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Encrypted Audio Signal Transmission in 5G Compatible Downlink Multiuser Pattern Division Multiple Access (PDMA) Wireless Communication System

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Abstract In this paper, we have made performance evaluative study for the 5G compatible downlink Pattern Division Multiple Access (PDMA) scheme implemented wireless communication system on encrypted audio signal transmission in AWGN and Rayleigh fading channel. The simulated system under consideration incorporates modern channel coding (Polar and (3,2)SPC) and different low order digital modulation (4-QAM, QPSK and DQPSK) schemes. With implementation of $G^{[2,3]}_{PDMA}$ pattern matrix for three users and considering total transmitted power of 40 Watt, 50%, 30% and 20% of total transmitted power have been assigned to first, second and third users and additionally phase shifting factors have been applied in power scaled transmitted signals of second and third users to resolve ambiguity in individual data separation. On consideration of encrypted audio signal transmission, it is observable from MATLAB based simulation study that the (3,2)SPC channel encoded power domain PDMA simulated system is very much robust and effective in retrieving transmitted audio data with achieving a BER of 10^{-3} at 21 Eb/No.

Keywords PDMA, Polar, (3,2) SPC, $G^{[2,3]}_{PDMA}$ pattern matrix, AWGN and Rayleigh fading channel, Bit error rate(BER), Normalized SNR(Eb/No)

1. Introduction

In present scenario of telecommunication sector, it is noticeable that an anticipated 1000-fold increase in mobile data traffic over the next decade and the explosion of new services and applications pose great challenges in existing orthogonal multiple access (OMA)-based 4G networks. Dai and et al., firstly introduced the principle of the complexity-constrained capacity-achieving NOMA design. Then a non-orthogonal pattern division multiple access (PDMA) scheme was proposed to meet up the exponentially growing demand of mobile users for computing and information application services. Their results demonstrated that the PDMA could be a promising multiple access technology with low latency, low signaling overhead and massive connectivity support for 5G [1]. At [2], Tang and et al., analyzed the theory performance of uplink PDMA and derived the exact closed-form expressions for outage probability (OP) in the Rayleigh fading channel and also evaluated the OPs of each user with different pattern and target signal-to-interference-plus-noise ratio. In their work, additionally, the comparison between PDMA and conventional orthogonal multiple access (OMA) in terms of sum data rate (SDR) was conducted and numerical simulation results verified that PDMA outperformed OMA in terms of OP and SDR. The conventional OFDM-based pattern division multiple access (PDMA) systems suffer from the problem of slow side-lobe attenuation. To alleviate this problem, we Li and et al., proposed a new modulation waveform design, namely the offset quadrature amplitude modulation based orthogonal frequency division multiplexing (OQAM-OFDM). The proposed design method added OQAM pre-modulation and filter banks to the conventional design of PDMA system. The application of the filter banks made the system to achieve a good frequency domain concentration performance and accelerated the side-lobe suppression effectively. Their simulation results showed that the proposed design method not only improved the spectrum utilization efficiency of the system but also efficiently reduced the block error rate in resistance to multipath interference [3]. Non-orthogonal multiple access (NOMA) techniques are an effective tool for increasing the user capacity in 5G networks. In NOMA users occupy a same resource element in any given time, and user separation is achieved through different interference cancellation strategies. In Pattern Division Multiple Access (PDMA), a different version of NOMA, sequences represent patterns

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that are assigned to users in a same Resource Element (RE). Maric and et al., presented a method of an algebraic construction of short quasi orthogonal PDMA patterns that were ideally suited for use in NOMA PDMA. In their work, the authors showed that within each family it was possible to construct patterns with different weights (level of diversity). Using link level simulations, they established the performance of their sequences, and compared them with PN sequences as well as with sequences in the other PDMA literature [4]. At [5], Vinod and Jose presented a 5G technique called Pattern Division Multiple Access (PDMA) using Compressed Sensing Algorithm for communication systems and defined resource group using PDMA patterns with reference to either time or frequency for data transmission. The authors demanded that an improved execution in terms of Spectral efficiency, bit error rate and uplink-downlink performance was obtained through implementation of Compressive Sampling Matching Pursuit (CoSaMP) algorithm. In [6], Jiang and et al., proposed, a joint transmitter and receiver design for pattern division multiple access (PDMA) utilizing power allocation to improve the overall sum rate and beam allocation to enhance the access connectivity by pattern mapping at the transmitter and a spatial filter to suppress the inter-beam interference caused by beam-domain multiplexing, and successive interference cancellation to remove the intra-beam interference caused by power-domain multiplexing by hybrid detection at the receiver. The authors proposed a PDMA joint design approach to optimize pattern mapping based on both the power domain and beam domain. Their simulation results showed that the proposed PDMA approach outperformed s the orthogonal multiple access and power-domain non-orthogonal multiple access approaches even without any optimization of pattern mapping and the optimization of beam allocation yielded a significant performance improvement than the optimization of power allocation.

2. Review of Encryption and Signal Processing Techniques

In this paper, both physical layer security and signal processing techniques have been implemented. A brief review of each technique is outlined below:

2.1. Hybrid Chaotic Maps based Encryption

In modern communication systems, the major goal is oriented to the security and the encryption methods are very much important to maintain integrity, authentication and privacy of information from unauthorized people. In Hybrid Chaotic Maps based Encryption technique, both Henon chaotic system and logistic chaotic maps are used. The Henon random map is described by the discrete Equations as:

$$X_{n+1} = 1 - aX^2{}_n + Y_n \tag{1a}$$

$$Y_{n+1} = bX_n \tag{1b}$$

Where, a and b are external parameter. From Equation (1b), we can write

$$Y_n = bX_{n-1} \tag{1c}$$

Substituting the value of Y_n from Equation (1c) in Equation (1b), we get

$$X_{n+1} = 1 - aX^2{}_n + bX_{n-1} \tag{2}$$

Using Equation (2), the initial values, X(0), and external parameter values, a and b are set at:

X(0)=0.1, X(0)=0.2, and X(0)=0.3, a=1.4, a=1.5 and a=1.6, b=0.3, b=0.4 and b=0.5 for user#1,user#2 and user#3 respectively.

