



An Introduction to WiMax

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1. Introduction

There are several needs that have to be met simultaneously for successful demodulation analysis. There is creating the ideal waveform, analyzing and understanding the waveform, applying this waveform to the test equipment, acquiring the signal through instrumentation, and finally analyzing the signals to measure the DUT's performance.

Before any of these steps can begin, it is important for users to understand the basics of WiMax modulation, and its essential components.

This paper will discuss the basics of WiMax modulation, to give readers a primer on how WiMax works and its essential components. An overview of how WiMax testing is done on the V93000 test system is also presented.

2. WiMax Fundamentals

Due to the steadily growing success of data networks an increasing need for high speed wireless data transmission emerged during the past decade. This led to the introduction of new modulation concepts and techniques enhancing the data rates to up to tens of Mb/s. Generally accepted standards deploy these new techniques and make them accessible to a large community of users.

This paper will use, as an example, an important new standard that presents the capabilities of the V93000, WiMax (Worldwide interoperability for Microwave Access). WiMax is based on the IEEE 802.16 standard and serves as a protocol for broadband wireless data communication in metropolitan area (MAN) and wide area networks (WAN). According to its specification it supports data rates up to 75 MB/s and distances up to several kilometers. There have been several amendments to the standard so far. The newest one, IEEE 802.16e-2005 (also known as Mobile WiMax) adds the support for mobility and fast handover to its predecessor, IEEE 802.16-2004. The modulation and multiplexing techniques WiMax uses are crucial for enabling the large data rates and understanding them is necessary for the implementation of the correct demodulation algorithm and its application.

2.1. Sub-Carrier Multiplexing

The basic multiplexing technique utilized, Orthogonal Frequency-Division Multiplexing (OFDM), is a specific kind of frequency division multiplexing. In OFDM the spacing between the subcarriers on the frequency axis is chosen in a way that the subcarriers are orthogonal to each other leading to a minimal overlap between adjacent carriers and thus increasing the spectral

efficiency. At the same time, OFDM decreases the inter symbol interference (ISI) since it allows to choose a longer symbol period than one normally applies in single carrier standards.

Additionally, WiMax supports the Orthogonal Frequency-Division Multiple Access (OFDMA) technique, a multi-user version of the OFDM modulation scheme. Essentially, it adds the concept of subchannelization to OFDM: Subcarriers which do not necessarily need to be adjacent to each other are grouped together to a subchannel. The scheduler can then choose the subcarriers within a subchannel which exhibit the highest signal-to-interference/noise ratio for the data transmission, thereby decreasing the effect of inter carrier interference (ICI).

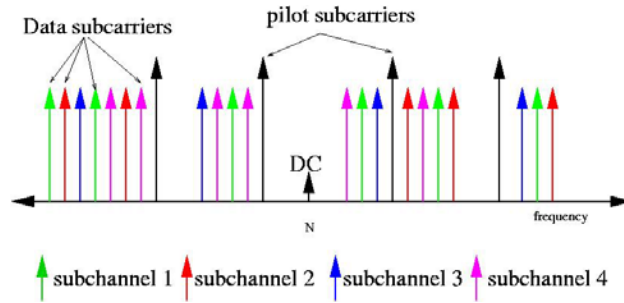


Figure 1 : Not necessarily adjacent subcarriers are grouped together to a subchannel in the OFDMA technique

Several permutation schemes are provided, according to which the subcarriers are assigned to a subchannel, such as Partial Usage of SubCarriers (PUSC), Full Usage of SubCarriers (FUSC) etc.

2.2. Subchannels and Symbols

A user normally gets assigned a number of subchannels. These subchannels then share a common modulation scheme which can range from QPSK to 16QAM to 64QAM. When the user is close to a base station and the signal quality is high, 64QAM can be chosen. In case of lower signal quality, 16QAM, QPSK or BPSK can be used. By this means the data rates are scaled with signal quality.

A subchannel for the duration of 1-3 symbols on the timing axis is called an OFDMA symbol unit and is the smallest element of resource allocation assignable to a user. OFDMA symbols can be assigned to different users independently based on their location with respect to each other. A connected area of OFDMA symbols sharing a common permutation scheme are referred to as a zone.

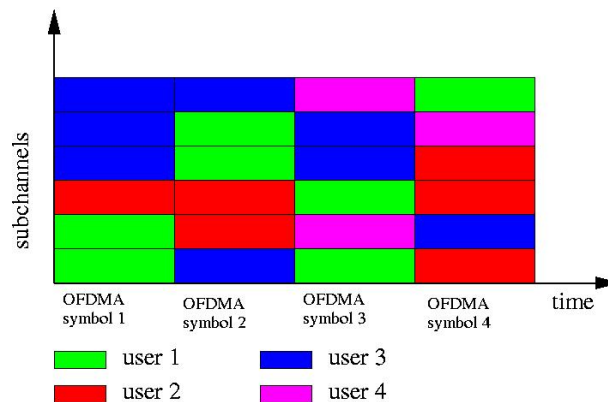


Figure 2 : OFDMA symbol blocks can be arbitrarily assigned to different users

3. WiMax Basic Demodulation and EVM

This section presents the demodulation API used in the Verigy V93000 software and demonstrates how to demodulate a WiMax waveform.

