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WiMAX Technology using Speech Recognition Security

A. Z. Yonis[1,*], M. F. L. Abdullah[2], M. F. Ghanim[3]

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Abstract

WiMAX (Worldwide Interoperability for Microwave Access) technology is a telecommunications technology that offers transmission of wireless data via a number of transmission methods; such as portable or fully mobile internet access via point to multipoint links. Biometric recognition refers to an automatic recognition of individuals based on a feature vector(s) derived from their physiological and/or behavioral characteristic. Biometric recognition systems provide a reliable personal recognition scheme to either confirm or determine the identity of an individual. The main issue of WiMAX is how to identify that only register user are allow access to WiMAX .The aim of this paper is to discuss a WiMAX arrangement system. Combining WiMAX protocol with biometrics system (physiological and behavioral-speech recognition) leads to the best method to manage users because it cannot be rigged, but in order to obtain high efficiency, better control and management of users. This paper presents one application of biometrics types, speech (physiological and behavioral), and link to WiMAX using MATLAB program.

Keywords: *WiMAX, Modulation, Biometrics, Speech recognition.*

I. INTRODUCTION

WIMAX forum promises to offer high data rate over large areas to a large number of users where broadband is unavailable. This is the first industry wide standard that can be used for fixed wireless access with substantially higher bandwidth than most cellular networks [1]. Wireless broadband systems have been in use for many years, but the development of this standard enables economy of scale that can bring down the cost of equipment, ensure interoperability, and reduce investment risk for operators.

AUTHORS INFO

[1*] A. Z. Yonis
e-mail: aws_zuher@yahoo.com
University of Mosul

[2] M. F. L. Abdullah
e-mail: faiz@uthm.edu.my
University Tun Hussein Onn Malaysia

[3] M. F. Ghanim
e-mail: mayada_faris@yahoo.com
University of Mosul

*Corresponding Author A. Z. Yonis
e-mail: aws_zuher@yahoo.com
Tel: 0060127935790

The first version of the IEEE 802.16 standard operates in the 10 to 66 GHz frequency band and requires line-of-sight (LOS) towers. Later the standard extended operation through different PHY specification for 2 to 11 GHz frequency bands enabling non line of sight (NLOS) connections, which require techniques that efficiently mitigate the impairment of fading and multipath [1]. Taking the advantage of OFDM technique the PHY is able to provide robust broadband service in hostile wireless channel.

The OFDM based physical layer of the IEEE 802.16 standard has been standardized in close cooperation with the European Telecommunications Standards Institute (ETSI) and High Performance Metropolitan Area Network (*HiperMAN*). Thus, the *HiperMAN* standard and the OFDM based physical layer of IEEE 802.16 are nearly identical. Both OFDM based physical layers shall comply with each other and a global OFDM system should emerge. The WiMAX forum certified products for BWA comply with the both standards.

WiMAX protection is to increase security and manage its operation; number of methods can be used to build a gate that allows authorized users to access and share WiMAX and prevent unauthorized access. This paper focused on using biometrics physiological and behavioral

(speech recognition) to manage WiMAX and enhance security.

This paper contains all the fundamentals of WiMAX communication system in section 2, while the functional blocks of WiMAX transmitter which include randomizer, block encoder, convolution encoder, interleaver, IQ mapper, OFDM modulation are presented in section 3, the channel model and characterizes of wireless channel is explained in section 4. All the details of WiMAX receiver OFDM demodulation, de-mapping, de-interleaver, convolutional decoder and block decoder and de-randomizer are explained in section 5. Section 6 and 7 contain the biometrics, physiological and behavioral of biometrics respectively. Speech recognition MATLAB functions are explained in section 8 and the whole simulation system with the test and results are included in sections 9 and 10.

II. Basics of WiMAX System

As compare with other communication system, WiMAX has three basic elements, a transmitter, a receiver, and a channel over which the information is sent [2]. The main components of a WiMAX communication system are shown in Fig. 1.

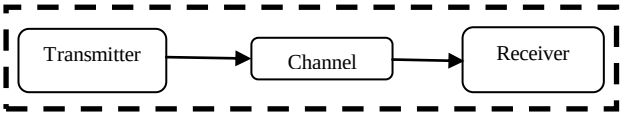

Fig. 1. Basic communication systems

III. WiMAX Transmitter

The functional blocks which compose the WiMAX transmitter are shown in Fig. 2. The MAC Protocol Data Units (PDU) is fed into the randomizer which randomizes the data. Afterwards, the randomized data is coded using block encoder (Reed Solomon), convolutional encoder. The coded data is interleaved by interleaver and mapped into QAM symbol. Then, the mapped data flows into the OFDM modulation which consist of assemble OFDM frame, 256 IFFT and cyclic prefix insertion. Afterwards the data is transmitted over AWGN channel.

