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Effect of Channel Equalization Schemes in Performance Evaluation of a Secured Convolutional Encoded DWT based MIMO MCCDMA System

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GJCST-E Classification : C.2.1

EFFECT OFCHANNEL EQUALIZATION SCHEMESINPERFORMANCE EVALUATION OFASECUREDCONVOLUTIONAL ENCODED DWTBASED MIMO MCCDMASYSTEM

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Abstract- **In this research work, performance of different channel equalization techniques and various M-ary modulation schemes (MPSK, MQAM and DPSK) for DWT based MIMO Multi-Carrier Code Division Multiple Access (MC-CDMA) wireless communication system has been analyzed through simulation. We propose this system using convolutional coding scheme over AWGN and Rayleigh fading channel with implementation of Walsh Hadamard code as orthogonal spreading code. In this paper, we derive a generalized analytical framework to evaluate the Bit Error rate (BER) with respect to Signal-to Noise Ratio (SNR) and also use Electronic Codebook (ECB) mode as cryptographic algorithm to encrypt the actual data for security issues.**

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I. Introduction

In the era of technologies the demand for wireless systems are rapidly increasing. To gain user satisfaction, multiple access technologies, high data transfer rates and flexible bandwidth allocation must be ensured by using the significant inventions of science and tech worlds [1]. Nevertheless high quality communication with low implementation cost is the centre of attraction of the users [2]. To fulfill user's requirements and to support a wide range of multimedia services, the 3rd generation or beyond wireless communication systems prefer Multi Carrier- Code Division Multiple Access (MC-CDMA) because of its high performance over multipath fading environment and increased capacity for a specified bandwidth [2,3]. MC-CDMA combines Code Division Multiple Access (CDMA) and Orthogonal Frequency Division Multiplexing (OFDM) to support multiple users at the same time as well as to ensure perfect utilization of frequency domain [1,4]. Moreover to curtail the dreadful presence of Inter Symbol Interferences (ISI) and to improve the Signal-to-Noise Ratio (SNR) performance, Discrete Wavelet Transform (DWT) based MC-CDMA is preferred over Discrete Fourier Transform (DFT) based MC-CDMA because of its ability to minimize the analytical complexity and to avoid the influence of delayed waves [2,5].

In our previous work presented in [2], the performance of Wavelet based MC-CDMA systems using Forward Error Correction (FEC) with interleaving in different modulation schemes on fading environment has been investigated. In this paper we propose this very system with Multiple-Input Multiple-Output (MIMO) where different channel equalization and different digital modulation techniques are used over AWGN and Rayleigh fading channel with implementation of convolutional coding scheme as error control coding and a cryptographic algorithm, Electronic Code Book (ECB) mode for secured transmission of data.

We preferred MIMO over other technologies because of its ability to increase the data rate that is to provide multiple forms of the same signal at the receiver without consuming much time [6]. Besides, the use of channel equalization schemes has enriched our proposal because it protects the data from Inter-Symbol-Interference (ISI) by adding redundant bits and exploiting the original transmitted data structure [7]. In our proposed DWT based MIMO MC-CDMA system, the Bit Error Rate (BER) performance of Minimum Mean Square Error (MMSE), Zero Forcing (ZF), Singular Value Decomposition (SVD) and Q-less QR decomposition based channel equalization techniques are compared. It may sound incredible, but with the colossal advancement of science and technology, network security faces a lot of threats. To overcome this problem, we have encrypted the original text message while transmitting using ECB algorithm where each plaintext is divided into several blocks that are encrypted using the same key and at the receiver end, the corresponding ciphertext is decrypted also using that key to retrieve the original message from its indecipherable form [8].

