IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 15, Issue 2, Ser. II (Mar-Apr 2020), PP 40-46
www.iosrjournals.org

USRP Implementation of Convolutionally Encoded OFDM and MIMO-OFDM

Abdulbagi Elsanousi[1], Tarteel Nur[2], Ahmed Alhaj[3]
[1]*Communication engineering,Kocaeli University,Izmit – Turkey*
[2]*Communication engineering, Garden City University, Khartoum –Sudan*
[3]*Communication engineering,Academy Of Engineering Sciences,Khartoum –Sudan*

Abstract:*Future-generation in wireless communications system is based on two main techniques which are MIMO (Multiple Input Multiple Output) and OFDM (Orthogonal Frequency Division Multiplexing). The combination of these two techniques lead to a better system known as OFDM-MIMO, this system is considered for wideband transmission to mitigate inter symbol interference and to enhance system capacity. The main techniques used in MIMO systems are diversity technique and spatial-multiplexing technique. The diversity technique is aimed to improve the reliability, while spatial-multiplexing technique that provides degrees of freedom or multiplexing gain aimed to ameliorate the data rate of the system.*

This paper shows the performance of the BER (Bit Error Rate) of OFDM-MIMO system using convolution code to encrypt the data stream that can be sent over communication channels. Simulation is made on Matlab program using AWGN channel .The simulation results show that the OFDM-MIMO using convolution code has better performance than OFDM-MIMO without convolution code.

This work was done practically by using two USRPs B210 (Universal Software Radio Peripheral) for transmitting and receiving, MIMO technique (2x2) was used as well as SISO technique. Then eventually, the transmitted signal is successfully recovered for both techniques.

Keywords*-MIMO; OFDM; BER; QPSK; Convolution Code; USRP.*

Date of Submission: 29-04-2020 Date of Acceptance: 13-05-2020

I. Introduction

With the rapid growth of digital communication in recent years, the need for high speed data transmission is gradually increased. Furthermore, future wireless systems are expected to support a wide range of services which includes video, data and voice. Orthogonal Frequency Division Multiplexing (OFDM) is a promising candidate for achieving high data rates in mobile environment because of its multicarrier modulation technique [1]. Orthogonal frequency division multiplexing (OFDM) is an extensively used modulation and multiplexing expertise, now becomes the key factor in telecommunications standards together with wireless LANs, DTT and radio distribution in to a large extent of the earth. .In the precedent time, as well as now, the OFDM is termed in the literature as Multi-carrier and Fourier Transform. OFDM is basically transmitting lower rate data over multi carrier in order to send long sequence in parallel data stream with IFFT orthogonal concept. The carriers are prepared orthogonal to each other by suitably choosing the frequency spacing among them. A multicarrier system, such as FDM or WDM divides the total available bandwidth in the spectrum into sub-bands for multiple carriers to send in parallel. [2] It multiplexed a large number of low data rate carriers to make a compound high data rate communication system. Orthogonally provides the carriers a suitable cause to be narrowly spaced with overlapping without inter carrier interference. [3] The basic principle of OFDM is to split a high rate data-stream into multiple lower rate data streams that are transmitted simultaneously over a number of subcarriers. OFDM sends multiple high-speed signals concurrently on orthogonal carrier frequencies. This results much more efficient use of bandwidth as well as robust communications during noise and other interferences. With OFDM, it is possible to have overlapping sub channels in the frequency domain, thus increasing the transmission rate. In order to avoid a large number of modulators and filters at the transmitter and complementary filters and demodulators at the receiver, it is desirable to be able to use modern digital signal processing techniques, such as fast Fourier transform (FFT). After more than forty years of research and development carried out in different places, OFDM is now being widely implemented in high-speed digital communications. In a basic communication system, the data are modulated onto a single carrier frequency. The available bandwidth is then totally occupied by each symbol. This kind of system can lead to inter-symbol-interference (ISI) in case of frequency selective channel. The basic idea of OFDM is to divide the available spectrum into several orthogonal sub channels so that each narrowband sub channels experiences almost flat fading. The major advantages of

OFDM are its ability to convert a frequency selective fading channel into several nearly flat fading channels and high spectral efficiency [4].