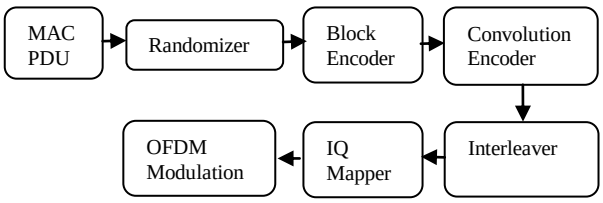

Fig. 2. Block diagram WiMAX transmitter

A. Randomizer

The information bits are randomized before the transmission. The randomizer, which is the first block in the transmitter, performs randomization of input data on each burst on each allocation to prevent a long sequence of 1's and 0's. This is implemented by using a Pseudo Random Binary Sequence (PRBS) generator, which is made of a 15 bits shift register and two XOR gates as shown in Fig. 3. The polynomial of PRBS generator is 1+x14+x15 with two XOR gates [1].

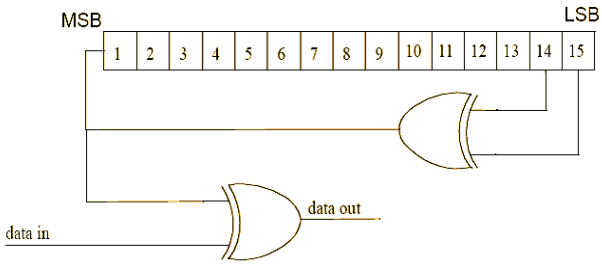

Fig. 3. Point PRBS for data randomization

B. Block Encoder, convolution encoder and interleaver

WiMAX system doesn't need the transmitter to retransmit any additional information which receiver uses for correcting errors and this occurred during the transmission over channel.

WiMAX utilizes *Forward Error Correction* FEC techniques to detect and correct errors. It use block encoder (Reed Solomon FEC), convolutional encoding and interleaving algorithms. WiMAX is using all these techniques to recover the errors that occurred due to fading or burst errors [3].

C. IQ Mapper (Constalletion Mapper)

In the modulation Mapper, the interleaved bits are converted to a sequence of complex valued symbols. WiMAX supports different modulation schemes as shown in Fig. 4. The modulation constellation used in WiMAX consist of two types of phase shift keying (PSK) modulation (binary (BPSK) and quadrature (QPSK)) and two types of quadrature amplitude (QAM) modulation (16QAM and 64QAM).

The complex constellation value is scaled by factor (Normalization constant), such that the average transmitted power is unity, c equals $1/\sqrt{2}$ for QPSK, $1/\sqrt{10}$ for 16-QAM, $1/\sqrt{42}$ for 64-QAM (assuming that all symbols are equally likely) [3].

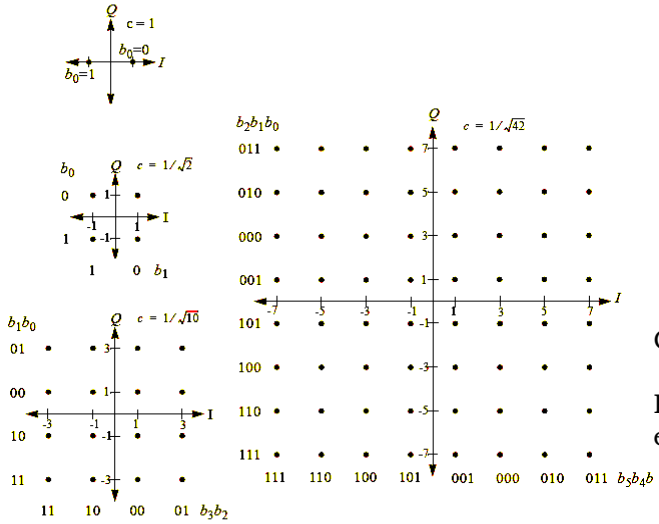

Fig. 4. BPSK, QPSK, 16-QAM and 64-QAM constellations

D. OFDM modulation

In WiMAX, each OFDM symbol consists of 256 subcarriers as shown in Fig. 5. They can be divided into.

1. 192 data subcarriers that are used for conveying data.

2. 8 pilot subcarriers that are used for conveying pilot symbols.