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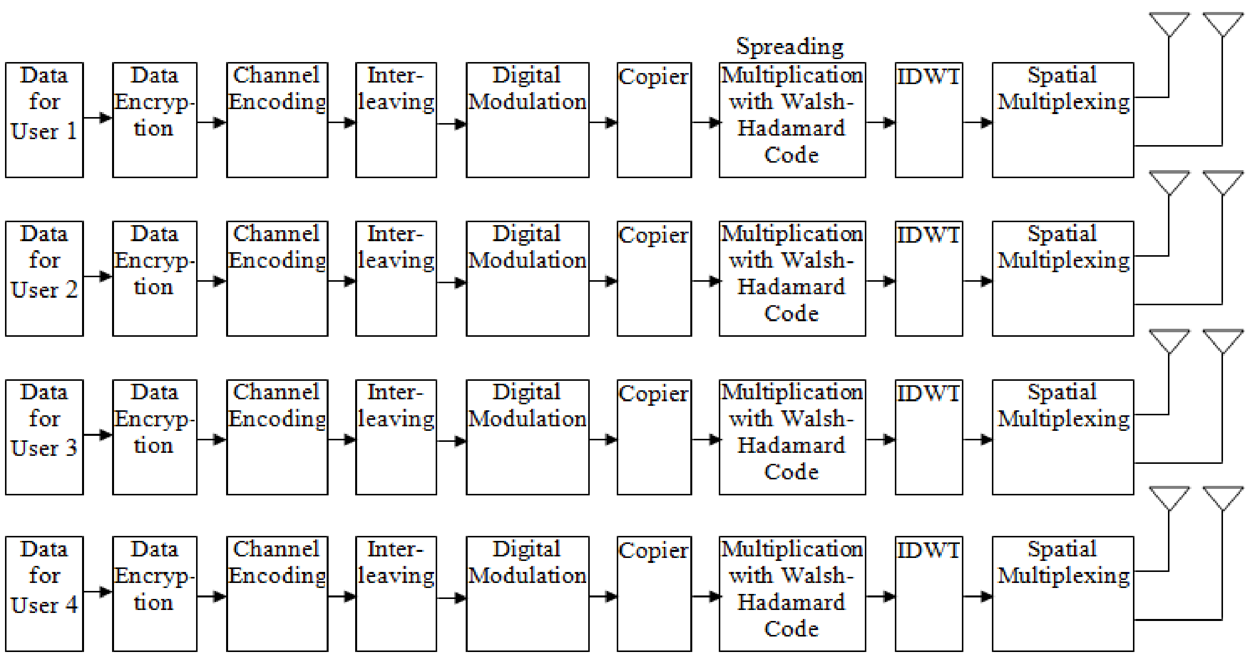
Our attempt is to propose an efficient MC-CDMA scheme that provides the most copacetic result taking the benefits of ubiquitous presence of different channel equalization and digital modulation schemes.

II. System Model

A simulated multi-user 2 × 2 spatially multiplexed and wavelet based MC-CDMA wireless communication system that utilizes spatial diversity coding scheme has been proposed as depicted in Figure 1. In such a communication system, the text message for different users is processed for encryption with ECB cryptographic algorithm so that unauthorized access of data can be prevented. The encrypted data are converted into binary bits and then channel encoded using ½-rated convolutionally encoding schemes and interleaved for minimization of burst errors. The interleaved and channel encoded bits are digitally modulated using BPSK, DPSK, QAM and QPSK. After that, the number of digitally modulated symbols is increased eight times in copying section (as the processing gain of the Walsh Hadamard codes is eight) and subsequently multiplied with Walsh Hadamard codes. The Walsh–Hadamard and channel encoded interleaved digitally modulated symbols are passed through inverse wavelet transformation and eventually fed into Space time block encoder for processing with implemented philosophy of Alamouti's G2 Space Time Block Coding scheme. The space time block encoded signals are then transmitted from each of the two transmitting antennas. In receiving section, the transmitted signals are detected using different channel equalization schemes (MMSE, ZF, SVD and Q-less QR decomposition). The detected two signals are passed through Space time block decoder and subsequently sent to forward wavelet transformation section. Its output is multiplied with assigned Walsh–Hadamard codes for despreading purposes. The despreaded digitally modulated symbols are then decopied, digitally demodulated, deinterleaved and channel decoded scrupulously. Finally the channel decoded binary bit stream is processed for performing decryption operation using the same key as encryption for retrieving the original transmitted text properly.



