Performance Analysis of IEEE 802.16e WiMax Physical Layer

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ABSTRACT

The recent trends in broadband wireless communication systems are demand for high data rates, large transmission range and minimum end to end delay. This is necessary to access the services such as Internet, Video conferences, and Multimedia applications. WiMax (Worldwide Interoperability for Microwave Access) technology provides Broadband Wireless Access (BWA) in metropolitan areas with a simpler installation and lower cost compare to wired networks. To understand the working of WiMax system and the role of various parameters on the system performance, the simulation model of WiMax physical layer using Matlab 7.10 version has been developed. Efforts have been taken to study the Bit Error Rate (BER) performance of this model under different channel conditions. Efforts are also taken to understand the effect of various Modulation techniques, Coding rates, cyclic prefix factors and FFT size on the system performance.

KEYWORDS

WiMax; CP; Propogation delay; Operating Parameters, FFT size.

Applications and High quality information streams are in demand and this demand will continue for the

near future. Wireless system is considered to be a perfect and attractive solution to provide high data rates communications particularly for mobile users [1]. The IEEE 802.16 standards (are also known as WiMax standards) are intended to offer wireless broadband access for the long range propogation [2]. WiMax is based on Wireless Metropolitan Area Network (WMAN) which provides very high data throughput over long distance (20 or 30 miles) in Non Line of Site (NLOS) propagation [3-4]. This technology aims to provide broadband wireless access as well as internet access.

The IEEE has divided the WiMax system into two groups.

1) Fixed WiMax (IEEE 802.16d-2004)
2) Mobile WiMax (IEEE 802.16e-2005)

1) Fixed WiMax supports fixed and nomadic applications. This is operating in frequency band of 2 GHz to 11GHz and provides the transmission rate upto 75 Mbps for the distance of approximately 30 miles (50 kms). In this type of WiMax a Single-Carrier (SC) modulation technique is used [3].

2) Mobile WiMax (IEEE 802.16e-2005) supports fixed,

Nomadic, mobile and portable applications. This is operating in frequency band of 2 GHz to 6 GHz and provides the data rate up to 75 Mbps over a distance of approximately 10 miles (15kms). In mobile

WiMax, Multi-carrier modulation technique (Orthogonal Frequency Division Multiplexing) is Used at physical layer.

In order to support the results mentioned above for three various propagating conditions a model used in reference has been modified to meet the requirements [5]. This model is based on IEEE 802.16 point-to-multipoint (PMP) mode, which means that one Base Station (BS) can serve multiple Subscriber Stations (SSs) concurrently. For the performance analysis of this network following parameters are chosen:

1) Various modulation techniques,
2) Various Coding rates,
3) Various cyclic prefix factors,
4) Various FFT sizes and
5) Various Bandwidths.

The modulation rate is directly proportional to throughput and inversely proportional to delay for point to multipoint communication. Results are analyzed in terms of through put and delay. The objective behind this analysis was to study the effect of different cyclic prefix and FFT for improving system performance at different digital modulation (QPSK, 16-QAM and 64-QAM) techniques for standard AWGN channel of WiMax system.

II. THE WIMAX SIMULATION MODEL

The model implemented is based on the mobile WiMax having following characteristics,

Standard: IEEE 802.16e

Carrier Frequency: Below 11GHz

Radio Technology: OFDM and OFDMA

Data Rate: 70 Mbps.

A White Paper on creating an executable specification in Simulink for WiMax is a useful resource to build a model [6]. The Model for the WiMax is built from the standard documents and is shown in figure 1. The Model itself consists of three main components namely Transmitter, Receiver and Channel. Transmitter and receiver have taken care of channel coding and modulation process, whereas channel is modeled as standard AWGN channel.