As the number of ultimately estimated 8bit integer values from audio signal of each user is 8192, the no. of variables presented in Equation (2) from generated Henon Chaotic map is 8192.

Equation (2) is applicable for n=1,2,3,4……………8191. The X(0)=0.1, X(0)=0.2 and X(0)=0.3 are the values of variable for user #1, user #2 and user #3 at n=0. The first generated encrypted keys K_1 are obtained from transforming Henon Chaotic maps into 8-bit integer values using the relation:

$$K_1(n) = \mathrm{mod}(\mathrm{round}(X(n)\times\lambda),256) \tag{3}$$

Where, λ= 12345678, λ= 65431234 and λ= 87654321 for user#1, user#2 and user#3

The one-dimensional Logistic chaotic map is given by

$$X_{n+1} = r * X_n * (1 - X_n) \tag{4}$$

Where, r is the control parameters with its value is in the interval of $3.57 < r \le 4$.

The initial values X(0)=0.1, X(0)=0.2 and X(0)=0.3, r=3.57, r=3.65 and r=4.00 are assigned for user #1, user #2 and user #3. The second generated encrypted keys K_2 are obtained from transforming Logistic Chaotic maps of Equation (4) into 8-bit integer values using the relation

$$K_2(n) = \mathrm{mod}(\mathrm{round}(X(n)\times\gamma),256) \tag{5}$$

where,γ= 23456789, γ=78923456 and γ= 98765432 for user #1, user #2 and user #3, If A(n) and B(n) are the 8192×1 sized 8 bit integer values obtained from the text messages for near and far user and executing binary bitwise XOR operation, we can write

$$A_{first}(n) = A(n) \oplus K_1(n) \tag{6}$$

$$B_{first}(n) = B(n) \oplus K_1(n) \tag{7}$$

$$A_{hybrid} = A_{first}(n) \oplus K_2(n) \tag{8}$$

$$B_{hybrid} = B_{first}(n) \oplus K_2(n) \tag{9}$$

Where, the symbol ⊕ is indicative bitwise XOR operation. Equation (8) and Equation (9) represent Hybrid chaotic maps based encrypted audio signals for three users [7].

2.2. Polar Channel Coding and Decoding

Polar codes represent an emerging class of error-correcting codes with power to approach the capacity of a discrete memoryless channel. In non symmetric form of polar coding with code length N(=8), the 1× 8 matrix sized binary source block u= (u_1, u_2, … , u_N) consists of K(=4), non-frozen information bits (0/1) and N–K frozen bits (typically considered as 0) assigning at {u4, u6, u7, u8} and {u1, u2, u3, u5} respectively. In execution of bit reversal operation, the rearranged 1× 8 matrix sized binary source block, $\bar{u}$ =($\bar{u}_1$, $\bar{u}_2$, … , $\bar{u}_N$) would contain non-frozen information bits at {$\bar{u}7$, $\bar{u}6$, $\bar{u}4$, $\bar{u}8$} instead of {$\bar{u}4$, $\bar{u}6$, $\bar{u}7$, $\bar{u}8$} and frozen bits at {$\bar{u}1$, $\bar{u}5$, $\bar{u}3$, $\bar{u}2$} instead of {$\bar{u}1$, $\bar{u}2$, $\bar{u}3$, $\bar{u}5$}.

The polar encoded code word **x** in binary format(0/1) with code rate R= K/N can be obtained as follows:

$$X= \lfloor \mathrm{mod}(\bar{u} * F_2^{\otimes 3}, 2 \rfloor \quad (10)$$

where, round function is used to get the nearest integer value and mode operation provides each elemental value of x to (0,1), $\mathbf{F}_2^{\otimes 3}$ is the 8× 8 sized matrix produced from the third Kronecker power of 2× 2 sized matrix $\mathbf{F}_2$ presented as:

$$F_2 = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} \quad (11)$$

This matrix is called the kernel matrix [8].

In polar decoding, the received polar encoded code word $\tilde{x}$ in binary format (0/1) is BPSK modulated producing (0/1) into (+1,-1) viz. $\tilde{x} \in \{+1,-1\}$. It is passed through AWGN channel and noise contaminated with a random noise variable $\tilde{n}$ having zero mean and variance σ^2. The AWGN channel's output $\tilde{y}$ with its components $\{\tilde{y}_1, \tilde{y}_2, \tilde{y}_3, \tilde{y}_4, \tilde{y}_5, \tilde{y}_6, \tilde{y}_7, \tilde{y}_8\}$ can be represented as:

$$\tilde{y} = \tilde{x} + \tilde{n} \quad (12)$$

The transition probability for AWGN channel is given by

$$P(\tilde{y}|\tilde{x}) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left(\frac{-([\tilde{y}-1]^2)}{2\sigma^2} \right) \quad (13)$$

The received AWGN channel LLR is calculated using the following relation [9]:

$$\tilde{y}_{llr} = \log\left(\exp\left(\left(\frac{-([\tilde{y}-1]^2)}{2\sigma^2} + \frac{-([\tilde{y}+1]^2)}{2\sigma^2} \right) \right) \right) = \frac{2\tilde{y}}{\sigma^2} \quad (14)$$

The 1×8 matrix sized noisy channel LLR, $\tilde{y}_{llr}$ undergoes bit-reversed operation forming a new modified noisy channel LLR, $\tilde{\tilde{y}}_{llr}$ with its components $\{\tilde{\tilde{y}}_{llr1}, \tilde{\tilde{y}}_{llr2}, \tilde{\tilde{y}}_{llr3}, \ldots, \tilde{\tilde{y}}_{llr8}\}$. At the non frozen bit locations, the estimated values $\{\tilde{\tilde{y}}_{llr4}, \tilde{\tilde{y}}_{llr6}, \tilde{\tilde{y}}_{llr7}, \tilde{\tilde{y}}_{llr8}\}$ are used to compute information bits using successive cancellation polar decoding technique [10].

2.3. (3,2)SPC Channel Coding

In SPC channel coding, the transmitted binary bits are rearranged into very small code words consisting of merely two consecutive bits. In such coding, (3,2)SPC code is used with addition of a single parity bit to the message u =[u_0, u_1] so that the elements of the resulting code word x = [x_0, x_1, x_2] are given by $x_0 = u_0$, $x_1 = u_1$ and $x_2 = u_0 \Theta u_1$ [11]

where, Θ denotes the sum over GF (2).