3. 56 null subcarriers that have no power allocated to them, including the DC subcarrier and the guard subcarriers toward the edge [1].

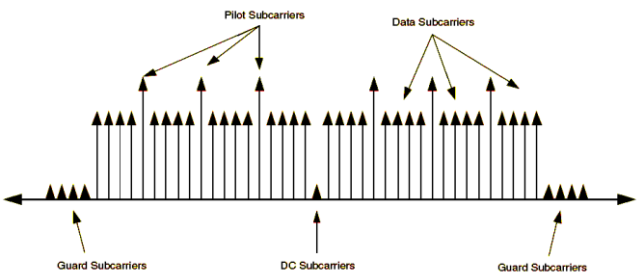

Fig. 5. Frequency domain representation of OFDM symbol

- Pilot modulation

Before inserting a pilot to its specified position, as shown in Fig. 6, it has to be modulated. Pilots can be generated by Pseudo Random Binary Sequence (PRBS) generator as shown in Fig. 7.

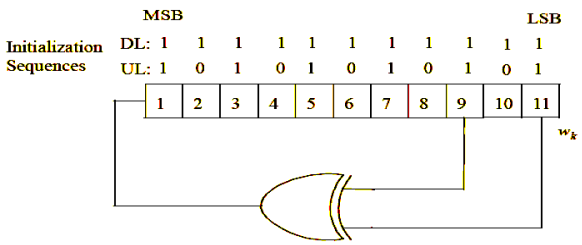

Fig. 6. PRBS for pilot modulation

The polynomial of PRBS generator is:

$$G(x)=X^{11}+X^{9}+1 \quad (1)$$

Pilot subcarriers are used for various estimation purposes.

- Inverse Fast Fourier Transform (IFFT)

To convert mapped data, which is assigned to all allocated data subcarriers of the OFDM symbol, from frequency domain into time domain, the IFFT is used. Time duration of the IFFT time signal could be computed by multiply as the number of FFT bins by the sample period. Zeros are added at the end and beginning of OFDM symbol. These zero carriers are used as guard band to prevent inter channel interference (ICI) [3].

- Cyclic Prefix insertion (CP)

A cyclic prefix is inserted before each transmitted symbol, to avoid inter symbol interference (ISI).

That is achieved by copying the last part of an OFDM symbol to the beginning as shown in Fig. 7.

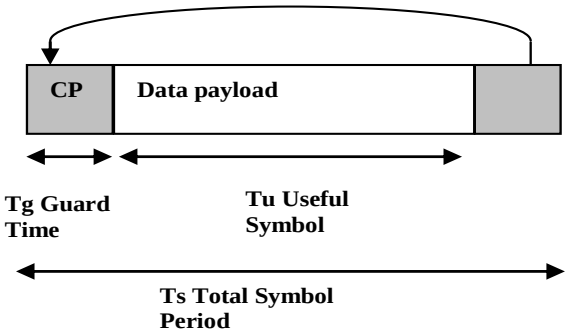

Fig. 7. Insertion of Cyclic Prefix (CP)

WiMAX supports four different duration of cyclic prefix (i.e. assuming G is the ratio of guard time to OFDM symbol time, this ratio is equal to 1/32, 1/16, 1/8 and 1/4) [3-4].

IV. CHANNEL MODEL

In order to evaluate the performance of the developed communication system, an accurate description of the wireless channel is required

to address its propagation environment. The radio architecture of a communication system plays very significant role in the modeling of a channel. The wireless channel is characterized by:

- Path loss (including shadowing)
- Multi-path delay spread
- Fading characteristics
- Doppler spread
- Co-channel and adjacent channel interference

All the model parameters are random in nature and only a statistical characterization of them is possible, i.e. in terms of the mean and variance value. They are dependent upon terrain, tree density, antenna height and beam width, wind speed and time of the year.

V. WiMAX Receiver

The functional blocks which compose the WiMAX receiver are shown in Fig. 8 where it is the reverse functional blocks of WiMAX transmitter. The received data coming from AWGN channel is fed into the OFDM demodulation, which consist of the removal of CP, Fast Fourier Transform (256 FFT) and disassemble OFDM frame. Then, the data is performed by de-mapper and afterwards the de-mapped data enter the de-interleaver, convolutional decoder and finally block decoder (Reed Solomon decoder). The final block in the receiver is de-randomizer.