II. MIMO–OFDM

Combining the two technologies multiple input multiple output and orthogonal frequency division multiplexing as a set of MIMO-OFDM is extremely valuable since more antennas can be supported by OFDM, this technology also enable massive bandwidth since the equalization in MIMO systems can be simplified enormously. The concept of adapting Multiple-Input Multiple-Output (MIMO) and Orthogonal Frequency-Division Multiplexing (OFDM) technologies , a higher data rates could be reached at indoor wireless systems up to several hundreds of Mbits/s and achieve spectral efficiencies of several tens of bits/Hz/s, which are unattainable for conventional single-input single-output systems[10].These enormous improvements of data rate and spectral efficiency come from the fact that MIMO and OFDM schemes are indeed parallel transmission technologies in the space and frequency domains, respectively. MIMO-OFDM when generated OFDM signal is transmitted through a number of antennas in order to achieve variation or to gain higher transmission rate then it is known as MIMO-OFDM[8].

Implementation of MIMO-OFDM system effectively, depends on the Fast Fourier Transform (FFT / IFFT) algorithm and MIMO encoding, such as Alamouti Space Time Block coding (STBC), the Vertical Bell-Labs layered Space Time Block code VBLASTSTBC, and Golden Space-Time Trellis Code (Golden STTC) [3].

There are various transmission systems where OFDM system has been adopted in, such as Wireless Fidelity (WIFI), Worldwide Interoperability for Microwave Access (WIMAX), Digital Video Broadcasting (DVB) and Long Term Evolution (LTE).

Orthogonal frequency division multiplexing (OFDM) has been comprehensively used in wireless communication since many years, resulting from its splendid immunity to multipath fading effects and frequency selective fading.

OFDM is a multicarrier transmission technique where the sub carrier’s frequency tones are reciprocally orthogonal to one another. The conversion of a serial data stream into a group of parallel data streams of longer time duration is the major principle of OFDM.[5-7].

III. Rayleigh Model

The common distribution that is used to describe statisticaltime varying nature of received envelope of flat fading signal is the Rayleigh distribution. The main idea of the Rayleigh flatfading channel model is that there is no line of sight betweentransmitter and receiver [8]. The received signal is reflected orscattered by multipath. The probability density function ofRayleigh distribution is given by:

$$P(x)=\begin{cases} \frac{x}{\sigma^2} e^{-\frac{x^2}{2\sigma^2}} & 0\leq x\leq\infty \\ 0 & x<0 \end{cases} \qquad (1)$$

Where σ and $\sigma 2$ are received root-mean-square and a.c power ofthe received signal respectively [8]. The Rayleigh channelcoefficients computed according to (2).

$$h = \left(\frac{1}{\sqrt{2}}\right) * \left(N(0,1) + j\big(N(0,1)\big)\right) \qquad (2)$$

IV. Unıversal Software Radıo Perıpheral

Universal Software Radio Peripheral (USRP) is a domain of software-defined radios, a technology that gives user opportunities to experiment with radio waves. Most USRPs connect to a host computer over a high-speed connection, to control the USRP hardware and transmit/receive data; the host-based software is used. Figure 1 shows transmitter and receiver connected with two laptops [9].

Corresponding author: name of corresponding author

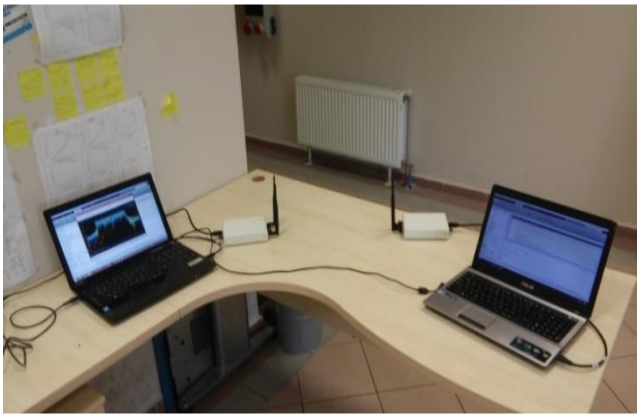

Fig. 1. Transmitter and receiver with USRP B210

The transmission and reception were done by using MIMO 2*2 with the diversity in which the data is sent over two antennas to combat the fading and improve the transmission gain. Moreover, the duplex mode that was used in the transmission is FDD.

V. Results

In this section, we present results for bit error rate of OFDM system using convolution code and without convolution code in AWGN channel. Figure 2 shows performance of MIMO-OFDM with convolution code and without convolution code in AWGN channel when 16QAM modulation is used. It was seen that the convolutional code was used as the channel coding. BER decreases when the number of antenna is increased.

