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WiMax transceiver, design, analysis, MATLAB-Simulink

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NOVEL SIMPLE DESIGN AND ANALYSIS OF WI-MAX TRANSCEIVER USING MATLAB-SIMULINK

Abstract

This paper provides analysis of WiMAX systems from its background to their architectures highlighting merits and demerits, topologies, structures and looks deep into transceiver systems architecture, then specializes on the radio frequency (RF) front-end part of the WiMAX transceiver system in which a model is designed. Thereafter, the model is implemented in MATLAB Simulink and the results are investigated and analyzed.

1. INTRODUCTON

Worldwide Interoperability for Microwave Access (WiMax) is a wireless communication framework that permits PCs and workstations to interface with fast information networks, (for example, the Internet) utilizing radio waves as the transmission medium with data transmission rates that can surpass 120 Mbps for each radio channel. The WiMax framework is characterized in a gathering of IEEE 802.16 industry standards and its different revisions are utilized for specific types of fixed and mobile broadband wireless access (Erceg & Hari, 2017; Lee, 2015).

WiMax is framework that is basically utilized as a wireless metropolitan area network (WMAN). WMANs can give broadband information communication access all through a metropolitan or city geographic region. WMANs are utilized all through the world and their applications involve client broadband wireless Internet services, leased lines and digital TV (IPTV) services. WiMax broadband wireless can rival optical broadband connections, digital subscriber line (DSL), and cable modem (Gray, 2006; Tarapiah, Atalla & Daadoo, 2017; Tebepah, 2018).

The 802.16 structure was planned for fixed area Nomadic service. Nomadic service is the giving of communication services to more than one location. While nomadic service might be given such a large number of locations, nomadic service ordinarily needs the movable communication device to be fixed in location through the use of communication service.

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For mobile service, the 802.16e was born. The 802.16e detail adds mobility management, extensible authentication protocol (EAP), handoff (call transfer), and power saving. WiMax has a few diverse physical radio transmission choices which permit WiMax framework to be sent in areas with various regulatory and frequency accessibility requirements. Several works on the topic of this paper can be found in literature (Erceg & Hari, 2017; Tembhekar, Thote & Zade, 2019).

1.1. Problem definition

Wireless communication is one of the most quickly developing enterprises in the present society. Mobile phones, wireless email and other ongoing innovative creations have prompted the interest for wireless access any place one goes. The consequence of this interest produced Wi-Fi (wireless fidelity) "hotspots" in which institutions; similar to Mustansiriyah University, set ups a wireless network to be gotten to by students and staff while in the campus area. The speed and range restriction have prompted an interest for more up to date innovation to additional grow the wireless market, to be named WiMAX.

2. METHODOLOGY

2.1. Design model

The novel design of the low-intermediate frequency (IF) RF front-end WiMAX transceiver involves integration of various components to work as a unit. The overall implemented model for the transmitter and the receiver is shown in Fig. 1.

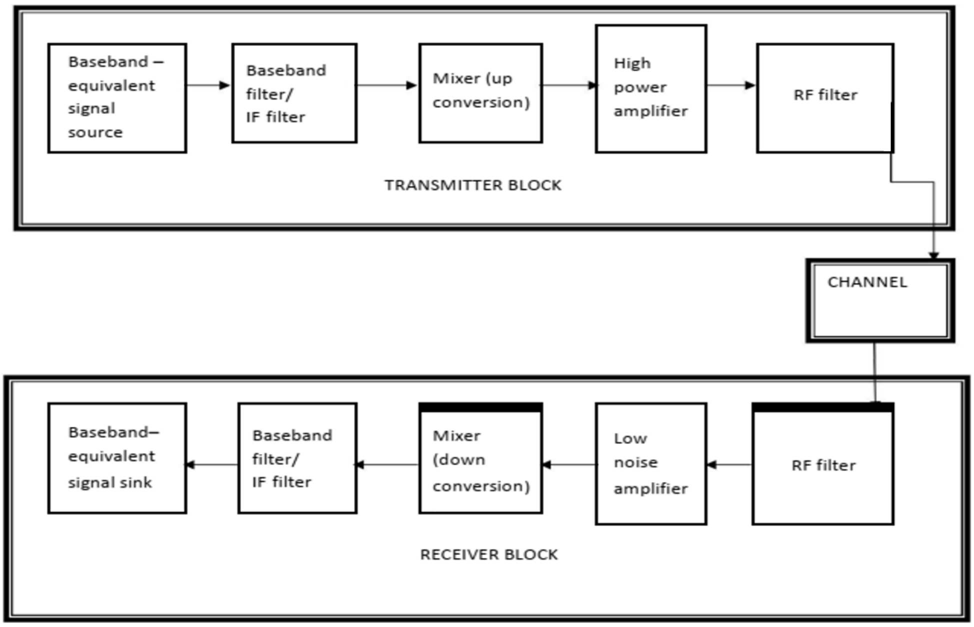

Fig. 1. Novel design of the low-IF-front Wi-Max transceiver

2.2. Design description

2.2.1. Baseband equivalent signal source

The signal source in the model includes the following components:

- A random integer generator block, used as source of random data,
- A modulator and a pulse shaping filter that performs Quadrature Phase Shift Keying (QPSK) modulation and root raised cosine pulse shaping,
- An up converter block that multiplies the modulated signal by a carrier frequency.

The sample frequency is set at 8 MHz.

2.2.2. Baseband equivalent signal sink

The signal sink in the model includes the following components:

- A down converter block that converts the signal from real passband to complex baseband,
- A root raised cosine pulse shaping filter that decimates back to one sample per symbol, and a QPSK demodulator block,
- Bit-Error-Rate (BER) calculation block.

The sample frequency is set at 8 MHz with a baseband bandwidth of 1 MHz.

2.2.3. IF filter

There are two band pass IF filter blocks are utilized. The strategy solution is Butterworth of order 3. In the pass-band and monotonic in general, the magnitude response of a Butterworth filter is extremely flat. 1 MHz and 10 MHz are the lower pass-band edge frequency and upper pass-band edge frequency respectively.

2.2.4. Mixer

A mixer can be described as a device with three ports that uses a nonlinear or time-varying element to convert frequency. Normally in a wireless communication systems all signal processing is done in baseband because it is easy to process low frequency signals. To be able to transmit through the wireless channel however the signal has to be brought to a higher frequency, which is done by modulation and up conversion in the transmitter, this effect has to be undone in the receiver which corresponds to demodulation and down conversion in the receiver (Muaayed F., 2020). Up and down conversions are done with mixers as follows:

Up converter

$$f_{IF} + f_{LO} = f_{RF}$$

The local oscillator frequency (f_{LO}) is set at 2.5 GHz, and f_{IF} at 10 MHz.

$$f_{RF} = (2500 - 10)\ \text{MHz} = 2.51\ \text{GHz}$$

Down converter

$f_{RF} - f_{LO} = f_{IF}$

The f_{LO} is set at 1.8 GHz.

f_{IF} = $(2510 - 1800)$ MHz $= 710$ GHz

This satisfies the Low-IF architecture theory in which the RF signal is translated to intermediate frequency closer to the baseband frequency.

2.2.5 RF filter

Two band pass RF filter blocks are utilized. The design strategy is Butterworth of order 3. The magnitude response of a Butterworth filter is extremely flat in the pass band and monotonic overall. 2.4 GHz and 2.6 GHz are the lower pass band edge frequency and upper pass band edge frequency respectively.

2.2.6. High power amplifier (HPA) and Low noise amplifier (LNA)

High-power amplifiers are principally utilized in transmitters and are planned to raise the signal's power level before sending it to the antenna. This power boost is important for the receiver to achieve the optimal signal-to-noise ratio, and it will not be detectable without the received signals.

Low Noise Amplifier (LNA) is the first amplifier in the RF receiver frontend; typically it is the first or second component after the antenna. It is intended to increase the power of the signal received, which is normally very small (could be as weak as –200 dBm. LNAs are designed to add as little noise as possible, such that the signal to noise ratio (SNR) stays above the minimum required SNR of the receiver. The SNR is defined as the ratio between the wanted signal and the noise and is usually specified in dBs. Every receiver has a minimum SNR at its input, if the SNR drops below this value, the error in the received signal will be high (Al-Rawi, 2020; Al-Rawi, Abboud & Al-Awad, 2020).

The HPA gain is set at 200 and The LNA gain is set at 120.

2.2.7. Channel

An Additive White Gaussian Noise (AWGN) Channel block set to signal-to-noise (Eb/No) mode. It specifies two bits per symbol because the modulation format is QPSK. The signal power is 1/(2·8) watts. This is because the original signal power at the modulator is one watt. The signal samples by factor eight by utilizing the root-raised cosine filter up, and then the power decreases by this factor. The real portion of the signal will be taken by the output of frequency up conversion block, thereby decreasing the power again, this time by a factor of two.

3. RESULTS AND DISCUSSION

MATLAB Simulink simulates the model in Fig. 2, and the parameters of its components are seen in Tab. 1.