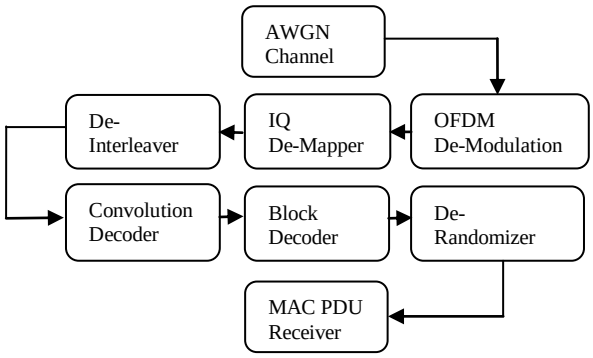

Fig. 8. Block diagram WiMAX Receiver

A. OFDM Demodulation

The OFDM demodulation is the reverse operation of OFDM modulation. Here, the signal is converted back from time domain to frequency domain. The first step in OFDM demodulation is to remove the CP. Then FFT is performed. Afterwards the OFDM frame is disassembled.

- Removal of CP

The first step after the arrival of data is to remove CP as shown in Fig. 9.

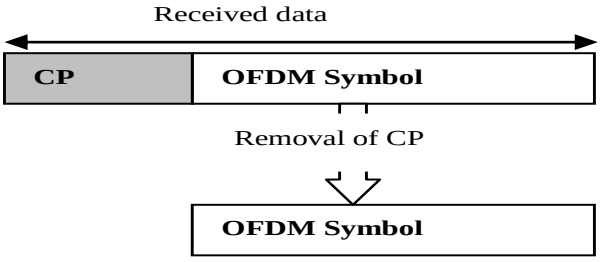

Fig. 9. Removal of CP

CP has no effect in case of using AWGN channel. It is useful when the multi-path channel is used. If CP is larger than the delay multi-path the ISI is completely removed.

- Fast Fourier Transform (FFT)

FFT is used to convert received data from time domain to frequency domain. Afterward, the zeros, which were added at the end and beginning of OFDM symbol (guard bands) at the transmitter are removed from the assigned places.

- Disassemble OFDM Frame

After performing FFT and removing guard bands, the data and pilots should be separated. This is achieved by using the disassembler.

B. De-Mapping

In order to convert the waveforms created at the modulation mapper to the original transformed bits, the de-mapper is used. The demapping is used for decision rules with the goal of making a decision about which bit "zero" or "one", was sent. The decision metric can be hard decision or soft decision. The minimum distance rule is the optimum decision in case of independent and identical distributed (IID) Gaussian noise [5].

C. De-interleaver, Convolutional Decoder and Block Decoder

The sequence of bits coming from de-mapper will be recovered the original bits after passing de-interleaver, convolutional decoder and block decoder.

D. De-Randomizer

The stream of bits coming from Block decoder is forwarded to the de-randomizer. The structure and the operation of the de-randomizer is the same of randomizer. That means, that de-randomizer is implemented by

the PRBS generator, which was explained in WiMAX transmitter.

VI. BIOMETRICS

The term "Biometrics" is derived from the Greek words bio (life) and metric (to measure). Biometrics refers to the automatic identification of a person based on his/her physiological or behavioral characteristics [6].

Biometrics is the science of establishing the identity of an individual based on the physical, chemical or behavioral attributes of the person. The relevance of biometrics in modern society has been reinforced by the need for large-scale identity management systems whose functionality relies on the accurate determination of an individual's identity in the context of several different applications.

The benefit of using or deploying biometrics is to increased security, increased convenience, reduced fraud, or delivery of enhanced services. In some applications, the biometric serves only as a deterrent; in others, it is central to system operation, regardless of the rationale for deploying biometrics.

VII. TYPES OF BIOMETRICS

The different types of biometrics fall into two categories: Physiological and Behavioral.

A) Physiological biometrics is based upon the recognition of physical characteristics, such as fingerprints, hand geometry, iris recognition, and facial recognition [7].