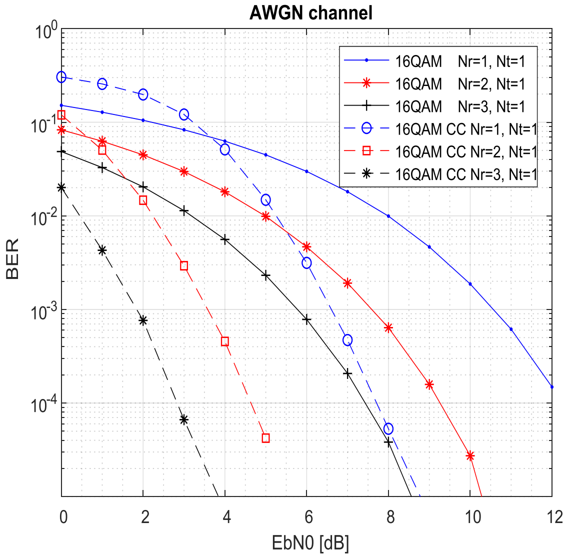

Fig. 2. Performance of MIMO-OFDM with convolution code and without convolution code under AWGN channel.

From figure 2 it's clear that the OFDM MIMO with convolution code hasbetter performance than OFDM MIMO without convolution code.

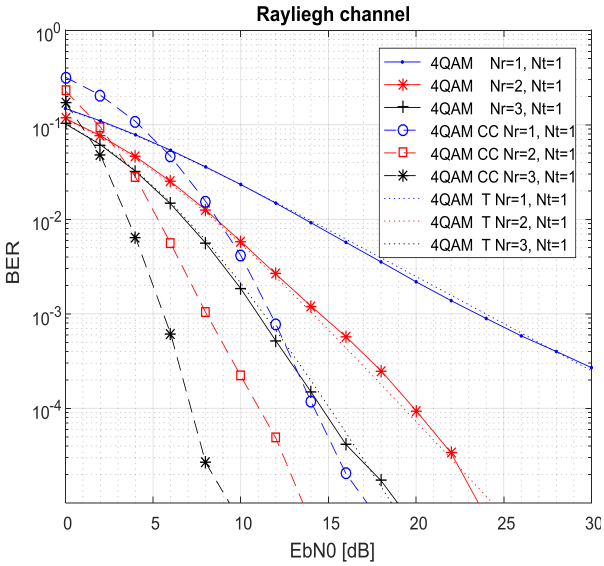

Fig. 3. Performance of MIMO-OFDM with convolution code and without convolution code under Rayliegh channel

Figure 3 shows performance of MIMO-OFDM with convolution code and without convolution code in Rayleigh channel when 4QAM modulation is used. It was seen that the convolutional code was used as the channel coding. BER decreases when the number of antenna is increased. BER under AWGN channel has better performance than Rayleigh channel.

VI. 2X2 MIMO EXPERIMENTAL WORKS

2x2 MIMO system was used experimentally by using two antennas in the transmitter and receiver. Diversity techniques used in MIMO techniques were used in this study. In other words, the same data is sent with two antennas to increase the reliability of the signal. In the transmitter, the FDD (frequency division duplexing) is used; FDD is a technique where the transmitter and receiver operate at different carrier frequencies. The distance between both the transmitter and receiver is approximately 50 cm. The parameters used in the system are given in Table 1.1

TABLE I. USRP MIMO TRANSMITTER – RECEIVER PARAMETERS

Model	B210
Center frequency	2.45 GHz
Gain	30 Db
Samples per frame	1900
Channel mapping	[1 2]
Master clock	6×10^6
İnterpolation factor	4

Algorithm 1 :

Begin

1- Create message
2- For creating LTE signal some parameters are considered (Channel encoding, modulation, message ...)
3- Create LTE Signal
4- Connect to Radio
5- Use parameters shown in table 1.1
6- Transmitting the LTE signal

2x2 MIMO antennas, convolution code as channel coding, QPSK and OFDM modulation were used. The USRP transmitter was operated at 2.45GHz with gain 30dB.

