# Performance Evaluation of OFDM and Modulation Techniques in Mobile WiMAX (IEEE 802.16e)

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# *Dedication*

## *....To My Family*

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## ABSTRACT

Mobile communication has developed very during the last few years. Due to this fast development in this field, subscribers of today are enjoying the use of many applications ranging from data, voice, audio to video irrespective of the place where they are stationed or moving about.

WiMAX technology is fast capturing the market in the field of mobile broadband access. WiMAX uses Orthogonal Frequency Division Multiple Access (OFDMA) at the physical layer. WiMAX uses an adaptive modulation technique to modulate the signal prior to transmitting it. Under adaptive modulation, BPSK, QPSK, 16-QAM and 64 QAM are used for modulating the data depending on the channel conditions.

Cyclic Prefix is used to improve the quality of the signal under hostile environments especially Rayleigh fading. Cyclic prefix adds bits to the start and end of data stream to spread the signal. The receiver removes the bits added prior to further processing of the signal. Cyclic prefixing improves the error performance of signals by minimizing Inter Symbol Interference (ISI).

This study focused on the performance of the WiMAX system in terms of Bit Error Rate (BER), Signal to Noise Ratio (SNR), Power Spectral Density (PSD) and Probability of Error (Pe). Two models namely one without the Cyclic Prefix and the other with the Cyclic prefix were built to study these parameters. On analyzing the results, it was observed that adding cyclic prefix improved the error performance marginally especially when the signal is BPSK modulated. The results of BER vs SNR and Pe vs SNR are different as Pe is the expected value of BER where BER approaches Pe when the simulation is run for a long period of

time and the BER is very high. Other situations, Pe and BER show different results under same conditions.

Finally based on the evaluation and conclusion, recommendations were made for further work.

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# List of Abbreviations

| | | |
|---|---|---|
| 3GGP | - | 3rd Generation Partnership Project |
| AAA | - | Authentication, Authorization and Accounting |
| AM | - | Amplitude Modulation |
| ASK | - | Amplitude Shift Keying |
| ASN-GW | - | Access Service Network Gateways |
| ASP | - | Application Service Provider |
| AWGN | - | Additive White Gaussian Noise |
| BER | - | Bit Error Rate |
| BPSK | - | Binary Phase Shift Keying |
| BS | - | Base Station |
| BWA | - | Broadband Wireless Access |
| CC | - | Convolution Code |
| CEPT | - | European Conference of Postal and Telecommunications Administrations |
| CSN | - | Connectivity Service Network |
| DAA | - | Detect and Avoid |
| DL | - | Downlink |
| DoS | - | Denial of Service |
| DPSK | - | Differential Phase Shift Keying |
| DSL | - | Digital Subscriber Line |
| DUR | - | Downlink to Uplink Ratio |
| ETSI | - | European Telecommunication Standard Institute |
| ECC | - | Electronic Communications Committee |

| | | |
|---|---|---|
| FDM | - | Frequency Division Multiplexing |
| FDMA | - | Frequency Division Multiple Access |
| FEC | - | Forward Error Correction |
| FFT | - | Fast Fourier Transform |
| FM | - | Frequency Modulation |
| FSK | - | Frequency Shift Keying |
| GW | - | Gateway |
| HAP | - | High Altitude Platform |
| HiperMAN | - | High Performance Radio Metropolitan Area Network |
| IEEE | - | Institute of Electrical and Electronic Engineers |
| IFFT | - | Inverse Fast Fourier Transform |
| IMS | - | IP Multimedia Subsystem |
| IP | - | Internet Protocol |
| ISI | - | Inter Symbol Interference |
| ITU | - | International Telecommunication Union |
| LOS | - | Line of Sight |
| LTE | - | Long Term Evaluation |
| MAC | - | Media Access Control |
| MB-OFDM | - | Multiband OFDM |
| MFSK | - | Multiple Frequency Shift Keying |
| MGF | - | Moment Generating Function |
| MPSK | - | Multilevel Phase Shift Keying |
| MS | - | Mobile Station |
| MTRNG | - | Mersenne Twister Random Number Generator |
| NSP | - | Network Service Provider |

| | | |
|---|---|---|
| NWG | - | Network Group |
| OECD | - | Organization for Economic Co-operation and Development |
| OFDM | - | Orthogonal Frequency Division Multiplexing |
| OFDMA | - | Orthogonal Frequency Division Multiple Access |
| PAPR | - | Peak-to-Average Power Ratio |
| Pe | - | Probability of Error |
| PSD | - | Power Spectral Density |
| PSK | - | Phase Shift Keying |
| PSTN | - | Public Switched Telephone Network |
| QAM | - | Quadrature Amplitude Modulation |
| QoS | - | Quality of Service |
| QPSK | - | Quadrature Phase Shift Keying |
| SNR | - | Signal to Noise Ratio |
| RNG | - | Random Number Generator |
| RS | - | Reed-Solomon |
| TDMA | - | Time Division Multiple Access |
| UP | - | Uplink |
| WiFi | - | Wireless Fidelity |
| WiMAX | - | Worldwide Interoperability for Microwave Access |
| WLAN | - | Wireless Local Area Network |
| WMAN | - | Wireless Metropolitan Area Network |

# CHAPTER 1: Introduction

## 1.0 Background

The telecommunication industry is facing unprecedented competition due to rapid changes in technology [1]. Customers also demand high levels of services from the service providers. The telecommunication service providers try new ways to meet customer demands and add value to their existing products and services using new technologies to gain competitive advantage and to increase customer loyalty.

Wireless technologies are used for many different applications today. Communication is one such industry where wireless technologies are heavily used. The telecommunication industry uses many wireless technologies ranging from fixed wireless to cellular mobile technologies. Worldwide Interoperability for Microwave Access or WiMAX in short is a telecommunication protocol or technology that has captured the attention of both the service providers and customers due to its ability to carry high speed data in a fixed or mobile wireless environment.

ITU, the United Nations specialized agency for telecommunications, is committed to playing a positive role in the development of the information society and to extending the benefits of advances in telephony and new information and communication technologies (ICT), such as broadband, broadband is expected to be one of the highlights of this year's show[3]. For the purpose of monitoring the growth of broadband uptake, as well as in the interest of consumers, each country needs to

The contents of the thesis is for internal user only

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