Time domain analysis for multiuser OFDM using DCSK modulation

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Abstract---In this proposed we successfully developed a multiuser OFDM-based chaos shift keying (MU OFDM-DCSK) modulation is presented. The LTE technique OFDM is nothing but it's a fourth generation language. Some drawback of the OFDM will cause the lower data rate in 4G language. In this system, the spreading operation is performed in time domain over the multicarrier frequencies. To allow the multiple access technique without using excessive bandwidth for transmission, each user has N_p previously developed private frequencies from the N available frequencies to transmit its reference signal and share with the other users the remaining frequencies available for transmission of its M spread bits. In this new design, N_p duplicated chaotic reference signals are generated mostly for the transmission of M bits instead of using M different chaotic reference signals is used for DCSK systems compared different than other systems. After that, the given transmission data that $N_P << M$, the MU OFDMDCSK scheme increases spectral efficiency, uses less energy and allows multiple-access scenario. Therefore, the use of OFDM technique reduces the integration complexity of the system where the parallel low pass filters are no longer needed to recover the transmitted data as in multicarrier DCSK scheme. At last we get the bit error rate performance which is under multipath Rayleigh fading channels in the presence of multiuser and additive white Gaussian noise interferences. A MATLAB execution result shows us that the accuracy of our analysis and show the advantages of this new hybrid design.

Keywords — Non-coherent spread spectrum communication system, multiple accesses, OFDM-DCSK, energy efficiency, performance analysis.

I. INTRODUCTION

The demand for wireless services is in constant rise. Multicarrier (MC) transmission, since it has the advantages of high spectral efficiency, robustness to frequency selective fading, and feasibility of low-cost transceiver implementation is a strong candidate for many wireless applications. Several combinations of multi-carrier and Code Division Multiple Access (CDMA), are proposed in the literature [1], [2]. In MCCDMA, one-bit chips are spread over M subcarriers in the frequency domain [1], while for MC-DS-CDMA, time and frequency spreading is used (i.e. TF-domain spreading) [2]. The chaotic signals have been shown to be well suited for spread-spectrum modulation because of their inherent wideband characteristic [3] [4] [5], mitigation of fading channels, jamming resistance and low probability of intercept (LPI) [6]. In addition, chaos-based sequences give good results as compared to Gold and independent and identically distributed sequences for reducing the peak-to-average power ratio (PAPR) [7]. A proposed system with a non-coherent receiver, named differential chaos shift keying (DCSK) system, in which chaotic synchronization is not used on the receiver side, delivers a good performance in multipath channels [8]. Furthermore, differential non-coherent systems are better suited than coherent ones for time and frequency selective channels [9]. In the DCSK system, each bit duration is divided into two equal slots. In the first slot, a reference chaotic signal is sent. Depending on the bit being sent, the reference signal is either repeated or multiplied by the factor −1 and transmitted in the second slot. A significant drawback of DCSK is that for each bit one reference and half the bit duration is spent sending non-information-bearing reference samples [3]. This can be accounted as being energy-inefficient and a serious data rate reducer. In [10], the spectral efficiency of the DCSK is improved, but the system receiver requires an RF delay line, which is not easy to implement because of the wide bandwidth involved.

In a study to overcome the problem of RF delay in DCSK systems, Xu et al. proposed a Code Shifted Differential Chaos Shift Keying (CS-DCSK) system. In their system, the reference and the information bearing signals are separated by Walsh code sequences, and then transmitted in the same time slot. For such systems, there is no need for a delay line at the receiver end. An improved version of the high spectral efficiency DCSK system is presented, where chaotic codes are used instead of Walsh codes, with different receiver structures. Another design based on an ultra-wideband system using chaotic signals for low complexity, low cost, low power, and low rate is presented. In this paper, we first introduce a new design of a multi-user, multi-carrier DCSK system (MC-DCSK). On the transmitter side, M subcarriers are assigned for each user, where one subcarrier is used to transmitting the references slot, while the M − 1 other frequencies will carry the transmitted bits. The proposed system solves the RF delay line problem mentioned, provides from the properties of DCSK system in terms of resistance to interference, increases the data rate, and optimizes the transmitted energy of the DCSK system with a simple transmitter/receiver design. The analytical performance derivation of DCSK communication system is studied and the transmission security is improved. In this paper, for the space available, we concentrate our efforts to explain the proposed system design, where the analytical derivation and cognitive multiple access techniques of MC-DCSK system will be studied in future work. Covers the architecture of the multi-user MC-DCSK system.