2.4. Designing of PDMA Pattern and Signal detection

In our present study, a 2×3 PDMA pattern matrix has been used where 3 users are multiplexed on two resource elements (REs). The PDMA pattern in such case can be written as:

$$G^{[2,3]}{}_{PDMA} = \begin{bmatrix} 1 & 1 & 0 \\ 1 & 0 & 1 \end{bmatrix} \quad (15)$$

Taking PDMA pattern $G^{[2,3]}{}_{PDMA}$, transmitted data of 3 users are mapped onto two REs. The transmission signal on these REs can be expressed as:

$$\begin{bmatrix} s_1 \\ s_2 \end{bmatrix} = \begin{bmatrix} 1 & 1 & 0 \\ 1 & 0 & 1 \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ w_3 \end{bmatrix} \quad (16)$$

where, s_j is the transmission signal on the j^{th} RE, and w_k is the modulation symbol of the k^{th} user

Unlike orthogonal transmission, transmission signal on each RE is linear combination of multiple modulation symbols:

$$\left. \begin{aligned} s_1 &= w_1 + w_2 \\ s_2 &= w_1 + w_3 \end{aligned} \right| \quad (17)$$

To resolve ambiguity in proper detection of users own data, power scaling and phase shifting are introduced in PDMA pattern matrix. Specifically, before two users symbols are mixed, a power scaling factor and a phase shifting factor are applied:

$$s = \sqrt{\beta}\, w_1 e^{j\varphi} + \sqrt{1-\beta}\, w_2 \quad (18)$$

where, β is the power scaling factor and ϕ is the phase shifting factor. In this present study, merely, phase shifting factor has been applied to data of user #2 and user #3. As each user is equipped with a single antenna and base station is equipped with two antennas, the fading channel matrix is 2 × 3 sized and it is represented as:

$$H_{CH} = \begin{bmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \end{bmatrix} \quad (19)$$

The PDMA equivalent channel response matrix H can be written as:

$$H = H_{CH}\, \Theta\, G^{[2,3]}{}_{PDMA}$$

$$= \begin{bmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \end{bmatrix} \begin{bmatrix} 1 & 1 & 0 \\ 1 & 0 & 1 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} & 0 \\ h_{21} & 0 & h_{23} \end{bmatrix} \quad (20)$$

where, Θ has been considered to represent element-wise product of two matrices. In PDMA equivalent channel response matrix H, the channel coefficients of first, second and third columns are applicable to user #1, user #2 and user #3. As signal transmitted from base station from two antennas use different resource (frequency), the signal received at user #1 from second antenna of base station is neglected. The signal received at the user #1, user #2 and user #3 can be written as:

$$z_1= h_{11}(w_1 +w_2) \quad (21)$$

$$z_2= h_{12}(w_1 +w_2) \quad (22)$$

$$z_3= h_{23}(w_1 +w_3) \quad (23)$$

From equation (21) through equation (23), it is observable that in every cases, another user's data are treating as interference which are needed to be eliminated. Primarily, digitally modulated complex symbol vectors for three users, $\hat{w}_1, \hat{w}_2$ and $\hat{w}_3$ are scaled in power such that the average power for each user is made to unity. If P be the total transmitted power and β_1, β_2 and β_3 are the power scaling factors (0.5,0.3 and 0.2) of three users,ϕ_2 and ϕ_3 are phase scaling factors for user #2 and user #3, the power and phase scaled signal vector of the three users can be written as:

$$\left.\begin{aligned} \hat{\hat{w}}_1 &= \sqrt{P\beta_1}\hat{w}_1 \\ \hat{\hat{w}}_2 &= \sqrt{P\beta_2}\hat{w}_2 e^{j\varphi_2} \\ \hat{\hat{w}}_3 &= \sqrt{P\beta_3}\hat{w}_3 e^{j\varphi_3} \end{aligned}\right| \quad (24)$$

On applying OFDM modulation to each data vector presented in Equation (24), the transmitted signal vectors for three users w_1, w_2 and w_3 are produced. In receiving section of each user, the AWGN noise contaminated Rayleigh faded signal is undergone OFDM demodulation. The OFDM demodulated signal vectors w_{10}, w_{20} and w_{30} are channel equalized and can be written as:

$$w11=(h11)-1w10$$
$$= \sqrt{P\beta_1}\hat{w}_{11} + \sqrt{P\beta_2}\hat{w}_{22}e^{j\varphi_2} \quad (25)$$

$$w22=(h12)-1\ w20$$
$$= \sqrt{P\beta_1}\hat{w}_{11} + \sqrt{P\beta_2}\hat{w}_{22}e^{j\varphi_2} \quad (26)$$

$$w33=(h23)-1w30$$
$$= \sqrt{P\beta_1}\hat{w}_{11} + \sqrt{P\beta_3}\hat{w}_{33}e^{j\varphi_3} \quad (27)$$

In equation (25) through (27), $\hat{w}_{11}$, $\hat{w}_{22}$ and $\hat{w}_{33}$ are the detected power scaled complex modulated symbol vectors for three users. These signal vectors are assumed to have average power of unity which are further rescaled to retrieve original signal vectors. In equations 25, 26 and 27, the $\sqrt{P\beta_2}\hat{w}_{22}e^{j\varphi_2}$, $\sqrt{P\beta_1}\hat{w}_{11}$ and $\sqrt{P\beta_1}\hat{w}_{11}$ are the interference terms, denoting W={$w^{(1)}$, $w^{(2)}$, $w^{(3)}$ and $w^{(4)}$} is the power scaled (unity average power) signal alphabet of 4QAM/QPSK/DQPSK and using ML decoding, the detected interfering complex symbols $\bar{w}_1, \bar{w}_2$ and $\bar{w}_3$ contained in interference term for user #1, user #2 and user #3 can be obtained from:

$$\bar{w}_1 = \arg\min \left| w_{11} - \sqrt{P\beta_1}\hat{w}_1 - \sqrt{P\beta_2}w^{(k)}e^{j\varphi_2} \right|, \quad k = 1,2,3,4 \quad w^{(k)} \in W \quad (28)$$

$$\bar{w}_2 = \arg\min \left| w_{22} - \sqrt{P\beta_1}w^{(k)} - \sqrt{P\beta_2}\hat{w}_{22}e^{j\varphi_2} \right|, \quad k = 1,2,3,4 \quad w^{(k)} \in W \quad (29)$$

$$\bar{w}_3 = \arg\min \left| w_{33} - \sqrt{P\beta_1}w^{(k)} - \sqrt{P\beta_3}\hat{w}_{33}e^{j\varphi_3} \right|, \quad k = 1,2,3,4 \quad w^{(k)} \in W \quad (30)$$