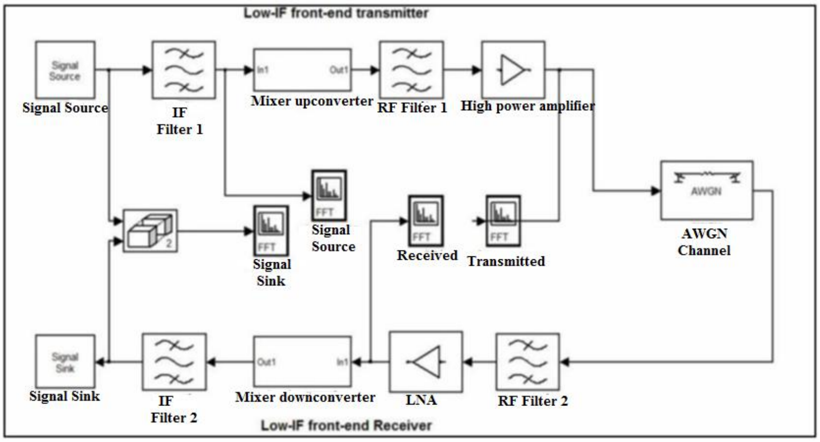

Fig. 2. Simulated model Low-IF-RF front end Wi-Max transceiver

Tab. 1. Parameters configurations

Parameters	RF Filter	IF Filter	HPA	LNA	Mixer	Power Amplifier	Channel
IIP2 (dBm)	–	–	–	0	0	0	1
IIP3 (dBm)	–	–	–	1	1	0	1
NF (dB)	1	5	2	1	0	0	8
Gain (dB)	-1	0	200	120	2	100	0
Order	3	3	–	–	–	–	–

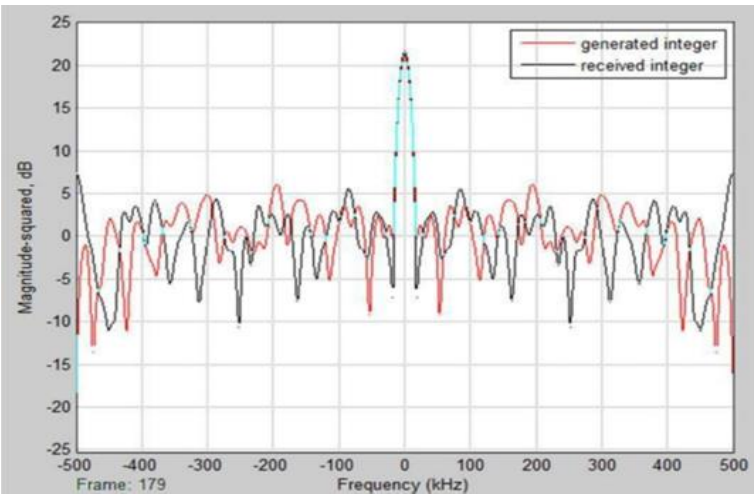

Fig. 3. Spectrum of Signals generated and received

A random integer signal of about twenty KHz is generated and received as appeared in Fig. 3. A modulator and a pulse shaping filter that achieves QPSK modulation and root raised cosine pulse shaping are passed through the generated signal, as shown in Fig. 4.

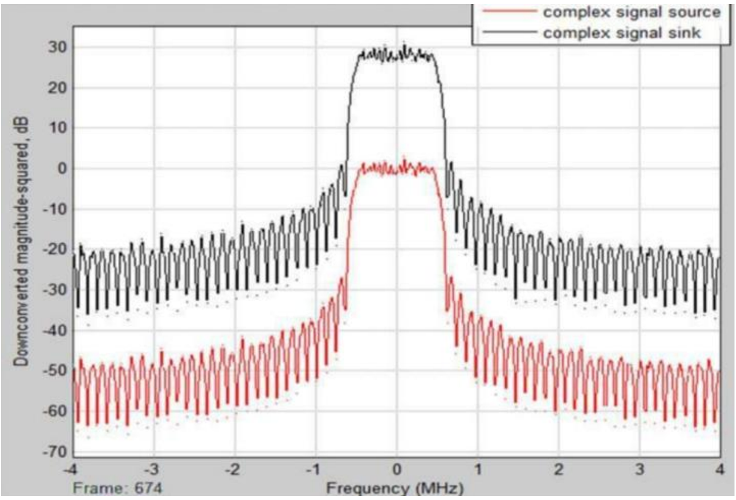

Fig. 4. Modulated QPSK signals transmitted and received

It is generated a base–band equivalent frequency signal (two to three) MHz with a one MHz bandwidth. As shown in Fig. 5, after being passed through the Low-IF RF front-end topology framework, this signal is transmitted and received.