II. LITERATURE SURVEY

Shiro Kondo[1], in this paper they apply a multicarrier communication technique for better transmission to a direct-sequence CDMA system, wherever we are having an information sequence which is increased by a spreading sequence which can modulates multiple carriers, instead of one carrier which is having number of drawback. The receiver provides correlators while transmission for every carrier in this system, and also the outputs obtained from correlators are combined with the given condition of maximal-ratio combiner in this transmission. These kinds of wireless communication are used for achieving better properties of exhibiting a narrowband interference suppression impact on transmission of data, beside hardiness to weakening, without. we have a tendency to use the data with band restricted spreading waveforms to achieve the properly stop self-interference, and also that we value system performance over a frequency selective signal transmission. Third Baron Rayleigh channel which is noisy channel within the presence of partial band interference.

Ajeesh P. Kurian [2], in this paper a unique direct sequence/spread spectrum (DS/SS) based communication system gives us the two-dimensional complicated valued chaotic Ikeda map because the spreading sequences we got from the transmission overhead. With this double spreading DS/SS system, the impact of multiple access interference will be lessened by selecting the spreading sequences with applicable cross-correlation properties. These studies are used to know that the planned system considerably outperforms the existing system with the Gold code DS/SS-BPSK system in synchronous channel conditions for transmission of the data. In asynchronous case of transmission through the wireless channel, the advance is substantial for low signal-to-noise ratio.

Ramin Vali [3] in these paper they represented the accurate expressions for sequence acquisition in a chaos-based spread-spectrum system are derived using the statistical properties for transmission which are of the chaos-based spreading sequences. The expressions are validated with the help of comparing the analytical predictions of the acquisition performance compared with the value of the simulation results for three channel scenarios. Additive white Gaussian noise and Rayleigh fading channels which are already used for noisy channel data are considered in the first two scenarios. As the third scenario a blind chip interleaving serial search algorithm is proposed and system performance is shown to improve to such a great extent.

Weikai Xu [4] in this paper, differential chaos shift keying based wireless communication (DCSK-CC) system with almost two numbers of users is planned. The only relay cooperative networks for transmission with decode-and-forward relay is investigated within the planned system per two given number of cooperation protocols which are mainly forms the typical cooperation and coordinate system cooperation. Simulation results in matlab shows us that, through a standard cooperation mechanism, the planned system encompasses an outstanding advantage of fine bit-error-Rate (BER) quality assessment parameters for performance over the CDMA-CC systems that have one path correlation receiver, at constant rate with a high SNR vary over multipath physicist weakening channels. Meanwhile, it is given that typical cooperation may be a higher cooperation strategy which is nothing but is relative to coordinate system cooperation within the planned system.

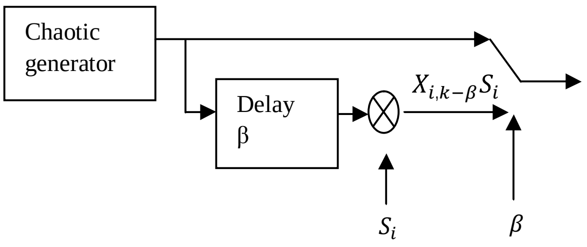
Lin Wang [5] in this paper each the inherently band differential- chaos shift-keying (DCSK) modulation as well as there is use of the space time block code (STBC) techniques will give us the data in both spaces that may mitigate the impact of multipath weakening. By applying STBC at the chaotic section level present in transmission overhead, a completely unique analog STBC-DCSK theme is planned during the implementation of this paper. The planned theme may be a straightforward configuration that uses the advantages of combination of the benefits of STBC and chaotic modulation. The theoretical bit-error-rate (BER) performance we got by application of this method and also the extremely consistent simulation results demonstrate that the STBC-DCSK theme outperforms the traditional single-input-single-output (SISO)-DCSK theme by concerning five dB at a BER in the graph represented in this paper. A lot of significantly, the planned theme maintains constant low transceiver value because the SISO-DCSK theme. Consequently, this planned theme may be a low-priced various for wireless native space network which is nothing but wireless local area network (WLAN) applications in transmission.