The detected power scaled complex symbols $\hat{\hat{w}}_1, \hat{\hat{w}}_2$ and $\hat{\hat{w}}_3$ for three users can be written as:

$$\hat{\hat{w}}_1 = (w11- \sqrt{P\beta_2}\bar{w}_1 e^{j\varphi_2})/(\sqrt{P\beta_1}) \quad (31)$$

$$\hat{\hat{w}}_2 = (w22- \sqrt{P\beta_1}\bar{w}_2)/(\sqrt{P\beta_2}e^{j\varphi_2}) \quad (32)$$

$$\hat{\hat{w}}_3 = (w33- \sqrt{P\beta_1}\bar{w}_3)/(\sqrt{P\beta_3}e^{j\varphi_3}) \quad (33)$$

On multiplying Equation (31) through Equation (33) with normalization factor, $\Xi(=\sqrt{2})$, the original complex digitally modulated data symbols for user #1, user #2 and user #3 are achieved viz [12,13].

$$\hat{\hat{\hat{w}}}_1 = \Xi\ \hat{\hat{w}}_1 \quad (34)$$

$$\hat{\hat{\hat{w}}}_2 = \Xi\ \hat{\hat{w}}_2 \quad (35)$$

$$\hat{\hat{\hat{w}}}_3 = \Xi\ \hat{\hat{w}}_3 \quad (36)$$

3. System Description

The block diagram of the 5G compatible downlink Pattern Division Multiple Access (PDMA) scheme implemented wireless communication system model in simplified form has been presented in Figure 1. In such simulated model, segments of different audio signals for three different users will be processed. The extracted binary data from audio signal for each user are undergone double encryption using hybrid chaotic maps based physical layer security scheme. The encrypted data are channel encoded and fed into pre signal processing section where interleaving, digitally modulation, power scaling with phase insertion (in case of signals for user 2 and user 3), serial to parallel conversion, OFDM modulation and parallel to serial conversion is done. The pre processed signals are PDMA encoded prior to transmission from each of the two transmitting antennas of Base station.

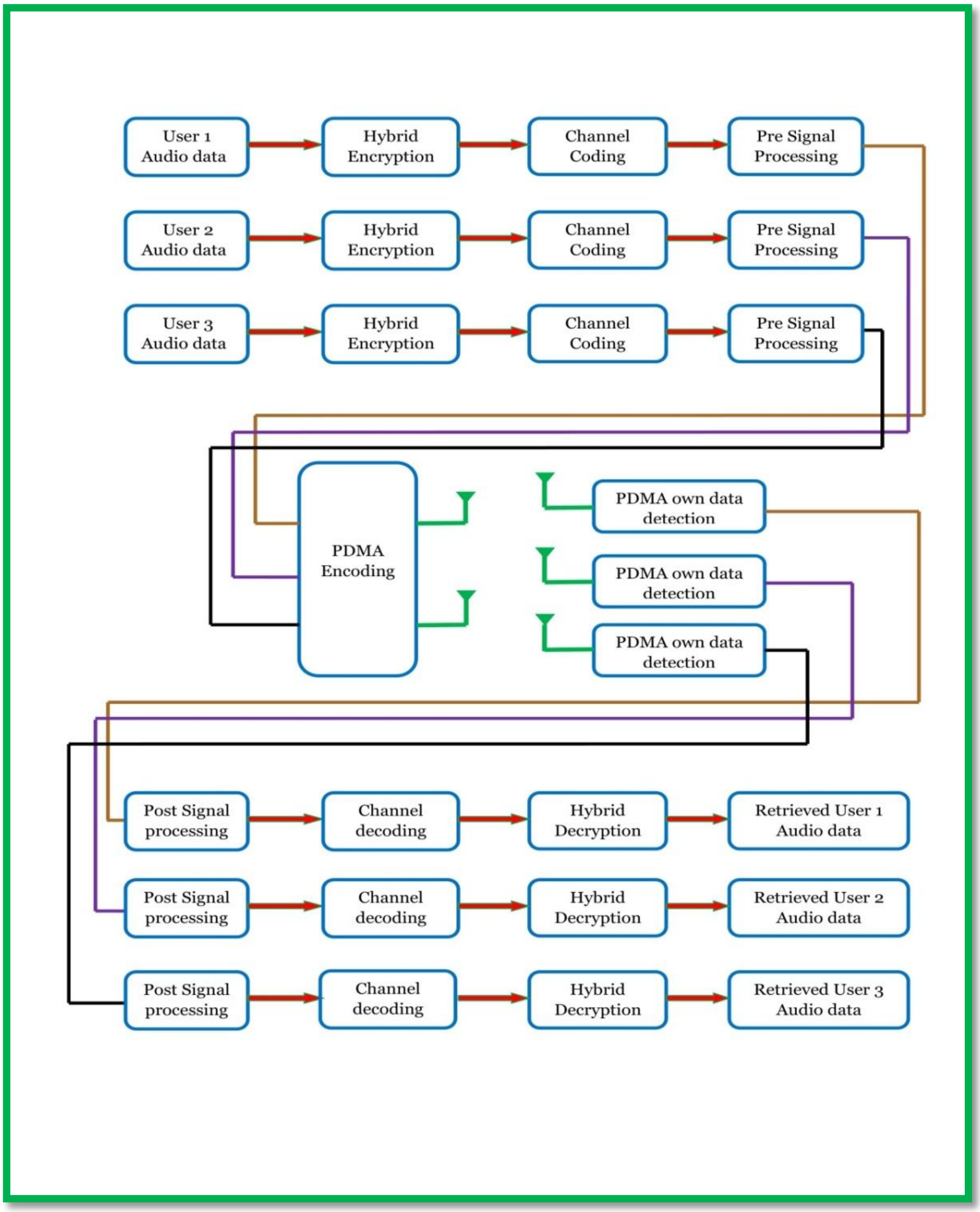

Figure 1. Block diagram of 5 G Compatible downlink Multiuser PDMA Wireless Communication System