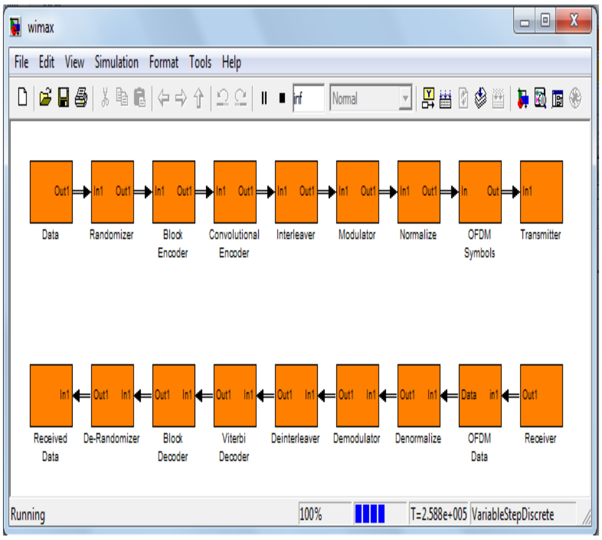

Fig.1: Block Schematic of WiMax System.

III. PERFORMANCE ANALYSIS

For performance evaluation, test is carried out on the model shown in figure 1. There are three modulation types available for modulating the data onto the subcarriers: QPSK, 16QAM, and 64QAM. In the UL, the transmit power is automatically adjusted when the Modulation coding sequence (MCS) changes to maintain the required nominal carrier-to-noise ratio at the BS receiver. 64QAM is not mandatory for the UL. Binary phase shift keying (BPSK) modulation is used during the preamble, on the pilots, and when modulating subcarriers in the ranging channel.

The IEEE-802.16e standard defines the allowed relative constellation error (RCE) as you can see in Table 1

TABLE I
ALLOWED RELATIVE CONSTELLATION ERROR VERSUS DATA RATE

Burst Type	Relative Constellation for SS (dB)	Relative Constellation for BS (dB)
QPSK-1/2	-15	-15
QPSK-3/4	-18	-18
16-QAM-1/2	-20.5	-20.5
16-QAM-3/4	-24	-24
64-QAM-1/2	-26	-26
64-QAM-2/3	-28	-28
64-QAM-3/4	-30	-30

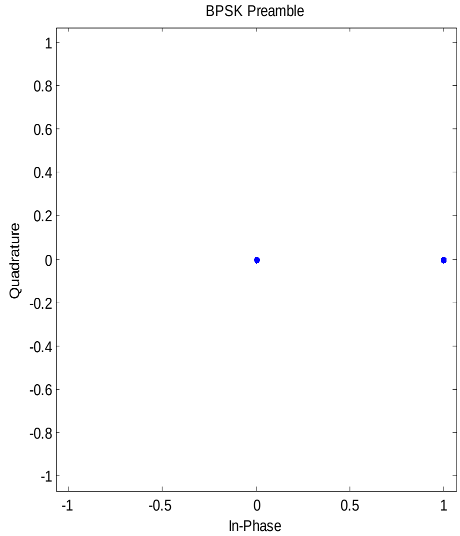

Fig.2. Scatter Plot

To get an appropriate measurement result for modulation quality, you must set the exact value for various frequency, timing and frame parameters for the WiMAX signal. There are two methods given in this WiMAX option for setting these parameters. First, you only need to select the standard with its bandwidth parameters.

The parameters are as below:

Bandwidth: 1.25 MHz, 3.5 MHz, 4.375 MHz, 5 MHz, 7 MHz, 8.75 MHz (default), 10 MHz, 20 MHz.

FFT size: 128, 512, 1024 (default), 2048

Guard period: 1/4, 1/8 (default), 1/16, 1/32

Frame duration: 2.5 ms, 4 ms, 5 ms (default), 8 ms, 10 ms, 12.5 ms.