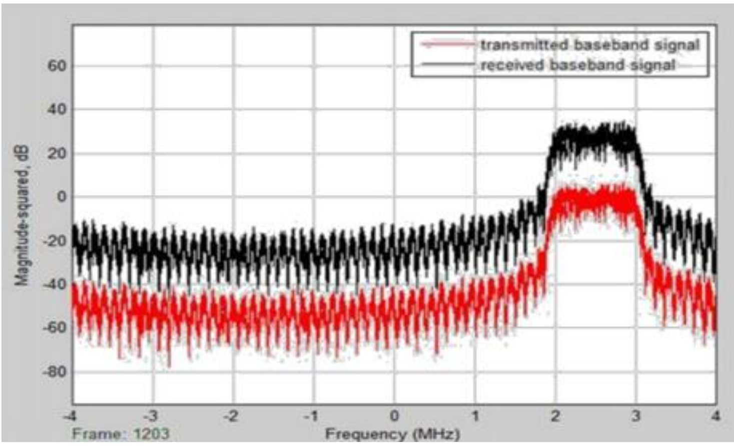

Fig. 5. Transmitted and received spectrum of base-band signals

The transmitted signal constellation is shown in Fig. 6, while the constellation of the signal received is shown in Fig. 7. The nonlinearity in the amplifiers and mixers caused the signal constellation to be spread. A nearly perfect 90° phase shift between the I and Q (In-Phase/Quadrature) paths is responsible for the limited bandwidth of the baseband signal. The BER is 0.5 because of the framework's relatively low noise figure (NF). Excessive noise in the device may have caused the signal to be overcome by noise, rendering the signal unrecoverable.

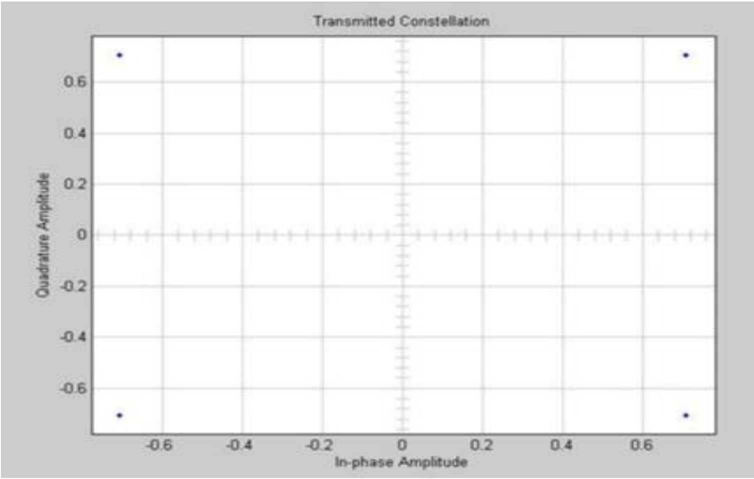

Fig. 6. The constellation Transmitted

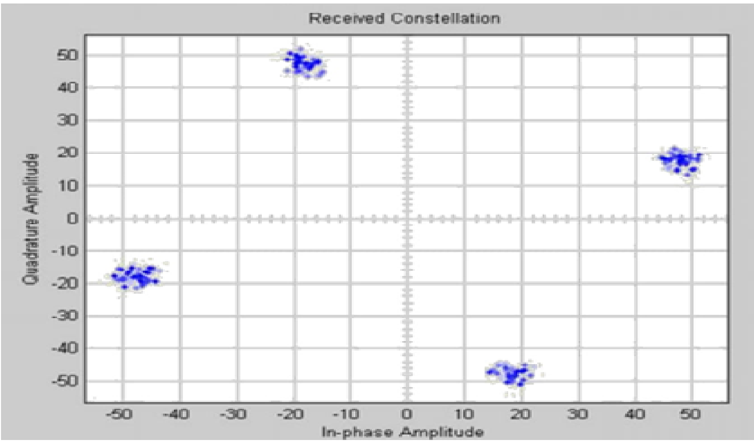

Fig. 7. The Constellation Received

4. CONCLUSION

The WiMAX technology can easily be inferred to be an innovative technology that is poised to revolutionize the world. A novel simple analysis and design methodology for a Low-IF RF front-end WiMAX transceiver was demonstrated in this paper. Using MATLAB Simulink, the model was implemented and successfully examined.

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