The signal transmitted from two transmitting antennas are in different resource elements such that the frequency of transmitted carrier is different. In receiving section of each user, own transmitted signal is detected along with other user's signal transmitted in identical resource element considered as interference. The received signal is processed for interference reduction and subsequently sent up to the post signal processing section where serial to parallel conversion, OFDM demodulation parallel to serial conversion, power rescaled with phase removing, digitally demodulation and deinterleaving occur. The post processed signals are channel decoded, hybrid decrypted and eventually audio signal of each user is retrieved.

4. Results and Discussion

In this section, simulation results using MATLAB R2017a have been presented to illustrate the significant impact of various types of channel coding and power allocation on performance analysis of 5G Compatible downlink Multiuser PDMA Wireless Communication System in terms of bit error rate (BER). It has also been considered that the channel state information (CSI) of the Rayleigh fading channel is available at the receiver and the fading channel coefficients are constant during simulation. The proposed model is simulated to evaluate the system performance under consideration of parameters presented in the Table 1.

Table 1. Summary of the simulated model parameters

Parameters	Values
Data type	Audio
No. of analog data sample for each user	8192
No. of binary bits generated from analog signal	65536
No of antenna at base station and each user	2 and 1
PDMA pattern matrix	$G^{[2,3]}_{PDMA}$
Total transmitted power	40 Watt
Assigned power to user 1, user 2 and user 3(of total transmitted power)	50%, 30% and 20%
Phase introduced in transmitted signals of user 2 and user 3	π and $\pi/4$
Channel encoding	Polar and (3,2)SPC
Symbol mapping	DQPSK, QPSK and QAM
Normalized SNR (Signal to noise ratio), Eb/No	0-30 dB

It is quite obvious from graphical illustrations presented in Figure 2 that the performance of the simulated system with implemented (3,2)SPC channel coding is very much well defined for user #1. In such case, the simulated system shows better performance in 4-QAM and worst performance in DQPSK digital modulation. On critical observation of simulation curve, it is seen that for a typically assumed Eb/No value of 5 dB, the estimated BER values are 0.1644, 0.2215 and 0.3436 which are indicative of system performance improvement of 1.2947 dB and 3.2015 dB in case of 4-QAM as compared to QPSK and DQPSK digital modulations. At 10% BER, requirement of Eb/No with DQPSK digital modulation is found to have value of 15.25 dB. It is reduced to 2.25 dB and 4.5 dB in case of QPSK and 4-QAM digital modulations respectively.

From Figure 3 for user #2, it is seen that the requirement of Eb/No with DQPSK digital modulation is 15.5 dB at 10% BER. It is reduced to 2.5 dB and 4.5 dB in case of QPSK and 4-QAM digital modulations respectively. For a SNR value of 5 dB (as previously considered), the estimated BER values are 0.2224, 0.2861 and 0.4079 which are indicative of (3,2) SPC channel encoded system performance improvement of 1.0938 dB and 2.6342 dB in case of 4-QAM as compared to QPSK and DQPSK digital modulations.

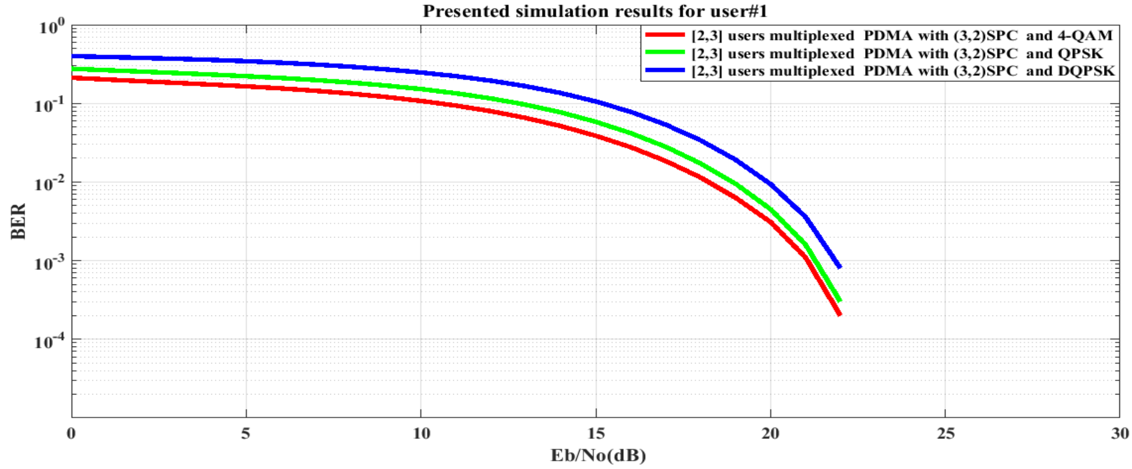

Figure 2. BER performance of (3,2)SPC channel encoded downlink Pattern Division Multiple Access (PDMA) scheme implemented 5G compatible wireless communication system for user #1 under utilization of various digital modulation schemes

