The answer to these demands might just be WiMAX. Worldwide Interoperability for Microwave Access (WiMAX) is a Broadband Wireless Access (BWA) technology that offers service to individuals and groups in subchannels. In this paper we aim to analyze the performance of IEEE 802.16-2004 including the Space-Time Block Coding (STBC) model and the Multiple-Input Single-Output (MISO). We found the rate of data transmission is being increased in certain models. For instance, 64QAM 3/4 performs efficiently with specific ranges of bandwidth. WiMAX could potentially be the answer to new consumer demands that the IT world has been in search of.**

Keywords—WiMAX; PHY; MISO; STBC; broadband; bandwidth; QoS; NLOS; PSD, MAC.

I. INTRODUCTION

Communication services are no longer limited to voice calls or the transmission of relatively small data texts. The popularity of Smartphones, tablets, and easy-to-carry laptops have changed the way individuals and businesses communicate. Cloud computing and Internet-based applications, to name a few, have also added new dimensions of complexity to technology. This is a new era of communication that demands speed and mobility. Thus, new technologies have been and must continue to be developed for the changing way in which we communicate.

The formulas for most enterprises depends on three factors: Provider, service, and the users. Currently, we have relatively efficient providers that are able to send out strong signals to fewer areas of non-coverage. We also have tech-savvy users that are more diverse in age and economic status than every before. One of the three key factors is lagging behind, however. That is service [1]. Service in the wireless communications world may best be defined as that auspicious relationship between vendor and user, where both are getting exactly what they want. The new era of communication demands that vendors provide a variety of bandwidth, so users may choose a package that meets their usage needs and budget. Ideally, vendors would provide a platform for users to browse the Internet, watch videos, download files, and maintain privacy with their Cloud computing account. All of this for an affordable price that does not lack high quality of service (QoS).

WiMAX is a new wireless communication technology based on the IEEE 802.16 standard. WiMAX technology covers a large area with a range of up to 31 miles. Additionally, it is dynamic at adapting and modifying transmission bounds due to its flexibility and ability to work with an assortment of amendments. It connects mobile devices from end-to-end, while transporting high-throughput broadband with speeds at up to 70 Mbps. In June 2004, committees gained the approval for fixed wireless access; WiMAX became known technically as IEEE 802.16 – 2004. In December 2005, the IEEE committee added new features such as optimizing mobile radio channels dynamically. With these improvements, they subsequently gained approval as IEEE 802.16 [2].

WiMAX contains plenty of features that provide enormous alternatives of transmission flexibility. Multipath routes of access and Non-Line-Sight (NLOS) environments are offered by WiMAX Physical Layer (PHY) as a powerful administration tool in an efficient manner [3]. WiMAX PHY depends on Orthogonal Frequency Division Multiplexing (OFDM). OFDM is the method of transmitting data at a high speed over multiple frequencies provided by commercial broadband systems such as video and audio. Adaptive

Modulation and Coding (AMC) can improve throughput regarding the propagation condition where the modulation becomes capable of optimizing the condition of the bit error rate (BER) performance which was caused by shadowing and variety fading path.

In this paper, we investigated the performance of IEEE 802.16 WiMAX system STBC when Uplink (UL) and Downlink (DL) are applied using a variety of bandwidth, while examing several values of Packet Error Rate. Next, we will briefly describe related work that has been done in same field in Section II to better understand how WiMAX may best be utilized. We shall then explore Simulation Models and define the circuit and other components in Section III. Next, illustrates the result of the investigation which has been applied and evaluated based on the MATLAB simulation in Section IV. Finally, the conclusion is exposed in Section V.

II. Related Work

Many researchers dedicated years of work on developing the efficient performance of the IEEE 802.16 WiMAX system of communication technology. It has previously been tested in many perspectives, such as high-speed, energy cost, rate of transmission, range of covering, decreasing the signal noise, and the capability to interaction with a variety of modulation.