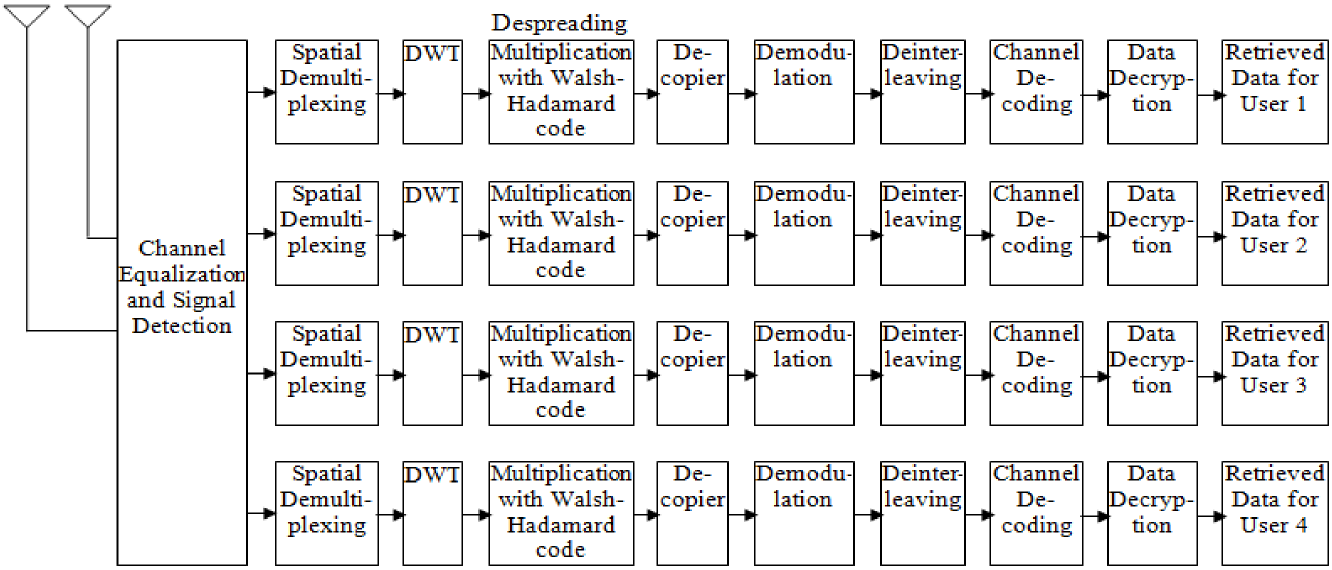


Figure 1 : Block diagram of a wavelet based MIMO MC-CDMA wireless communication system

III. Simulation Parameters

Here, we have used MATLAB 7.5 for simulation of DWT based MIMO MC-CDMA system where different graphical waveforms for different channel equalization schemes and different digital modulation techniques as well as some data for Bit Error Rate (BER) as a function of Signal-to-Noise-Ratio (SNR) per bit have been found. The proposed model for the wavelet based MIMO MC-CDMA transmitter and receiver in Figure 1 is simulated with considering the following parameters shown below in the Table 1.

Table 1 : Summary of simulation model parameters

Parameters	Types
User	4
Input Data	Text
Signal processing scheme	Wavelet
Processing gain	8
Modulation	BPSK,DBPSK,QPSK and 4QAM
SNR	0-10 dB
Spreading code	Walsh-Hadamard Code
Channel coding scheme	Convolutional
Signal detector (Equalizer)	MMSE, ZF, SVD and Q-less QR Decomposition
Channel	AWGN and Rayleigh fading
Cryptographic algorithm	Electronic Codebook (ECB)
Antenna Configuration	2 x 2

IV. Simulation Results and Discussion

In our dissertation, the performance of different channel equalization (MMSE, ZF, SVD AND Q-less QR decomposition) and digital modulation techniques (BPSK, QPSK, 4QAM and DBPSK) is compared in the perspective of bit error rate of MIMO MC-CDMA system based on DWT as a result of simulation, where convolutional coding technique and a cryptographic algorithm (Electronic Codebook Mode) are implemented for security purposes over AWGN and Rayleigh fading channel for wide range of SNR from 0 dB to 10 dB. From all the figures, it is seen that the bit error rate is decreasing with the increase of SNR as expected [2].

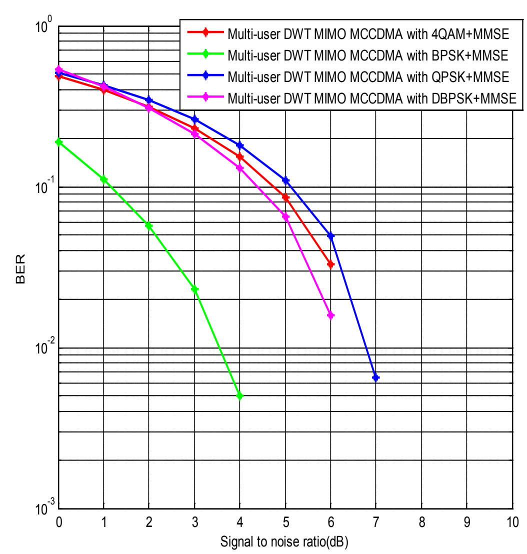


Figure 2 : Effect of different digital modulations under MMSE channel equalization technique in DWT based MIMO MC-CDMA system with implementation of convolutional coding scheme