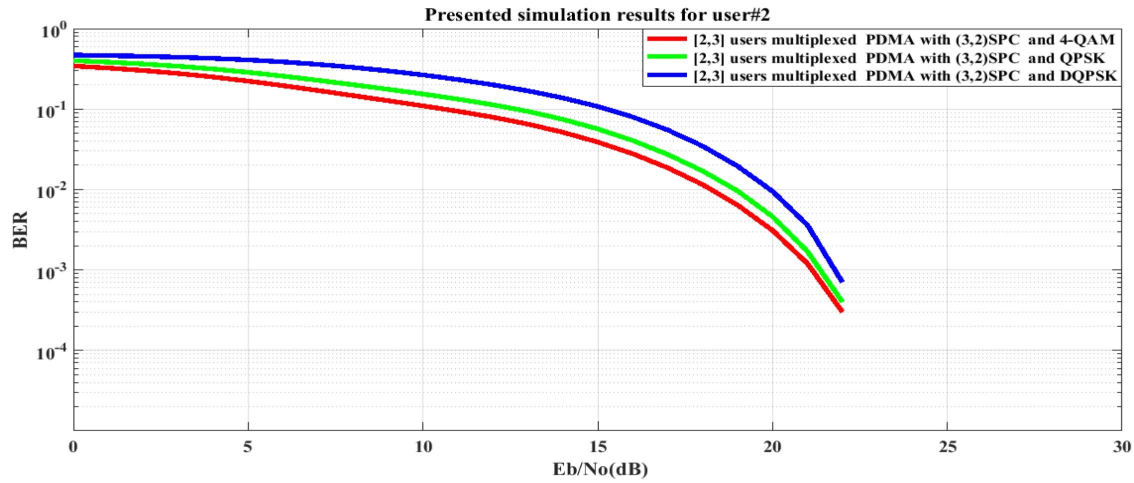

Figure 3. BER performance of (3,2)SPC channel encoded downlink Pattern Division Multiple Access (PDMA) scheme implemented 5G compatible wireless communication system for user #2 under utilization of various digital modulation schemes

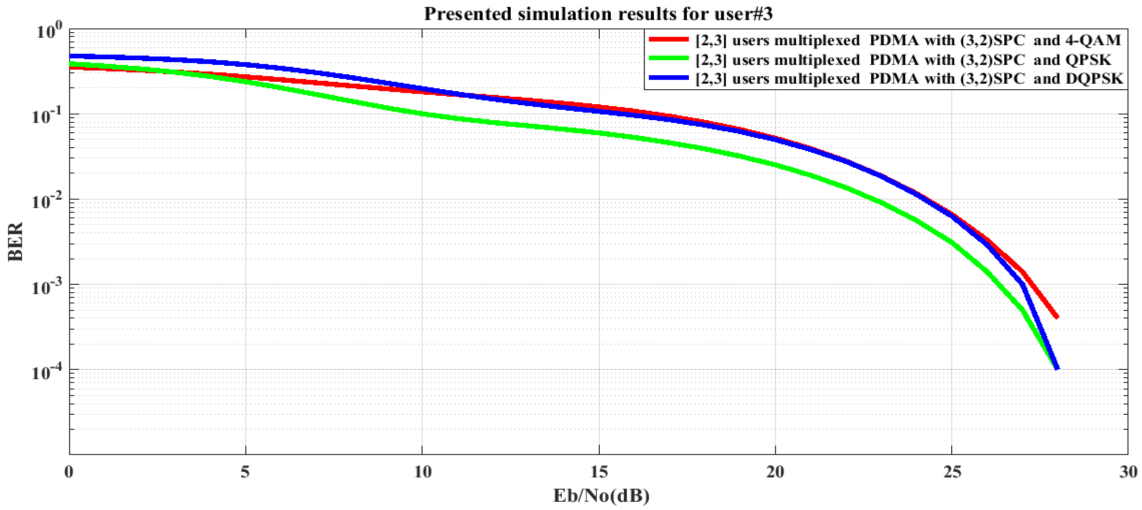

Figure 4. BER performance of (3, 2)SPC channel encoded downlink Pattern Division Multiple Access (PDMA) scheme implemented 5G compatible wireless communication system for user #3 under utilization of various digital modulation schemes

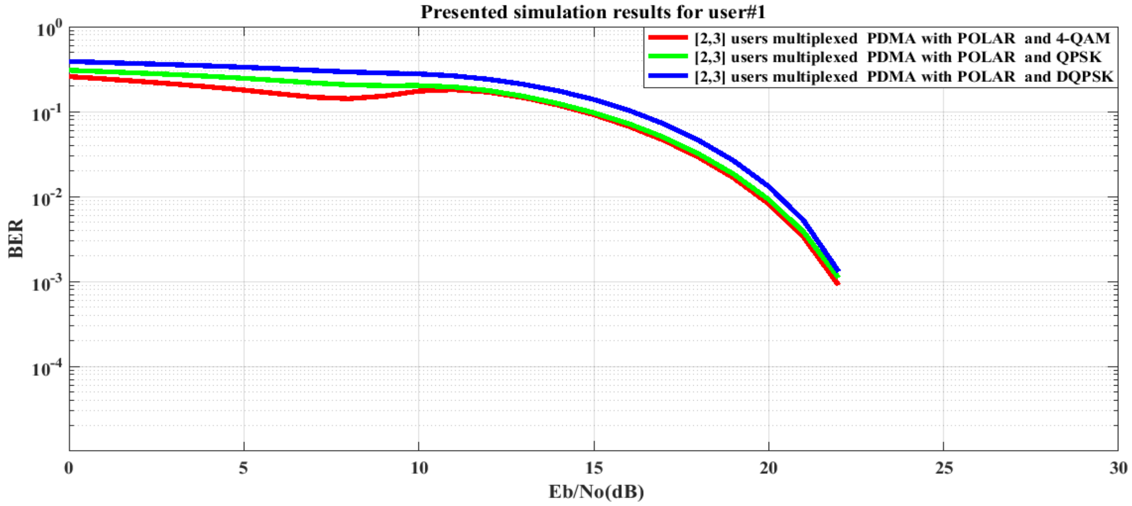

Figure 5. BER performance of POLAR channel encoded downlink Pattern Division Multiple Access (PDMA) scheme implemented 5G compatible wireless communication system for user #1 under utilization of various digital modulation schemes