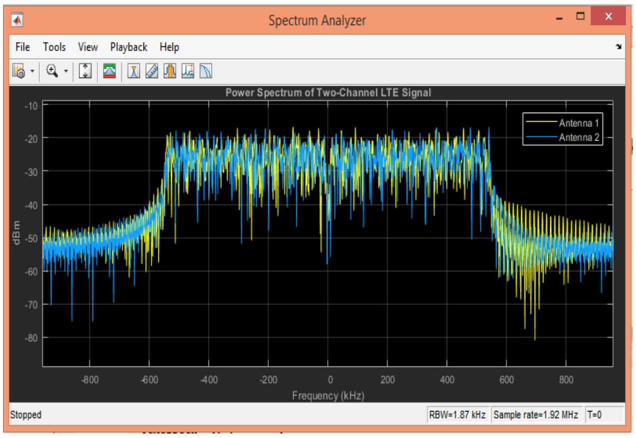

Fig. 4. Power spectrum of two-channel LTE signal

Figure 4 shows the illustration of the power spectrum of the two LTE channel signal. The blue signal refers to the transmitted signal from second antenna while the yellow one refers to the transmitted signal from the first antenna. In order to receive the LTE signal on the receiver with USRP, the steps in algorithm 2 were used in Matlab software.

Algorithm 2 :

Begin

1- Connect to Radio
2- Use parameters shown in table 1.1
3- Capture Signal
4- Frequency offset estimation and correction
5- Cell Search and Synchronization
6- OFDM Demodulation and Channel Estimation
7- SIB1 Decoding (Viterbi decoder)
8- Plot Channel Estimate for First OFDM Symbol

In order to be able to receive the transmitted signal from the transmitter at the receiver, OFDM, QPSK demodulation and Viterbi decoder must be used.

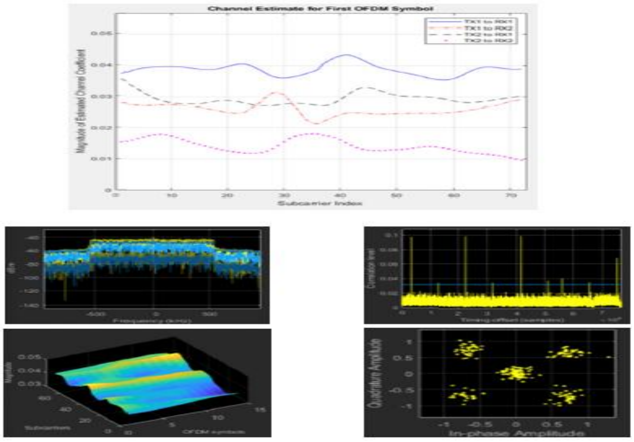

Fig. 5. 2x2 MIMO received signal spectrum

In order to recover the transmitted signal correctly parameters such as gain, frequency and position of the antenna should be considered, received signal is shown to be equivalent to the one that is transmitted. Figure 5 shows received signal. QPSK constellation and channel estimation.

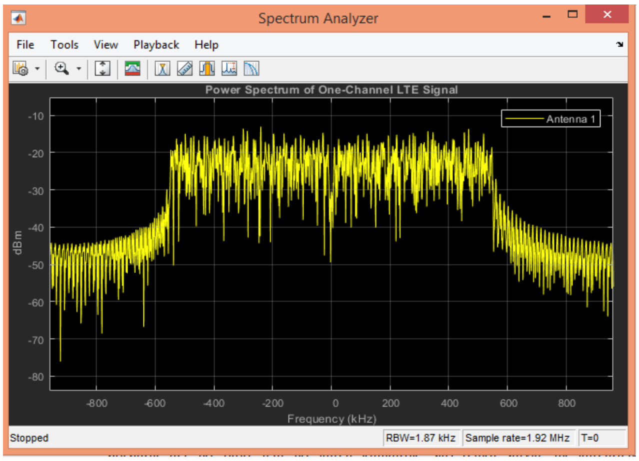

Fig. 6. Power spectrum of single-channel LTE signal

Figure 6 illustrate the power spectrum of single-channel LTE signal during transmission one antenna is used, in order to recover the transmitted signal correctly parameters such as gain, frequency and position of the antennas should be considered. Received signal is shown to be equivalent to the one that is transmitted. Figure 7 shows received signal, QPSK constellation and channel estimation.