The authors in [4] evaluated the performance of OFDM and AMC over a multipath fading channel using variety modulation and scheme coding. Based on their simulation, their analysis is that they needed AMC's optimizing mechanism to preform variety modulation and scheme coding to reach a depending status. They have strived to achieve an immediate adapt spectral efficiency with a multiple channel Signal-to-Noise Ratio (SNR) and, at the same time, preserving a reasonable Bit Error Rate (BER)

The researchers in [5] analyzed the performance of the WiMAX system in a specific environment: an urban microcell. They applied MIMO techniques after extending SIS mode. Their approach studied the behavior of mode in both scenarios UL and DL simulating Packet Error Rate (PER). They employed 3GPP spatial channel models and based on that, they build their matrix channel. The authors found that SNR STBC with lower values prefers DL; Space-Time Frequency Coding (STFC) with lower values prefers UL.

Authors in [6] offer systems that can make decisions to send and receive data based on BER to control transmission and reception behavior. In order for their system to make a decision switching mode, they added modulation to monitor the bit error rate; so their adaptive system was built with two modes. Their ultimate goal analyzed the moment where switch must occur to change a system in an efficient manner without coding to limit the probability of BER.

Authors in [7] evaluate the characteristics of BER performance with a variety of channel conditions in one model to analyze the effects of different techniques of modulation (QPSK, 16-QAM and 64-QAM). Their aim is to present their idea for beginners to help them understanding system performance under a variety of propagation conditions to choose the best mode. They surveyed a couple of propagation conditions while modifying the parameters, such as coding rates, Fast Fourier Transform (FFT), and Bandwidths to show the different results.

Authors in [8] studied the BER performance within real-time audio data communication under different channel encoding rates and channel conditions. The evaluation was done with a variety of modulations (BPSK, QPSK, 8-QAM, and 16-PSK).

III. Simulation Model

MATLAB is an environment of stimulation; it is built in a high level language where it has capability to run C, C++, and Java as a programming compiler. Additionally, it is considered as a great generator to process mathematical formulas. Users can interact with it smoothly to develop an algorithm or to invent a new model. This is due to the fact that MATLAB contains a huge library which is already built into it. However, MATLAB is friendly with models that have interfaces. In this paper, the experiment of WiMAX simulation model has been done based on IEEE 802.16-2004 OFDM PHY Link, including Space-Time Block Coding implemented in MATLAB R2012a version (7.14.0.739) under Windows 64 bits Operating System.

A. PHY Layer of WiMAX

The physical layer anticipates scalable manner based on OFDM and it supports AMC to have a good signal to carry data. PHY is considered as the first aspect of standard IEEE802.16 which has features to provide good Non-Line-of-Sight propagation (NLOS) for MISO. Many commercial broadband systems are supported by PHY layer with a variety of bandwidth ranged between 1.25 MHz and 20 MHz, where throughput transmission is developed by the Media Access Control (MAC), which is seen as the second aspect of IEEE 802.16. However, in order to achieve good signal PHY, they need to use less space and reduce signal and increase speed.

B. Randomization

First procedure that is being done in PHY is in the randomization circuit. When the randomization circuit receives a packet of data from Model Parameters of higher layers, it produces a random binary number. It sends data of bit in both DL and UL performances to FEC and the Modulator Bank that minimize the data transmission and fix the size of block.

C. Modulation and Coding Schemes

Forward Error Correction (FEC) & Modulator Bank Circuit contain seven hardware channels of modulation and coding schemes. These include: Reed-Solomon (RS), Binary Phase-Shift Keying (BPSK), Quadrature Amplitude Modulation (QAM), and Quadrature Phase Shift Keying Modulation (QPSK) dealing with data bit.