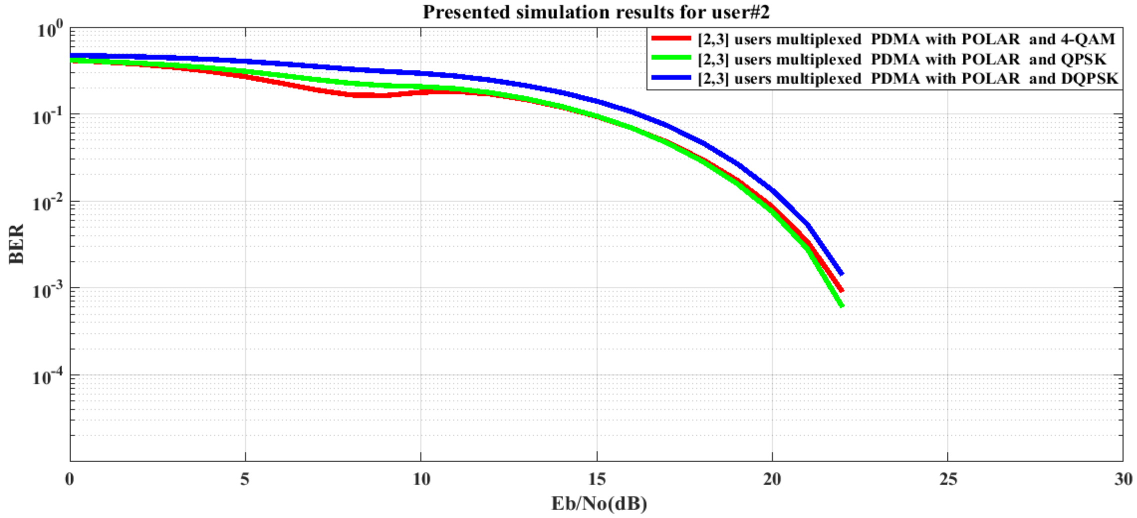

Figure 6. BER performance of POLAR channel encoded downlink Pattern Division Multiple Access (PDMA) scheme implemented 5G compatible wireless communication system for user #2 under utilization of various digital modulation schemes

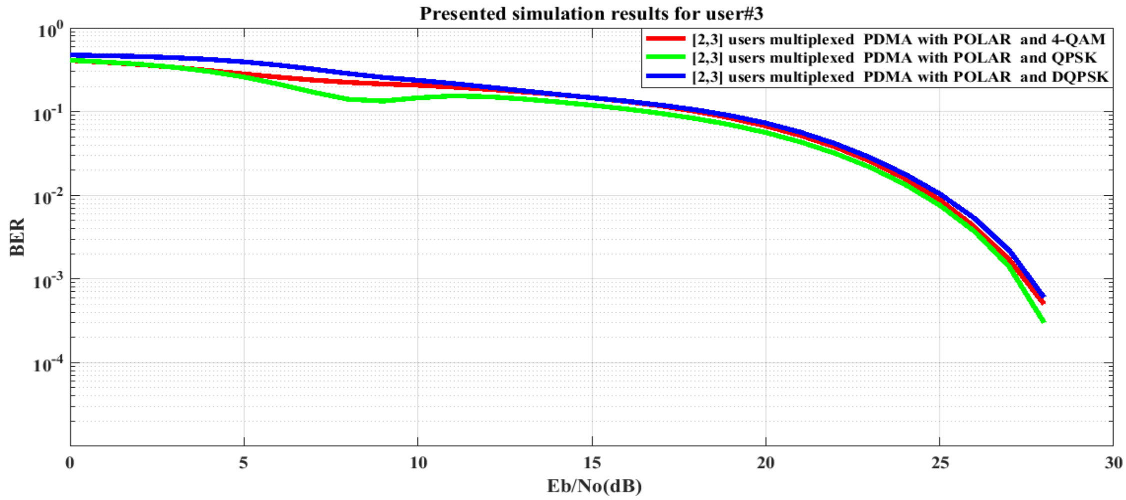

Figure 7. BER performance of POLAR channel encoded downlink Pattern Division Multiple Access (PDMA) scheme implemented 5G compatible wireless communication system for user #3 under utilization of various digital modulation schemes

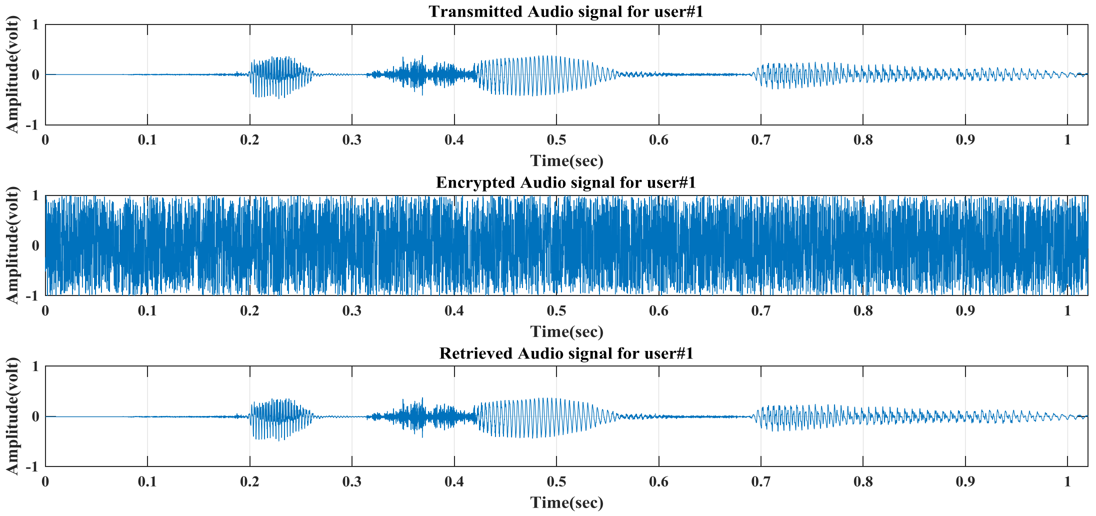

Figure 8. Transmitted, Encrypted and Retrieved audio signals at Eb/No value of 30 dB for user#1