The first thing which is needed before demonstrating and referencing a demodulation procedure is an appropriate waveform to start with. There are a couple of ways of creating a waveform: The recommended method is to use software products for bench equipment such as Agilent's Signal Studio to create a waveform with exactly the features the user wants it to exhibit.

The V93000 software supports the encrypted output format of Signal Studio and can be used to play and capture the waveform.

The captured data are then fed into the V93000 demodulation engine which outputs multiple results such as mean rms EVM value over all symbols, mean EVM value over the data symbols, respective peak EVM values, IQ data for constellation plots etc. The demodulation engine in the V93000 software is Agilent IP and identical to the IP Agilent uses for its bench equipment. This leads to an optimal correlation between the V93000 tester and bench.

Crucial for a successful application of the demodulation engine are the correct parameter settings which need to be applied to the demodulation engine before it is started. The table below lists and explains the most important parameters for the demodulation of WiMax waveforms.

Table 1 WiMax V93000 Parameters

Parameter Name	Reference 10MHz (5MHz) WiMax waveform	Description
fofdmSmpFreq	22400000 (11200000)	Sampling rate
fofdmEqTraining	2	For equalizer training (2 means training uses data and pilots)
fofdmSymTimeAdj	-3.125	Symbol timing adjust in %
fofdmTrkAmp	FALSE	Uses pilots to track amp
fofdmTrkPhase	TRUE	Uses pilots to track phase
fofdmTrkTiming	FALSE	Uses pilots to track timing
fofdmDataModSel	0	Automatic modulation format detection per symbol
wmanBW	1000000 (5MHz)	Nominal signal band width
wmanBWRatio	28/25	Bandwidth ratio: sampling factor between min. sampling rate and nominal BW
wmanOfdmaFFTLengh	1024 (512)	Number of subcarriers (fft size)

wmanOfdmaZoneLengthInSymb	18	Length of the zone in number of symbols
wmanOfdmaZoneOffsetInSymb	0	Offset of zone in number of symbols
fofdmMeasInt	18	Length of evaluated symbol interval on the time axis
fofdmMeasOffset	0	Offset of evaluated symbol interval on the time axis
fofdmGuardInt	1/8	Guard interval (fraction of the symbol time used for CP in order to reduce ISI)
wmanOfdmaLinkType	0/1	0 = DL, 1 = UL
wmanOfdmaPulsSearchEnabled	TRUE	If bursts are detected
wmanOfdmaULSyncMode	2	Needs to be set to 2 for UL in order to get correct synchronization
wmanOfdmaUseBlindSync	TRUE	Needs to be set to TRUE for UL in order to get correct pilot synchronization
wmanOfdmaZoneType	1	Specifies permutation mode of zone (1 = PUSC)
wmanStd	2	2 and 3 work for WiMax 802.16e
wmanOfdmaUseDataBurstAnalysis	FALSE	If one has more than one burst/zone this parameter is set to TRUE and additional vector parameters need to be given.

Parameter tuning can be a time-consuming task which is far from being straightforward, especially if the features of a waveform are not known well enough. Of great help here is the Agilent 89600 VSA software normally used in bench equipment. It deploys the same demodulation engine as the V93000 software, and has a sophisticated front-end which tunes and detects many parameters automatically. It can serve as reference for EVM tests in the V93000 software.

The following sample code shows how to use the demodulation engine from within the V93000 software environment:

```

// Header
#include "Demodulation.h"

// Get captured waveform:
ARRAY_COMPLEX cData = MEAS_DEF(measName) .getComplexWaveform(1);

// Create Demodulation class instance:
Demodulation demod(TM::BLUETOOTH);

// Get a list of all parameters which can be adapted for this mod format:
demod.getListOfInputParameters(
    vector<string> &parameterNames,
    vector<string> &parameterTypes);

// Change the value for a parameter:
demod.setInputParameter(
    string parameterName,<type> value);

// Check the value which is currently set for a specific parameter:
demod.getInputParameter(
    string parameterName,<type> &value);

// Execute demodulation:
demod.execute(
    ARRAY_COMPLEX &cData,
    float sampleRate);

// Get the list of available result parameters:
demod.getListOfResults(
    vector<string> &resultNames,
    vector<string> &resultTypes);

// Get a specific result:
demod.getResult(
    string resultName,<type> &value);

<type> = int, bool, float, double, string, vector<double>

```

4. Conclusions

There are a lot of challenges to measuring EVM for WiMax. Having the right tools to make the measurements is crucial. This paper has attempted to show the basics of WiMax Modulation and how these tests are implemented on the V93000. WiMax EVM can be easily tested in production on the V93000 in a very short period of time, using the built in support for Signal Studio to generate the waveforms to be applied to the DUT (Device Under Test), and the built-in demodulation engine to analyze EVM from DUT outputs.

5. References

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