In Figure 2, the performance of different digital modulation schemes (BPSK, QPSK, 4QAM and DBPSK) is compared in MIMO MC-CDMA system using MMSE channel equalization scheme. From the figure, it is noticeable that the system outperforms in BPSK digital modulation as compared to others (QPSK, 4QAM and DBPSK). For example, the BER values are 0.0229 and 0.2615 in case of BPSK and QPSK digital modulations respectively in a typically assumed SNR value of 3 dB as shown in Table 2, that is, the system performance achieves a gain of 10.58 dB. It is also observable from Figure 4 that at 10% BER value, the system performance with BPSK is superior to QPSK by 4 dB SNR value.

Table 2 : BER performance of the DWT based MIMO MC-CDMA system with implementation of MMSE channel equalization, convolutional coding and various digital modulation schemes

SNR (dB)	BER with MMSE Channel Equalization			
	4QAM	BPSK	QPSK	DBPSK
0	0.4893	0.1899	0.5098	0.5350
1	0.4024	0.1112	0.4301	0.4169
2	0.3151	0.0569	0.3459	0.3091
3	0.2310	0.0229	0.2615	0.2133
4	0.1535	0.0050	0.1810	0.1313
5	0.0863	0	0.1088	0.0649
6	0.0327	0	0.0492	0.0159
7	0	0	0.0065	0
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0

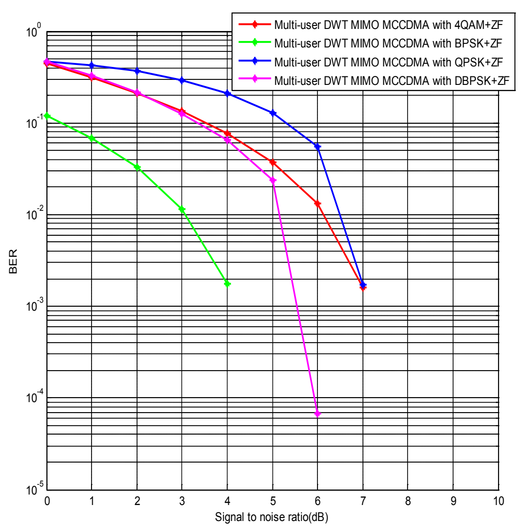


Figure 3 : Effect of different digital modulations under ZF channel equalization technique in DWT based MIMO MC-CDMA system with implementation of convolutional coding scheme

In Figure 3, it is remarkable that at higher SNR value area (5 dB – 7 dB), the estimated BER values at different digital modulations (BPSK, QPSK, 4QAM, DBPSK) ranges from minimum 0.0000 to maximum 0.0017 with implementation of Zero Forcing (ZF) channel equalization scheme (Table 3). Here, BPSK also gives the best performance among others as shown in the figure. The system shows almost identical performance in low SNR value area with 4QAM and DBPSK digital modulations. After SNR value of 5 dB, the BER value falls dramatically for DBPSK digital modulation whereas the BER of others decreases almost linearly with the increase of SNR.

Table 3 : BER performance of the DWT based MIMO MC-CDMA system with implementation of ZF channel equalization, convolutional coding and various digital modulation schemes.

SNR (dB)	BER with ZF Channel Equalization			
	4QAM	BPSK	QPSK	DBPSK
0	0.4412	0.1208	0.4668	0.4695
1	0.3131	0.0680	0.4296	0.3261
2	0.2115	0.0326	0.3686	0.2130
3	0.1336	0.0116	0.2924	0.1270
4	0.0765	0.0017	0.2092	0.0650
5	0.0373	0	0.1275	0.0237
6	0.0133	0	0.0555	0.0001
7	0.0016	0	0.0017	0
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0

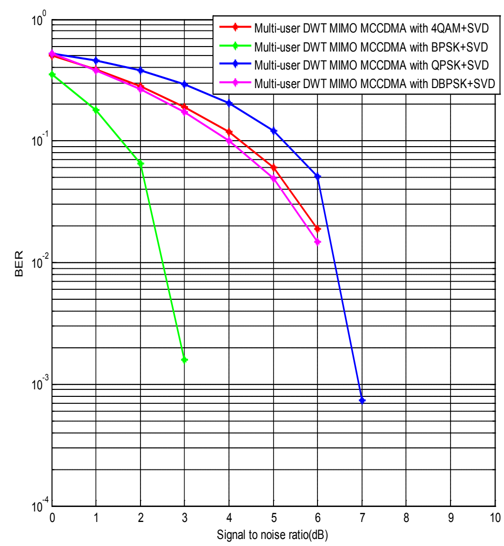


Figure 4 : Effect of different digital modulations under SVD channel equalization technique in DWT based MIMO MC-CDMA system with implementation of convolutional coding scheme

