



## Interpretation of IEEE 802.16e (Wimax)

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**GJCST-E Classification** : C.2.1



*Strictly as per the compliance and regulations of:*



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**Abstract** - The development of 802.16 standards for Broadband Wireless Access technologies was motivated by the rapidly growing need for high-speed, ubiquitous and cost-effective access. The limitations of conventional Broadband wireless access have been overcome with the scalable features of WiMAX. The aim of this paper is to analyse all compulsory features of the WiMAX OFDM physical layer specified in IEEE 802.16e. This paper gives an overview about the WiMAX standard and studies the performance of a WiMAX transmitter and receiver. This is done in order to study the WiMAX network practically. WiMAX network is implemented and analysed in great detail with the help of simulation results. Simulation is performed in the Matlab simulink.

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## I. INTRODUCTION

Accompanying the explosive growth of the Internet during the last decades, the current expansion of wireless technology promises a greater impact on how people communicate, interact and enjoy their entertainment. With the demand for greater range of services, such as video conferences, or applications with multimedia contents, the telecommunication industry is changing. The increased dependence on computer networking and the Internet has resulted in a wider demand for connectivity to be provided "any where, any time", which leads to the rise in the requirement for higher capacity and high reliability in broadband wireless telecommunication systems. Wireless networks have become increasingly interoperable with each other and this reflects a paradigm shift towards new generations of mobile networks where seamless mobility across heterogeneous networks becomes fundamental. This generation is referred to as fourth generation (4G).

Future users will be connected through different available access networks when they move from one place to another (at home, in the office, on the bus, on the train or in the shopping mall) [1]. For example, a video teleconference can transparently switch from an enterprise Wireless Local Area Network (WLAN) to the traditional cellular environment when driving home and to the fixed home network when arrived. This shows that the users can access and maintain a seamless connectivity anywhere, anytime through any access technology owned by any operator to use any available service.

### a) WiMAX Technology

WiMAX (also known as IEEE 802.16) is a wireless digital communication system that is intended for wireless "metropolitan area networks" (WMAN). It can provide broadband wireless access (BWA) up to 30 miles (50 km) for fixed stations, and 3 - 10 miles (5 - 15 km) for mobile stations. In 2005, when IEEE introduced first Mobile WiMAX standard 802.16e, and some of the added features of 802.16e were:

Enhanced mobility and portability capabilities, improved NLOS coverage by using adaptive antenna system (AAS) with multiple inputs multiple output (MIMO) technology, increased system gain and improved indoor penetration by adopting denser sub channelization and handovers for portable and mobile access.

### b) WiMAX 802.16/d/e and Related Standards

Table 1 shows a summary for WiMAX 802.16 /d/e and related standards specifications.

Table 1 : WiMAX Standards

Parameters	802.16	802.16d/HiperMAN	802.16e
Completed	December 2001	June 2004	2005
Spectrum	10-66 GHz	<11 GHz	<6GHz
Channel Conditions	Line-of-sight service	Nonline-of-sight Service	Nonline-of-sight Service
Bit Rate	32-134 Mbps in 28MHz channel bandwidth	Up to 75 Mbps in 20MHz channel bandwidth	Up to 15 Mbps in 20MHz channel bandwidth
Modulation	QPSK, 16QAM and 64 QAM	OFDM256FFT, QPSK, 16QAM and 64QAM	Scalable OFDMA, QPSK, 16QAM and 64 QAM
Mobility	Fixed	Fixed	Nomadic/mobile
Channel Bandwidths	20, 25 and 28 MHz	1.75-20MHz	1.75-20 MHz

## II. ARCHITECTURE

### a) WiMAX Network Architecture

WiMAX architecture comprises of several components but the basic two components are BS and

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SS. Other components are MS, ASN, CSN and CSN-GW. The WiMAX Forum's Network Working Group has developed a network reference model according to the IEEE 802.16e air interface to make sure the objectives of WiMAX are achieved. To support fixed, nomadic and mobile WiMAX network, the reference model (Figure 1) can be logically divided into four parts [5].