B) Behavioral biometrics can be described not as a physical characteristic, but are traits that are learned or acquired over time as differentiated from physical characteristics. Some examples are: speech, signature or keystroke recognition. Speech identification or Voice analysis studies the sounds, phonetics, and vocals generated by a person as early as the 1960s. The individuality of these characteristics are produced by the mouth, nasal cavities, and vocal tract which is unique to everyone much like a fingerprint [6]. A voice identification system requires that a "voice reference template" be created so that it can be evaluated against new voice entries. One must speak a set phrase several times so that the system can build the reference template. "Voice identification systems incorporate several variables or parameters in the recognition of one's voice/speech pattern including pitch, dynamics, and waveform". Speech recognition has several advantages [8]:

i. The cost of implementation is low because there is no special hardware required. A simple telephone or microphone is all that a user needs to authenticate using her voice.
ii. Convenient, and easy to use.
iii. Speech authentication is easy to use and easily accepted by users. It is quite natural to speak. It is not as natural to put an eye up to a reader. The concept of identifying people by voices is also quite natural. Every time someone answers a telephone call, the natural instinct is to try to identify the caller by his voice.
iv. Perhaps most important to the future of speech biometrics is that it is the only biometric that allows users to authenticate remotely. Allowing a user to call a phone number and authenticate with her bank vocally to perform a transaction is much easier than asking the user to go to the bank in person and authenticate via fingerprint.
v. Another advantage is that the storage size of the voiceprint is small.

VIII. SPEECH RECOGNITION MATLAB FUNCTIONS USING CORRELATION

This paper focuses on a behavioral characteristics biometrics (Speech) to manage the WiMAX network users. The theoretical steps of speech recognition are explained in the general structure of Speech recorder which is shown in Fig. 10:

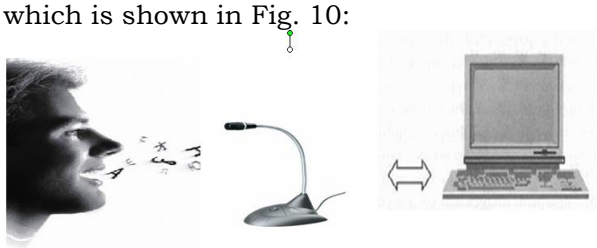

Fig. 10. Block diagram of a Speech recorder

The input voice signal is correlated with the voice signals already recorded in previous sessions. All recorded audio patterns must be placed in the working directory. If both voice signals match the user will be allowed to use WiMAX. Otherwise the user is unable to access WiMAX.

Description x*corr* estimates the cross-correlation sequence of a random process. Autocorrelation is handled as a special case.

The true cross-correlation sequence is,

$$R_{xy}(m)=E\{x_{n+m}y_n\}=E\{x_n y_{n-m}\} \quad (2)$$

where x_n and y_n are jointly stationary random processes, $-\infty < n < \infty$, and $E\{\cdot\}$ is the expected value operator. *xcorr* must estimate the sequence because, in practice, only a finite

segment of one realization of the infinite-length random process is available.
c = xcorr(x,y) returns the cross-correlation sequence in a length *2*N-1* vector, where *x* and *y* are length *N* vectors *(N>1)*. If *x* and *y* are not the same length, the shorter vector is zero-padded to the length of the longer vector.
In general, the correlation function requires normalization to produce an accurate estimate. Fig. 11 shows the steps of the speech recognition.

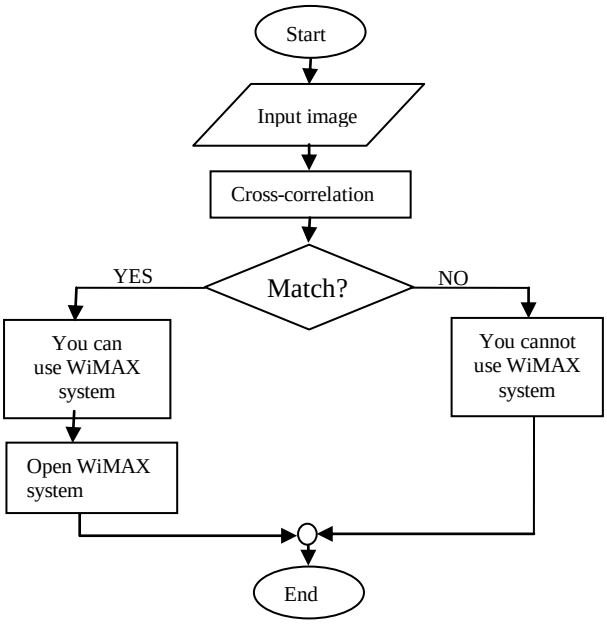

Fig. 11. Steps of speech recognition

IX. Simulation using MATLAB

The software simulation using MATLAB can be divided into two major parts

i. WiMAX simulation
ii. Speech recognition

The aim of the simulation model achieved by this paper is to evaluate the performance of WiMAX, which was built based on the IEEE 802.16e WiMAX, ETSI HiperMAN, PHY layer Model. The simulation models have been built by using only the mandatory blocks,. The model consists of three parts as shown in Fig. 12 (i.e., transmitter, receiver and AWGN channel).