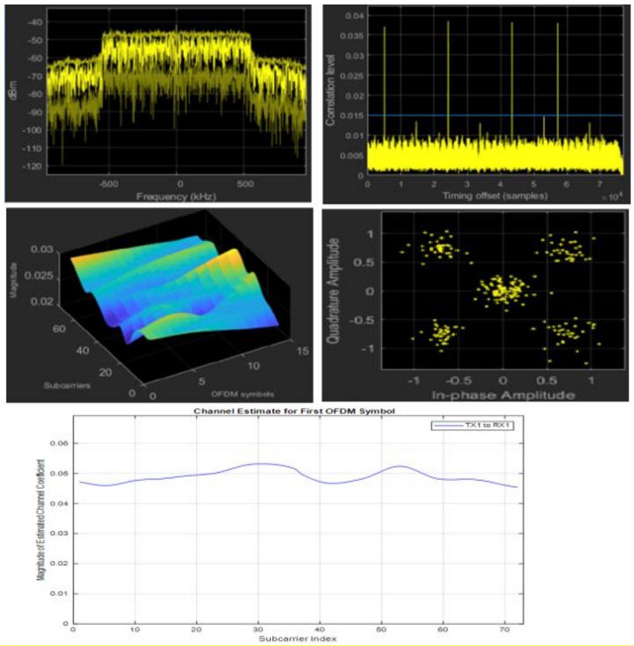

Fig. 7. SISO Received signal spectrum

VII. Conclusion

In this paper, BER performance analysis of MIMO-OFDM systems was performed with convolution code and without convolution code. AWGN channel was used for analysis. However, MIMO-OFDM and SISO-OFDM system were analyzed separately by using Matlab software. Furthermore, this study was experimentally implemented using two software-based radios, USRP B210.

In the simulation study, the following result was found, the lowest BER in the MIMO-OFDM system was obtained from the highest number of the transmitter and receiver antennas. As well as, the data transmitted by channel coding was performed better than the data transmitted without channel coding.

In the experimental study, SISO-OFDM system was performed by using one antenna in transmitter and receiver. In addition, 2x2 MIMO system was used experimentally by using two antennas in the transmitter and receiver. Furthermore, diversity technique is used in this study. In other words, the same data is sent through two antennas to increase the reliability of the signal. Frequency Division Duplex (FDD) is used between the transmitter and receiver. Then the messages that are sent in both methods were taken without error.

References

[1]. T. Wei and B. Khoshnevis, "Integration of process planning and scheduling: a review," Journal of Intelligent Manufacturing, vol. 24, no. 6, pp. 51–63, 2000.

[2]. R. Meenakshi Sundaram and S. Fu, "Process planning and scheduling — A method of integration for productivity improvement," Computers & Industrial Engineering, vol. 15, no. 1–4, pp. 296–301, 1988.

[3]. Y. Chu, F. You, J. M. Wassick, and A. Agarwal, "Integrated planning and scheduling under production uncertainties: Bi-level model formulation and hybrid solution method," Computers and Chemical Engineering, vol. 72, pp. 255–272, 2015.

[4]. F. S. Chan, V. Kumar, and M. Tiwari, "Optimizing the Performance of an Integrated Process Planning and Scheduling Problem: An AIS-FLC based Approach," 2006 IEEE Conference on Cybernetics and Intelligent Systems, pp. 1–8, 2006.

[5]. W. Tan and B. Khoshnevis, "Integration of process planning and scheduling— a review," Journal of Intelligent Manufacturing, vol. 11, no. 1, pp. 51–63, 2000.

[6]. D. Yip-Hoi and D. Dutta, "A genetic algorithm application for sequencing operations in process planning for parallel machining," IIE Transactions (Institute of Industrial Engineers), vol. 28, no. 1, pp. 55–68, 1996.

[7]. B. Yuan, C. Zhang, X. Shao, and Z. Jiang, "An effective hybrid honey bee mating optimization algorithm for balancing mixed-model two-sided assembly lines," Computers and Operations Research, vol. 53, no. 5–8, pp. 32–41, 2015.

[8]. Abdulbagi A., Sıtkı O., Performance Analysis of OFDM and OFDM-MIMO Systems under Fading Channels, Engineering, Technology & Applied Science Research, 2018, 8(4), 3249-3254.

[9]. National Instruments, USRP-2901 Block Diagram, available at: http://www.ni.com/documentation/en/software-defined-radio-device/latest/usrp-2901/block-diagram/

[10]. J. Jayakumari, "MIMO-OFDM for 4G Wireless Systems", International Journal of Engineering Science and Technology, Vol. 2, No. 7, pp. 2886-2889, 2010.

Abdulbagi Elsanousi, et. al. "USRP Implementation of Convolutionally Encoded OFDM and MIMO-OFDM." *IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)* 15(2), (2020): 40-46.