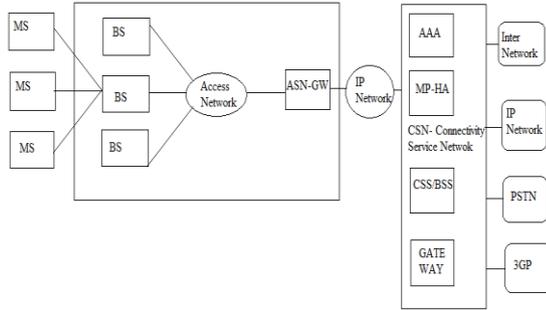


Figure 1 : WiMAX Network Architecture

• *Base Station (BS)*

The BS provides connection between operator networks and wireless subscriber devices. To enable wireless communications consists of antennas, transceivers, and other electromagnetic wave transmitting equipments.

• *Subscriber Station (SS)*

Also called Mobile Station (MS). The SS is the user that needs to use services while in motion at vehicular speed. These SS are battery operated compared to the fixed station. Generally mobiles and laptops are used as SS.

• *Access Service Network (ASN)*

It is owned by NAP, formed with one or several base stations and ASN gateways (ASN-GW) which creates radio access network. It provides all the access services with full mobility and efficient scalability. Its ASN-GW controls the access in the network and coordinates between data and networking elements. ASN-GW performs traffic management function within the ASN.

• *Connectivity Service Network (CSN)*

Provides IP connectivity to the Internet or other public or corporate networks. It also applies per user policy management, address management, location management between ASN, ensures QoS, roaming and security.

i. *Design Details*

As any other communication system, WiMAX has three basic elements, a transmitter, a receiver, and a channel over which the information is sent.

WiMAX comprises of two main parts:

1. WiMAX base station
2. WiMAX receiver

1. *WiMAX Base Station* : It is often called WiMAX tower or booster. The base station broadcasts radio frequencies to the receiver end.

- Responsible for: Providing air interface to the MS and it performs in MAC and PHY.
- Additional functions: Frequency reuse, handoff, tunnel establishment, QoS & classification of traffic etc.
- Management: Session management, bandwidth management for uplink and downlink and multicast group management etc.
- Practical Face: Tower in outdoor environment and electronic equipment in indoor environment.

2. *WiMAX Receiver* : WiMAX receiver receives the radio frequency from the WiMAX base station and makes sure the connectivity of WiMAX network is in range.

- Responsible for: Providing connectivity between subscriber equipment (such as mobile phone or laptop) and a WiMAX base station.
- Additional function: Packet priority, network interoperability and QoS.
- Connection: Backhaul, high speed microwave link which is also referred to a connection between core network and WiMAX system.
- Provides User: VoIP, multimedia and Internet access and many mobile applications.
- Practical face: Customer Premises Equipment (CPE) for indoor and outdoor purposes.

ii. *WiMAX Simulation Model*

The Simulink model of WiMAX PHY developed for the study is as shown in Figure 2, the model consists of transmitter and receiver section linked by the Channel sub systems.

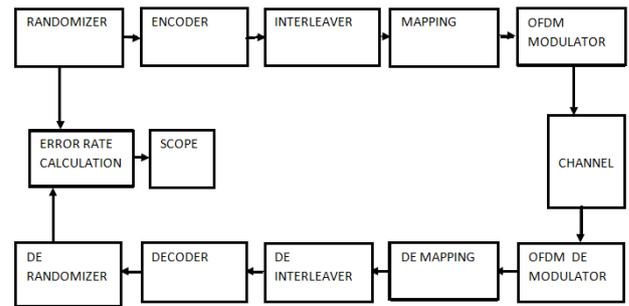


Figure 2 : Block Diagram of WiMAX Simulation Model

Main subsystems are detailed as:

a. *Randomization*

Randomization is the first process carried out in the physical layer after the data packet is received from the higher layers. Each burst in Downlink and Uplink is randomized. Randomizer operates on a bit by bit basis. The purpose of the scrambled data is to convert long sequences of 0's or 1's in a random sequence to improve the coding performance . The main component

of the data randomization is a Pseudo Random Binary Sequence generator which is implemented using Linear Feedback Shift Register. The generator defined for the randomizer is given by Equation 1:

$$1 + x^{14} + x^{15} \tag{1}$$

b. *Reed Solomon Encoding*

The purpose of using Reed-Solomon code to the data is to add redundancy to the data sequence. The encoding process for RS encoder is based on Galois Field Computations to do the calculations of the redundant bits. Galois Field is widely used to represent data in error control coding and is denoted by GF (2<sup>m</sup>). WiMAX uses a fixed RS Encoding technique based on GF(28) which is denoted as:

$$RS (N = 255, K = 239, T = 8)$$

Where:

N = Number of Bytes after encoding

K = Data Bytes before encoding

T = Number of bytes that can be corrected

Eight tail bits are added to the data just before it is presented to the Reed Solomon Encoder stage. This stage requires two polynomials for its operation called code generator polynomial g(x) and field generator polynomial p(x). The code generator polynomial is used for generating the Galois Field Array whereas the field generator polynomial is used to calculate the redundant information bits which are appended at the start of the output data. These polynomials are defined by the standard as below:

Code Generator Polynomial:

$$g(x) = (x + \lambda^0)(x + \lambda^1)(x + \lambda^2) \dots (x + \lambda^{T-1})$$

Field Generator Polynomial:

$$p(x) = x^8 + x^4 + x^3 + x^2 + 1$$

c. *Interleaving*

Interleaving is done by spreading the coded symbols in time before transmission. The incoming data into the interleaver is randomized in two permutations. First permutation ensures that adjacent bits are mapped onto nonadjacent subcarriers. The second permutation maps the adjacent coded bits onto less or more significant bits of constellation thus avoiding long runs of less reliable bits.

d. *Modulation*

The interleaver reorders the data and sends the data frame to the IQ mapper. The function of the IQ mapper is to map the incoming bits of data from interleaver onto a constellation. In the modulation phase the coded bits are mapped to the IQ constellation, starting with carrier number -100 on up to carrier number + 100. To simplify transmitter and receiver designs, all symbols in the FCH and DL data bursts are transmitted with equal power by using a normalization factor. The

constellation-mapped data is subsequently modulated onto all allocated data carriers in order of increasing frequency offset index.

iii. *Simulation Results*

For performance analysis of the PHY model, simulation is performed by considering the standard test vectors specified in the WiMAX standard document. Several test cases and test vectors for each component are provided in hexadecimal format.

Input Data (35 bytes long)

45 29 C4 79 AD 0F 55 28 AD 87 B5 76 1A 9C 80 50 45  
 1B 9F D9 2A 88 95 EB AE B5 2E 03 4F 09 14 69 58 0A  
 5D

In WiMAX, this is simulation of transmitter. In figure 3 (a) the diagram simulation is after randomizer input. Different types of encoder is used for encode the data and figure 3(b) is the output after the encoder block. Interleaving is a technique commonly used in communication systems to overcome correlated channel noise such as burst error or fading. The interleaver rearranges input data such that consecutive data are spaced apart. Figure3 (c) is simulation after interleaver block of WiMAX. During the symbol mapping stage, the sequence of binary bits is converted to a sequence of complex valued symbols and figure 3(d) is the output after the mapper block.

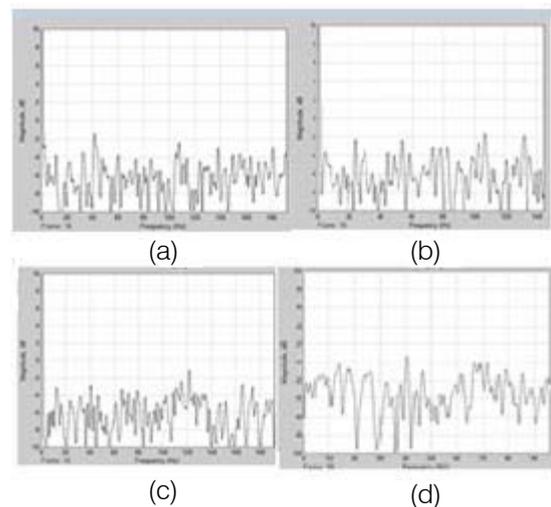


Figure 3 : Signal after (a) Randomizer block, (b) Encoder block, (c) Interleaver, (d) Mapper

A scatter plot or scatter graph is a type of mathematical diagram using Cartesian coordinates to display values for two variables for a set of data. The data is displayed as a collection of points, each having the value of one variable determining the position on the horizontal axis and the value of the other variable determining the position on the vertical axis which shows in figure4.