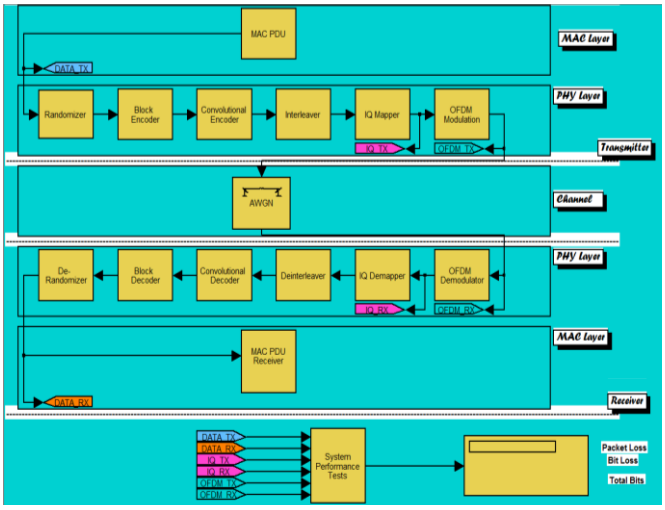

Fig. 12. WiMAX simulink in MATLAB

X. Simulation Test and Result

The model implemented here is based on the WiMAX which has the following characteristics:

Standard:	IEEE 802.16e
Carrier Frequency:	Below 11GHz
Frequency Bands:	2.5GHz, 3.5GHz, 5.7GHz
Bandwidth:	1.5MHz to 20MHz
Radio Technology:	OFDM and OFDMA
Data Rate:	70 Mbps [9]

After the model simulation is created, each block of the model can be tested. WiMAX standard document has test vectors for each block of model. The test is to make sure that each block works correctly.

For instance, when the implementation of RS encoder is completed, it is tested by entering the test vector of randomized data (Hex) mentioned above as input. The output vector of RS encoder is similar to the reed–solomon encoded data vector (Hex) mentioned above. That means that RS encoder block works correctly.

After the whole model has been tested by using the above tests and to ensure that each block works correctly, the performance of WiMAX with QPSK as a modulation type and code rate equal ¾, is simulated as shown in and Fig. 13.

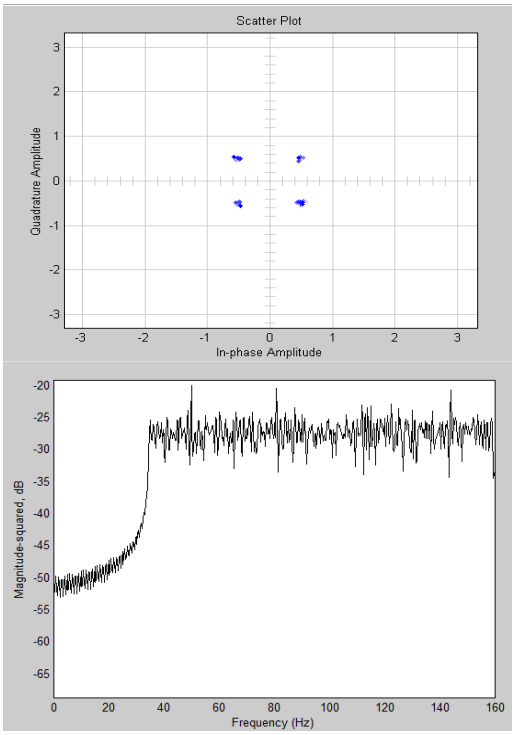

Fig. 13. WiMAX test result outputs graphics

XI. SPEECH RECOGNITION PROGRAM IN MATLAB

When executing the speech recognition program in MATLAB the user will choose an input voice signals for recognition. After selecting one of the input voice signals, a correlation will be executed within the database stored before. If the user's voice signal selection is not matched with any voice signal of the database, the voice message "Sorry you are not allowed to use WiMAX system" will be generated and the access to WiMAX system is not allowed, Otherwise the voice message "Welcome you can use WiMAX system" will be generated and WiMAX system is accessed by the user to send data.

XII. CONCLUSION

The interface of WiMAX has been developed so that it is compatible with the biometrics system (speech recognition), where this paper presented a method to prevent unauthorized persons from using WiMAX. The benefits of biometric usage and deployment are derived from having a high degree of certainty regarding an individual's identity. The benefits led directly or indirectly to cost savings, increase convenience, reduce fraud, or delivery of enhance services of WiMAX.

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