TABLE I. TABLE LIST THE VARIOUS MODULATION AND CODING SCHEMES

AMC	Modulation	RS code	Overall Code Rate
1	BPSK	-	1/2
2	QPSK	(32, 24)	1/2
3	QPSK	(40, 36)	3/4
4	16 QAM	(64, 48)	1/2
5	16 QAM	(80, 72)	3/4
6	64 QAM	(108, 96)	2/3
7	64 QAM	(120, 108)	3/4

WiMAX supports circuit of modulation to increase robustness for improvement the signal condition.

D. *Inverse Fast Fourier Transform (IFFT)*

IFFT block plays a major role in transforming data bits by using the OFDM symbol generator from frequency domain to time domain [6]. Thanks to this procedure, data can be sent over channels

E. *Interleaving*

Interleaving decides the performance based on the channel condition and rate of data. It behaves as randomization on the position of the bit not to change the bit state. Interleaving transforms bit based on OFDM symbols from data with block size to number of coded that depend on modulation; as a consequence, interleaving produces variety of frequency [9].

F. *OFDM*

Many commercial broadband systems use the OFDM technique to transmit multimedia with high speed. This technique has becomes well known because it reaches the rate of bit transmission in wireless communication. Additionally, fourth generation wireless communication exists.

G. *AWGN Channel*

Additive White Gaussian Noise (AWGN) preforms two sides of operating. It acts as both a transmitter and a receiver.

IV. SIMULATION RESULTS

The result of WiMAX simulation using STBC is presented in the subsection.

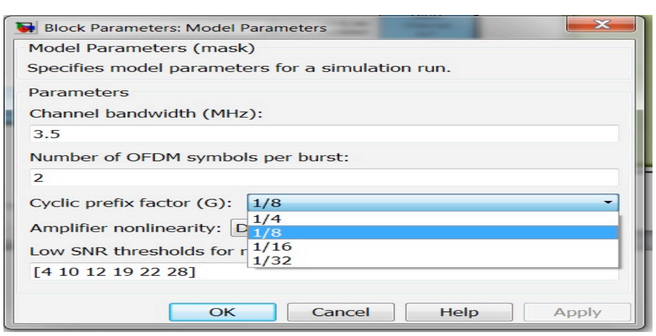
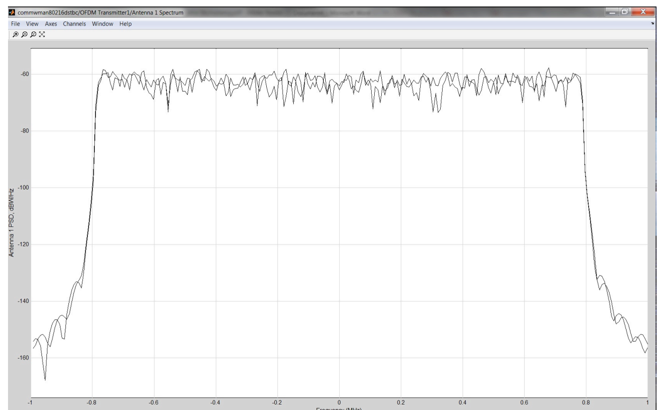


Fig. 1. Model Parameters

Fig.1 allows a user to change the bandwidth of the channel, and cyclic prefix factor where entering different values affects the result of the signal and EBR. Additionally, the varieties of options help to observe the bit error rate

Fig.2 presents Power Spectral Density (PSD) versus Frequency. The graph displays the relation of signal power and Doppler shift during transmission. The parameter is using low bandwidth that started 3.5 and cyclic prefix factor 1/8. Consequently, once antenna spectrum achieves the peak, it starts to bend quickly, at around -60.