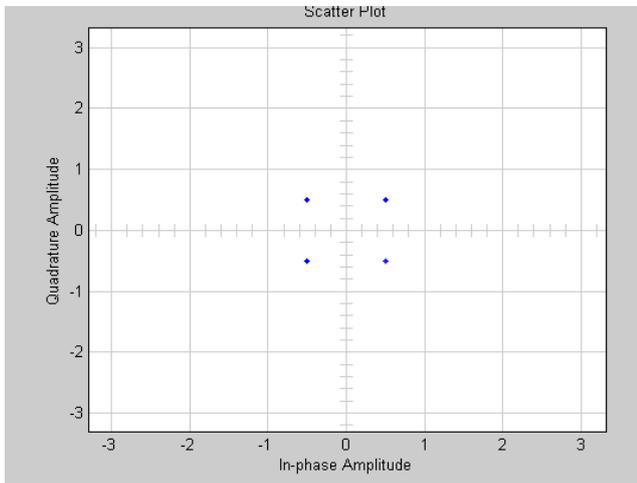


Figure 4 : Scatter plot after mapping

Modulation is very necessary for communication for long distances. So figure 4(a) is output after modulation block. After modulation the AWGN channel is used this adds noise and fading which shows in figure 5(b) that is before demodulation. Scatter plot shows the output before the de-mapper figure 5(c) and after de-mapper the output is figure 5(d) which has some effect of noise due to channel and we can see that the scatter plots are not pointed due to noise.

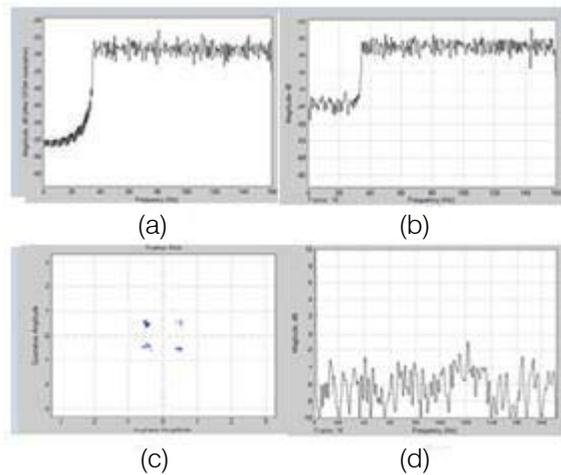


Figure 5 : Signal After (a) Modulator Block (b) Before Demodulator (c) Before De-Mapper (d) After De-Mapper

After de-mapping of signal, signal passes through the decoder block which decodes the original signal and figure 6(a) shows the output after decoder and finally at the receiver end de-randomizer is done to get the original signal which shows in figure 6(b).

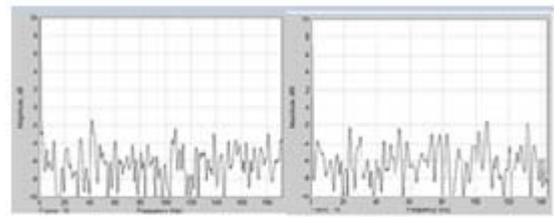


Figure 6 : Signal After (a) Decoder Block, (b) De-Randomizer Block

After running the simulink block in MATLAB the waveforms that are analyzed are shown in figure, figure, figure, and figure. The results are analyzed by observing the error rate calculation in MATLAB.

### III. CONCLUSION

As foreseen by many researchers, the next generation wireless mobile communications (4G) will be based on the heterogeneous underlying infrastructure integrating different wireless access technologies in a complementary manner. By using the simulation tool, I have analyzed the various waveforms after each block of the signal transmitted and received over the channel in a WiMAX network.

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