From critical examination on Figure 4, it can be unanimously mentioned that the system under investigation shows the best performance in BPSK digital modulation as compared to others (QPSK, 4QAM and DBPSK) with implementation of Singular Value Decomposition (SVD) channel equalization technique. This is because the BER value for BPSK is the lowest than others. For example, if we consider only BPSK and QPSK digital modulations, it can be shown from Table 4 that, for a typically assumed SNR value of 3 dB, the BER values are 0.0016 and 0.2920 for BPSK and QPSK digital modulations respectively viz., the system performance achieves a gain of 22.61 dB. It is also shown from the figure that, the BER values of BPSK and QPSK decrease rapidly within 2dB-3dB and 6dB - 7dB respectively whereas the decreasing rate is linear for both before these SNR values. The system shows almost identical performance in low SNR value area with 4QAM and DBPSK digital modulations.

Table 4 : BER performance of the DWT based MIMO MC-CDMA system with implementation of SVD channel equalization, convolutional coding and various digital modulation schemes

SNR (dB)	BER with SVD Channel Equalization			
	4QAM	BPSK	QPSK	DBPSK
0	0.5083	0.3544	0.5237	0.5221
1	0.3872	0.1787	0.4586	0.3805
2	0.2816	0.0650	0.3792	0.2644
3	0.1919	0.0016	0.2920	0.1718
4	0.1181	0	0.2038	0.1007
5	0.0604	0	0.1214	0.0490
6	0.0190	0	0.0515	0.0150
7	0	0	0.0007	0
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0

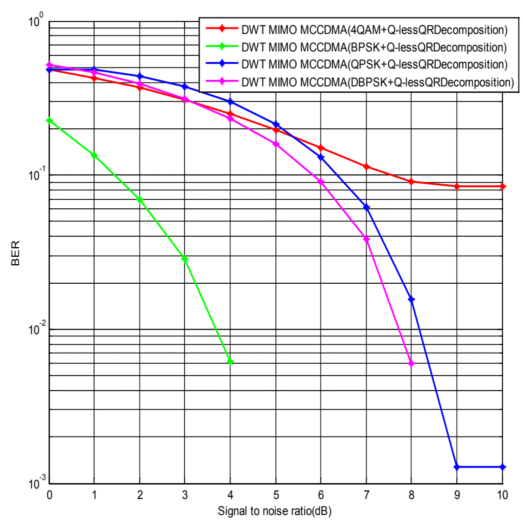


Figure 5 : Effect of different digital modulations under Q-less QR decomposition based channel equalization technique in DWT based MIMO MC-CDMA system with implementation of convolutional coding scheme

From Figure 5, it can easily be noticed that, the system using Q-less QR decomposition based channel equalization scheme provides the best performance with BPSK as before whereas it gives the worst performance with 4QAM in the perspective of the decreasing rate of BER. It is remarkable that, at higher SNR value area (4 dB –10 dB), the estimated BER values at different digital modulations ranges from minimum 0.0062 to maximum 0.0850 as shown in Table 5. As an example, it can be shown that, at 10% BER value, the system performance with BPSK is superior to 4QAM by 6.3 dB SNR value.

Table 5 : BER performance of the DWT based MIMO MC-CDMA system with implementation of Q-less QR decomposition based channel equalization, convolutional coding and various digital modulation schemes

SNR (dB)	BER with Q-Less QR decomposition based Channel Equalization			
	4QAM	BPSK	QPSK	DBPSK
0	0.4841	0.2265	0.4866	0.5214
1	0.4297	0.1340	0.4814	0.4634
2	0.3708	0.0696	0.4420	0.3926
3	0.3105	0.0286	0.3778	0.3145
4	0.2517	0.0062	0.2982	0.2346
5	0.1974	0	0.2128	0.1584
6	0.1506	0	0.1309	0.0912
7	0.1142	0	0.0621	0.0386
8	0.0914	0	0.0157	0.0060
9	0.0850	0	0.0013	0
10	0.0850	0	0.0013	0