Frequency (MHz)

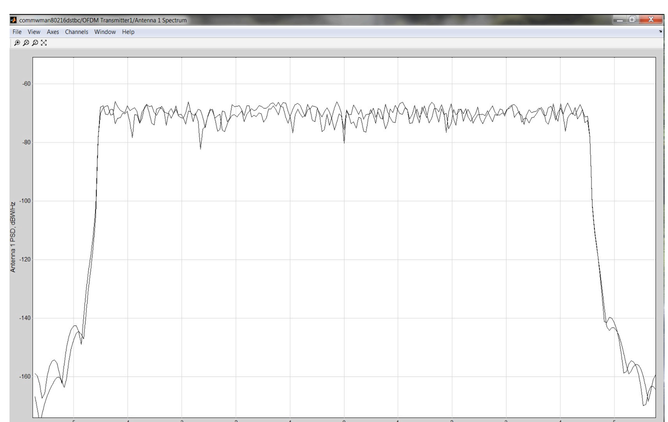
Fig. 2. OFDM Transmitter / Antenna Spectrum

Fig.3 presents the same factor that was presented in Fig.1 with different value of bandwidth and cyclic prefix factor. We used 20 MHz as the rate of bandwidth and 1/32. At these rates, performance takes a great deal of time.

Magnitude (dB)

Fig.4 shows a Quadrature Amplitude vs. an In-phase Amplitude Simulation. The behavior of signals in the demodulation block receives a scattering pattern indicating that the process is done in an adaptation modulation. However, the diagram shows the scatter almost in every square if we use low bandwidth, and a small rate of the cyclic prefix factor.

Magnitude (dB)



Magnitude (dB)

Frequency (MHz)

Fig. 3. OFDM Transmitter / Antenna Spectrum

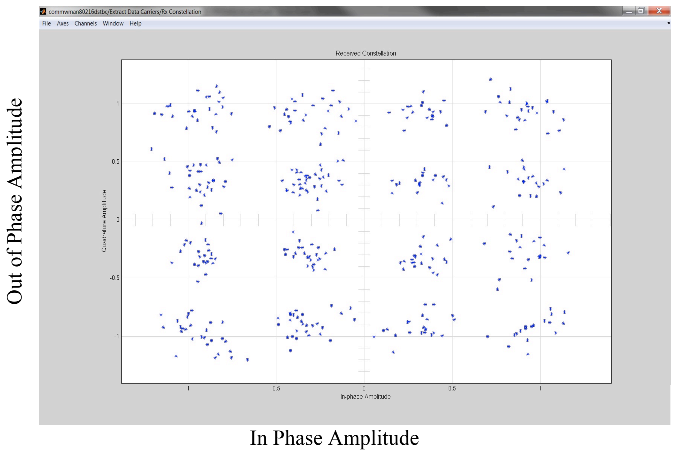


Fig. 4. Extract Data Carrier / Rx Constellation

Fig.5 shows the scatter which is created by transmission of output for signal being convergent in AM/AM and PM/AM when the bandwidth value is high, and cyclic prefix factor is large.