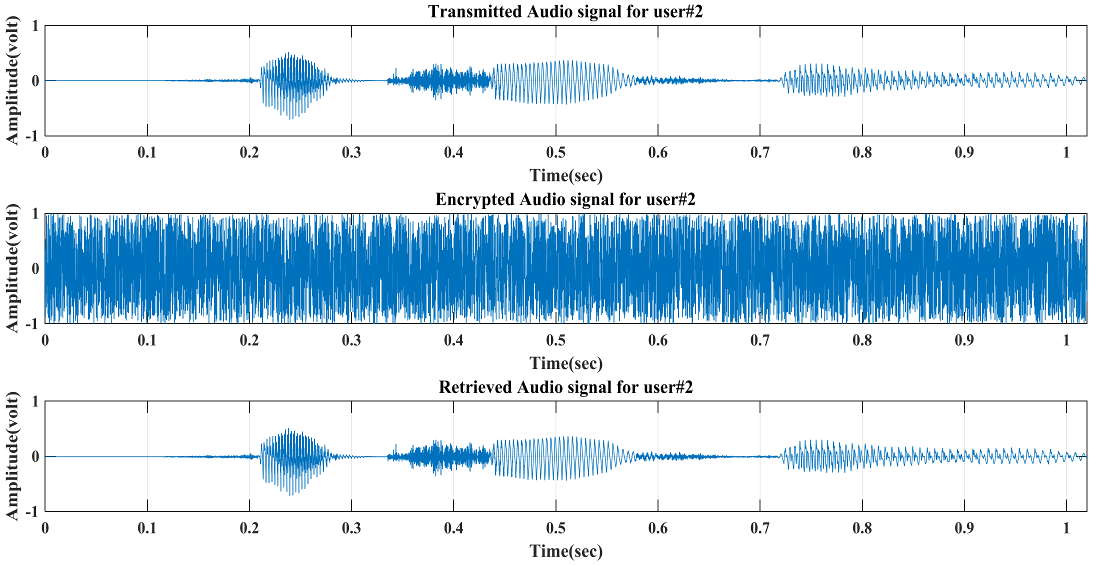

Figure 9. Transmitted, Encrypted and Retrieved audio signals at Eb/No value of 30 dB for user#2

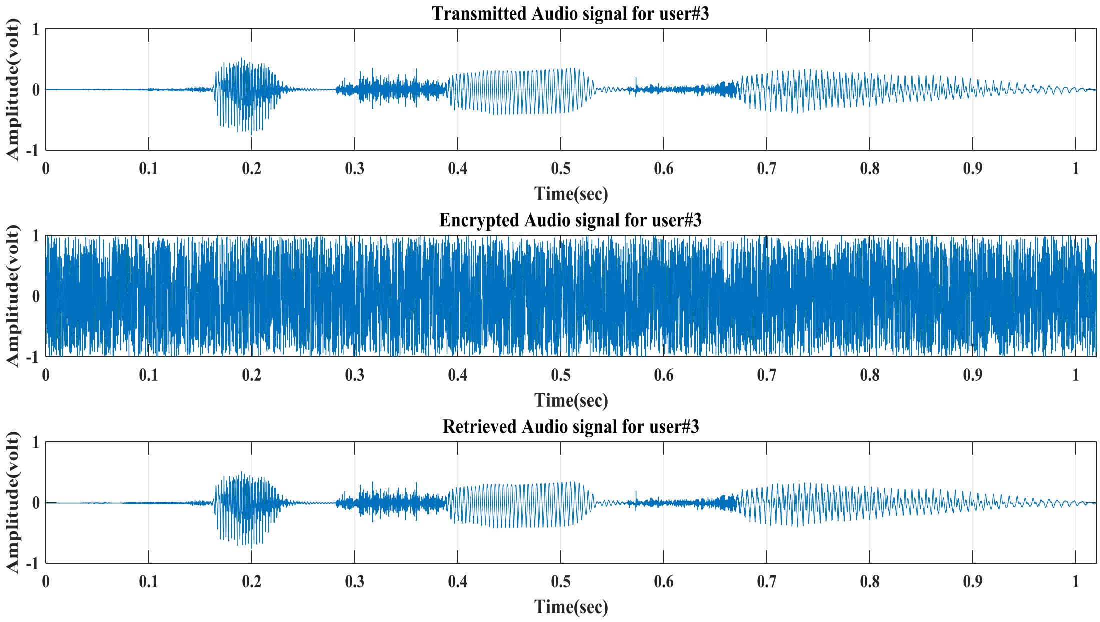

Figure 10. Transmitted, Encrypted and Retrieved audio signals at Eb/No value of 30 dB for user#3

It is quite obvious in graphical illustrations presented in Figure 4 for user #3 that the performance of the (3,2)SPC channel encoded system is not well discriminated in case of DQPSK and 4-QAM over a wide range of Eb/No values (10 dB-26 dB). In this case, it is found that the simulated system shows comparatively better performance in QPSK digital modulation.

From Figure 5 for user #1, it is noticeable that the Polar channel encoded simulated system shows better performance in 4-QAM and worst performance in DQPSK digital modulation. For a typically assumed Eb/No value of 5 dB, the estimated BER values are 0.1788, 0.2465 and 0.333 which are indicative of system performance improvements of 1.3945 dB and 2.7008 dB in case of 4-QAM as compared to QPSK and DQPSK digital modulations. It is also observable that the system performance in 4-QAM digital modulations coincides with that for QPSK over Eb/No values (10 dB-22 dB).

In Figure 6 for user #2, it is seen that the Polar channel encoded simulated system shows worst performance in DQPSK digital modulation. The system performance in case of 4-QAM and QPSK digital modulations is not well discriminated from each other for Eb/No region (10.5 dB-21 dB).

In Figure 7 for user #3, as low power is assigned to user #3, the Polar channel encoded system performance degrades. On critical observation on the presented graphs, the system performance in case of QPSK digital modulation seems to be better.

The graphical illustrations presented in Figure 8 through 10 are clearly indicative of retrieving audio signals uniquely at Eb/No value of 30 dB for 3 users. The presented graphs also ratified that the encrypted audio signal for each of 3 users is not understandable.

5. Conclusions

In this paper, the performance of 5G compatible downlink multiuser PDMA wireless communication system has been investigated on secured audio signal transmission with utilization of various channel coding techniques. In all cases, the proposed simulated system out performs in 4-QAM and shows worst performance in DQPSK digital modulation. The simulation results show that the implementation of (3, 2) SPC channel coding technique with utilization of 4-QAM digital modulation scheme ratifies the robustness of 5G compatible downlink multiuser PDMA wireless communication system in retrieving audio signal transmitted over noisy and Rayleigh fading channels.

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