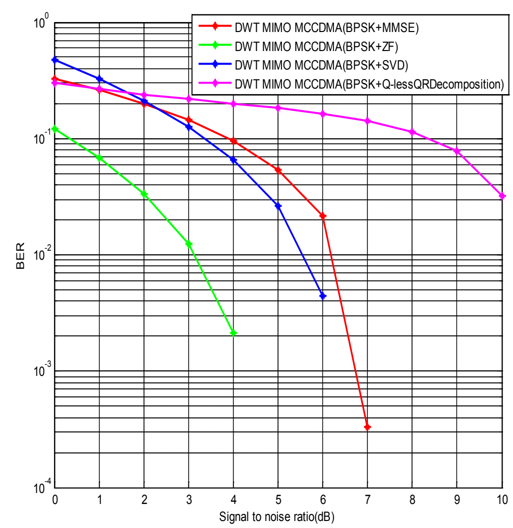


Figure 6 : Effect of different channel equalization techniques in DWT based MIMO MC-CDMA system with implementation of convolutional coding and BPSK digital modulation schemes

In Figure 6, the performance of different channel equalization schemes (MMSE, ZF, SVD, Q-less QR decomposition) in DWT based MIMO MC-CDMA system has been investigated with BPSK digital modulation incorporating with convolutional coding technique. A remarkable system performance has been observed from this figure with implementation of ZF channel equalization scheme. The system shows the worst performance in Q-less QR decomposition based channel equalization scheme as compared to others. For example, considering SNR value of 4 dB, the BER values are 0.0021 and 0.2009 in case of ZF and Q-less QR decomposition based channel equalization schemes respectively (Table 6), that is, the system performance achieves a gain of 19.81 dB. From the figure, an interesting property can be noticed that, a dramatical decreasing of BER has been occurred for MMSE channel equalization scheme after 6 dB SNR value.

Table 6 : BER performance of the DWT based MIMO MC-CDMA system with implementation of convolutional coding, BPSK digital modulation and various channel equalization schemes

SNR (dB)	BER with BPSK Digital Modulation			
	MMSE	ZF	SVD	Q-less QR Decomposition
0	0.3253	0.1202	0.4714	0.2998
1	0.2612	0.0685	0.3252	0.2664
2	0.2005	0.0335	0.2114	0.2402
3	0.1447	0.0124	0.1263	0.2191
4	0.0952	0.0021	0.0659	0.2009
5	0.0537	0	0.0266	0.1835
6	0.0215	0	0.0045	0.1648
7	0.0003	0	0	0.1424
8	0	0	0	0.1143
9	0	0	0	0.0784
10	0	0	0	0.0324

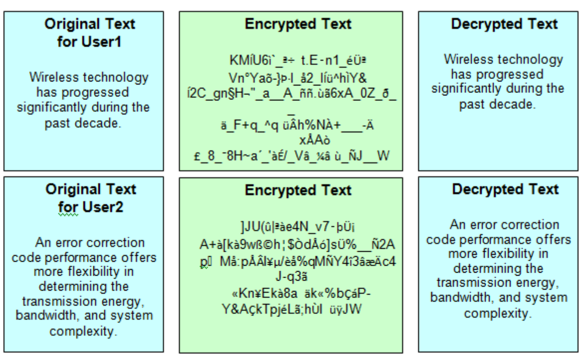


Figure 7 : Transmitted original messages, encrypted and decrypted messages using Electronic Codebook (ECB) mode of operation

In Figure 7, the transmitted, encrypted and decrypted messages for different users at SNR value of 10 dB have been presented. It is observed from the figure that, in all cases the encrypted text message is totally unintelligible, that is, it does not have any similarity to that of the original text message whereas this message can be retrieved with the decrypted one. Hence, it can be concluded that, this system ensures secured communication because it is possible to protect the transmitted data from eavesdropping of third party using this cryptographic algorithm.

V. Conclusion

In this thesis work, the performance of a 2 × 2 multi antenna supported 4G compatible DWT based MC-CDMA wireless communication system adopting convolutional coding and various channel equalization schemes with different digital modulations has been studied. In the context of system performance, it can be concluded that with BPSK digital modulation under implementation of ZF channel equalization scheme, the system provides the most satisfactory result. Furthermore, by using ECB cryptographic algorithm, confidentiality of data, which is one of the burning issues nowadays, can be ensured. Hence, by adopting this system, secured transmission of data with lower BER performance is possible.

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