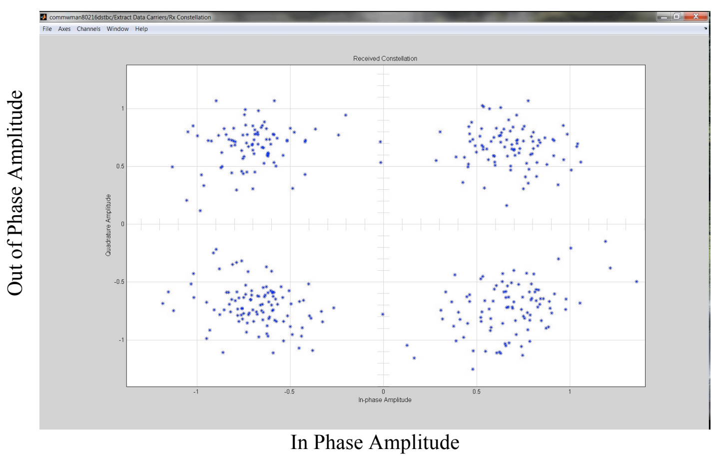


Fig. 5. Extract Data Carrier / Rx Constellation

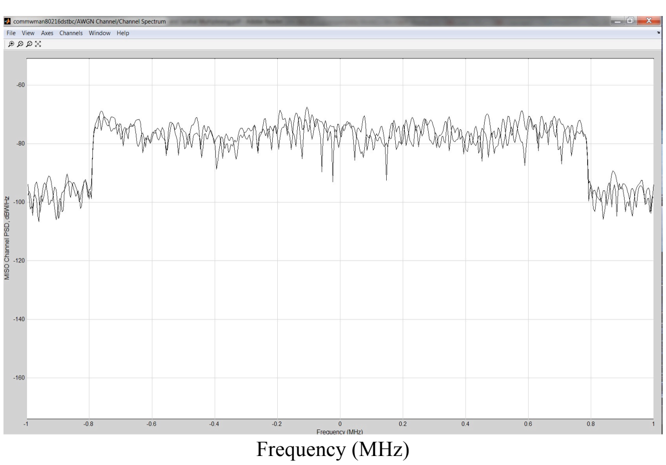


Fig. 6. AWGN Channel / Channel Spectrum

Fig.6 presents MISO Channel PSD versus Frequency. The diagram shows the output of a signal at the channel. Moreover, the signal starts with less than -100 of dBW/Hz. After that, it reduces around (-70) - (-90) while using low bandwidth and a small rate of the cyclic prefix factor.

Fig.7 gives different characteristics than Fig 6 for starting and reducing when a different parameter is applied.

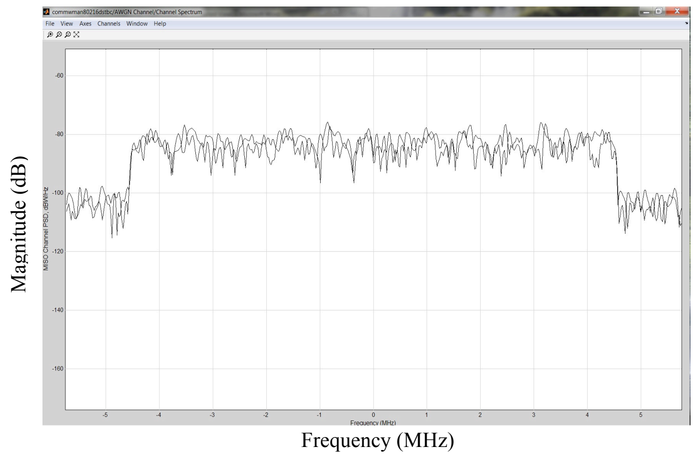


Fig. 7. AWGN Channel / Channel Spectrum

TABLE II. SIMPLE OF VARIETY OF TEST IN MODEL

	BANDWIDTH (3.5 MHZ) CYCLIC PREFIX FACTOR (1/8)	BANDWIDTH (20 MHZ) CYCLIC PREFIX FACTOR (1/32)
BER	0	6.705E – 06
#ERRORS	0	11
#BITS	5.27E + 05	1.641E + 06
EST. SNR (DB)	16.86	8.592

V. SIMULATION ANALYSIS

The performance of IEEE 802.16 usually gives different results when different parameters are being applied. Those changes affect the signal condition, speed of transmission, and various other factors [10]. When an individual analyzes BER while using a low value of bandwidth and a small rate of cyclic prefix factor, the outcome will be zero. Nevertheless, BER gives (6.705e - 06) as a result, when a person sets the channel bandwidth as 20 MHz, and cyclic prefix factor (1/32). Besides BER, the model performs a different number of Error, and different of numbers of Bits.

The following figs. 8, 9, 10, 11, 12, 13, 14, and 15 present the results of simulation of modulation used in WiMAX system. Each fig represents BER versus SNR, where the number of error bits effect signal transmission. The signal is fed with specific energy. This energy provides more capacity in the system by using an efficient bandwidth. However, for signal strength improvement, it is the select high value of cyclic prefix factor.