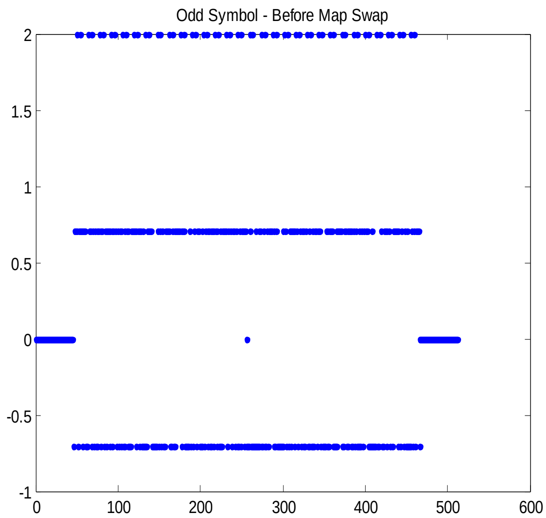

Fig.3.Odd Symbol-Before Map swap

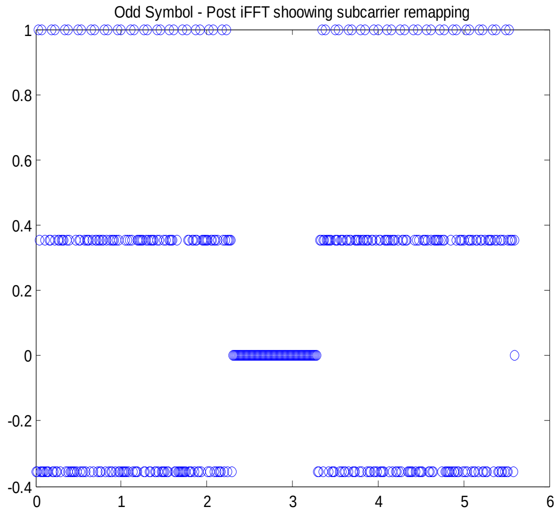

Fig.4. Odd Symbol Post iFFT showing subcarrier remapping

For the 512 carrier implementation, carriers 0 to 45 and 467 to 512 are unmodulated guard carriers. The pilots that define the subchannels are then arranged as per figure 234 for odd/even symbols.

The performance of system has also been tested for change of cyclic prefix factor, FFT size and Bandwidth. The upgradation in the size of FFT helps to improve the system performance. More the size of FFT less is the bit error rate and maximizes the throughput. But the size of FFT is limited in concern with system complexity. The effect of FFT size on system performance is shown in the figure 7.

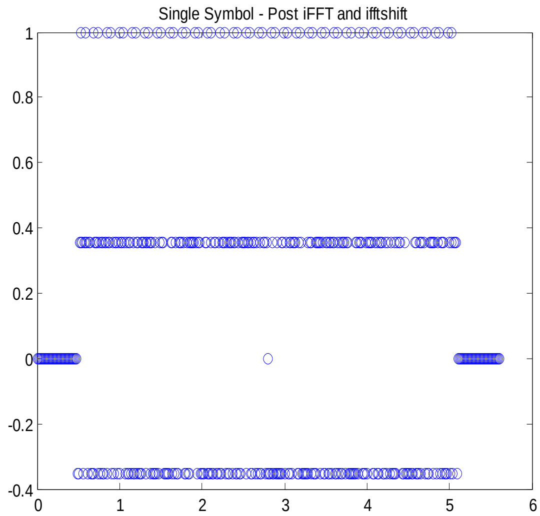

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Fig.5.Single Symbol-Post iFFT and iFFT shift

Matlab calculates its FFT (or iFFT) based around Fs/2. Thus, to avoid a big hole at Fs/2, the carriers have to be re-mapped