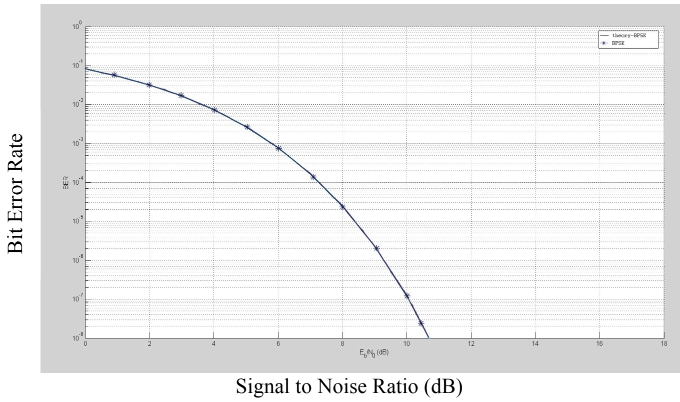


Fig. 8. Fig.8: Simulation result of BPSK

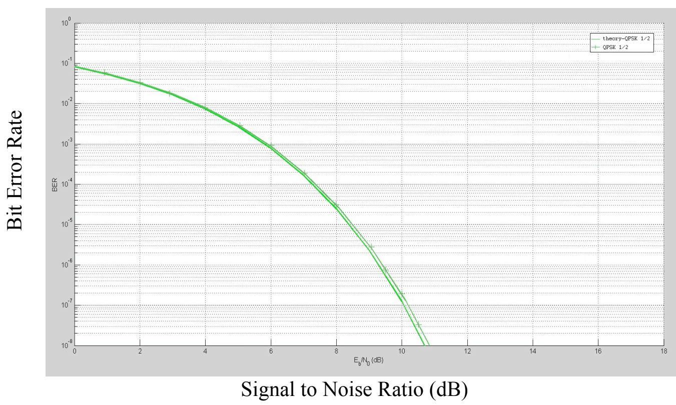


Fig. 9. Simulation result of QPSK 1/2

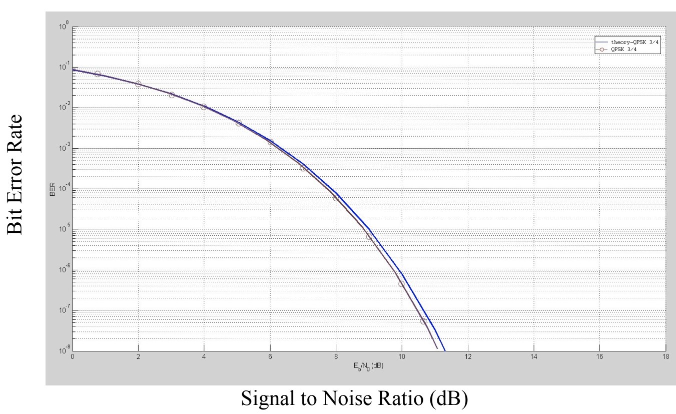


Fig. 10. Simulation result of QPSK 3/4

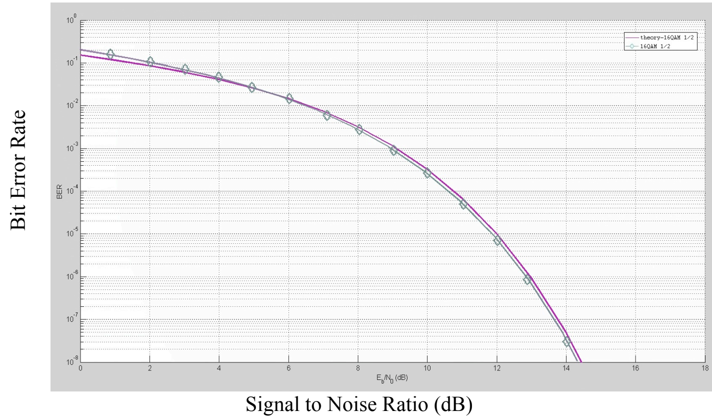


Fig. 11. Simulation result of 16QAM 1/2

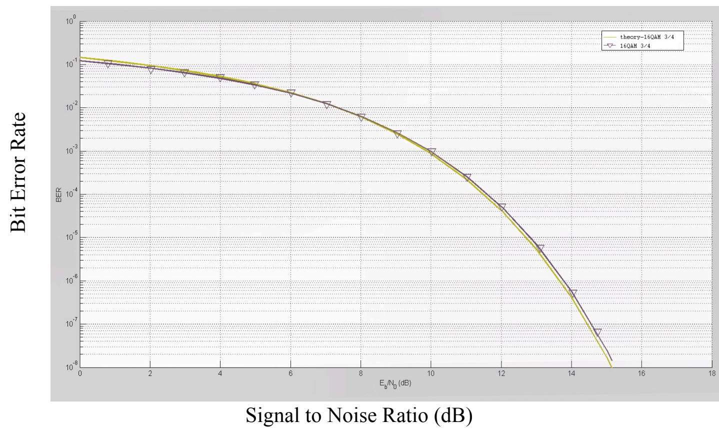


Fig. 12. Simulation result of 16QAM 3/4

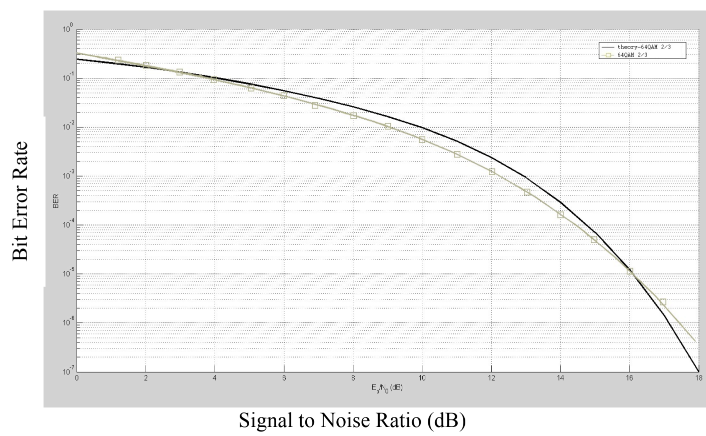


Fig. 13. Simulation result of 64QAM 2/3

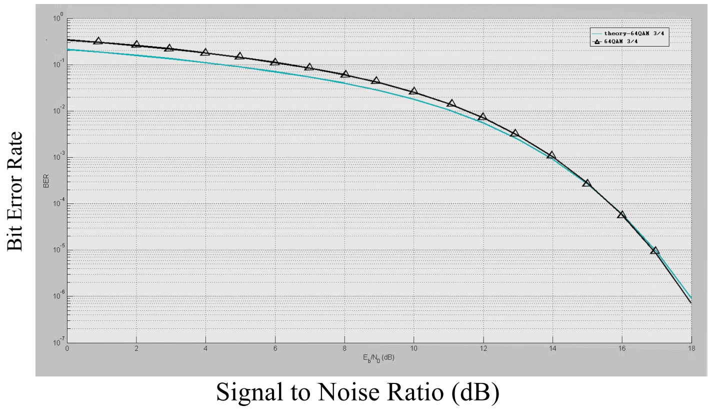


Fig. 14. Fig.14: Simulation result of 64QAM 3/4

VI. Conclusion

In this paper, studying for the performance of IEEE 802.16 PHY includes STBC to evaluate the effectiveness of changing the parameter and how that will affect the signal condition and increasing or decreasing time of processing. Also, examining the variety of bandwidth maxing with diversity of cyclic prefix factor to have optimal performance of frequency and time. Transmission is increasing in certain models such as 64QAM when individuals compare it with multi-input.

With its promising features, WiMAX seems a natural answer to the rising demands of consumers. Its rate of speed and reliability are able to offer users quality of service, mobility, and dependability that they demand in the globalized and mobile age of technology.

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