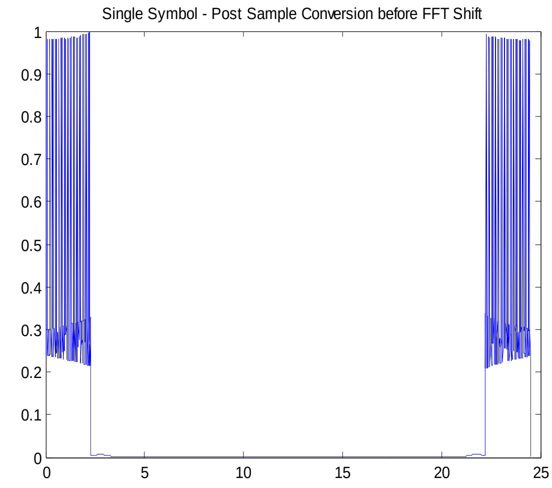

Fig.6.Single symbol –Post sample conversion before FFT shift

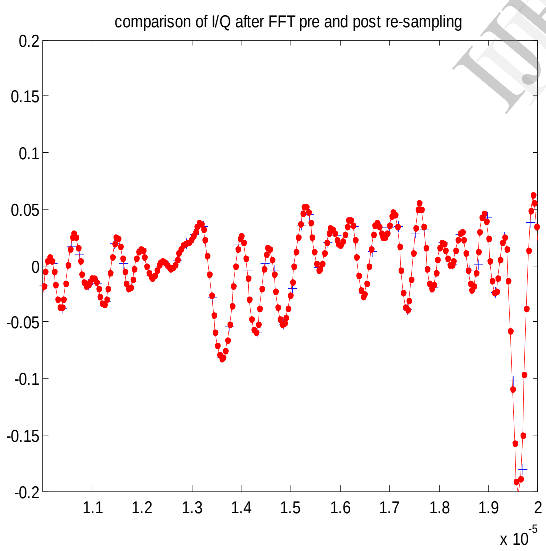

Fig.7.Comparison of I/Q after FFT pre and post re-sampling

Resample each from the original sampling rate to the SVWB sampling rate . The resampling factor to get close enough to the difference between the two sampling rates is p/q = 79/18

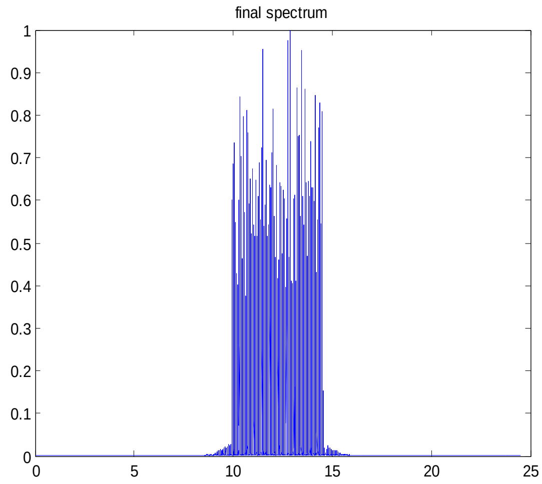

Fig.8.Final Spectrum

The WiMAX specially allows the DL and UL to step back from 64 QAM, to 16QAM, to QPSK and finally to BPSK based on degrading CQICH feedback. Changing modulation types in this simulation is straight forward

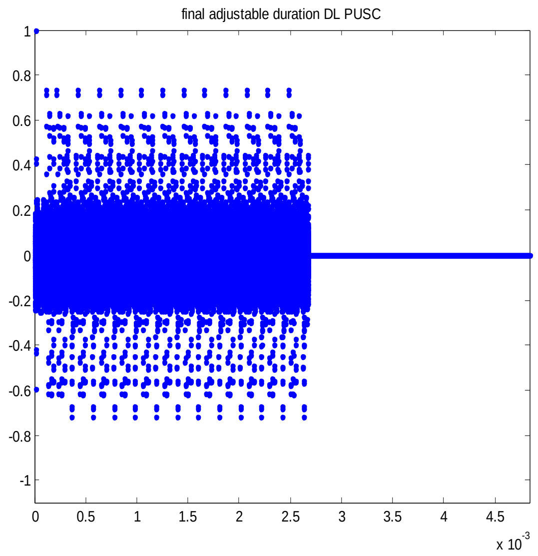

Fig.9.Final Adjustable duration DL PUSC

IV. CONCLUSION

With the design values performance analysis has been carried out. Components of the system can be tested against a defined standard IEEE 802.16e. The model presented can be used to implement coding and modulations schemes. The simulation results will enable user to select the best option to suit their requirements. From the simulation results analysis we can conclude that BPSK modulation consumes less signal power compared to higher ordered 64 QAM (20.5dB) modulations. Hence system performance is optimized with adaptive modulation. For good propagation conditions a high order modulation scheme with low coding redundancy such as 64 QAM is used in order to increase the transmission data rate. During fading signal the system selects an energy efficient modulation scheme such as BPSK or QPSK. This helps in making efficient use of the bandwidth and increases overall system capacity. In addition, higher values of cyclic prefix factor helps to improve the signal strength upto 18dB for QPSK 3/4 modulation scheme. Apart from 256, higher size of FFT can also be chosen to upgrade the performances of the system in concern with system complexity.

V. REFERENCES

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