Georges Kaddoum [6] in this paper new Multi-Carrier Differential Chaos Shift Keying (MC-DCSK) modulation system is used to provide the good trade-off between robustness, energy efficiency and high data rate, while still being simple in computational computation compared to conventional multi-carrier spread spectrum systems for transmission. This system can be seen as a parallel extension to the implemented DCSK modulation where one chaotic reference sequence is transmitted over a predefined subcarrier frequency signals. Multiple modulated data streams are transmitted over the remaining subcarriers of the original transmission. The receiver design given in this makes this system easy to implement where there is no need of radio frequency (RF) delay circuit to demodulate received data.

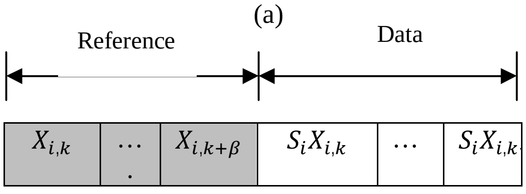
III. PROPOSED METHOD

A. DCSK Communication System

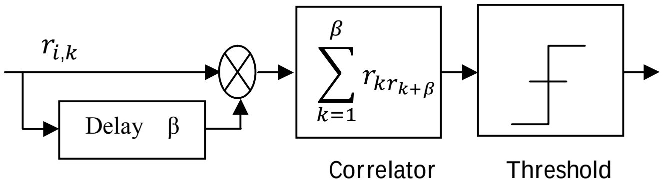
We start this section by explaining the DCSK communication system in order to understand the novel extension parts of the proposed system and to use this as a comparative benchmark to illustrate the achieved performance enhancements. As shown in Fig. 1, within the DCSK modulator, each bit $si = \{-1, +1\}$ is represented by two sets of chaotic signal samples, with the first set representing the reference, and the second carrying data. If +1 is transmitted, the data-bearing sequence is equal to the reference sequence, and if -1 is transmitted, an inverted version of the reference sequence is used as the data-bearing sequence.



(a)



(b)



(c)

Fig.1. Block diagram of the general structure of the DCSK communication system: (a) transmitter (b) frame (c) receiver.

Let 2β be the spreading factor in DCSK system, defined as the number of chaotic samples sent for each bit, where β is an integer. During the i^{th} bit duration, the output of the transmitter $e_{i,k}$, become

$$e_{i,k} = \begin{cases} x_{i,k} & for\, 1 < k \leq \beta \\ s_i x_i, k - \beta & for\, 1 < k \leq 2 \end{cases} \quad (1)$$

Where, x_k is the chaotic sequence used as reference and $x_k - \beta$ is the delayed version of the reference sequence x_k. Fig. 1 illustrates that the received signal rk is correlated to a delayed version of the received signal $x_k + \beta$ and summed over a half bit duration T_b (where $T_b = 2\beta T_c$ and T_c is the chip time) to demodulate the transmitted bits. The received bits are estimated by computing the sign of the output of the correlator, as illustrated in Fig. 1 (c). As shown in Fig. 1, half of the transmitted energy and half of the bit duration time are spent sending a non-information bearing reference. Therefore, the data rate of this architecture is seriously reduced compared to other systems using the same bandwidth, leading to a loss of energy and spectral efficiency.

B. Chaotic Generator

In this paper, a second-order Chebyshev polynomial function (CPF) is employed

$$x_{k+1} = 1 - 2x_k^2 \quad (2)$$

This map is chosen for the easy way in which it generates chaotic sequences and the good performance [10]. In addition, chaotic sequences are normalized such that their mean values are all zero and their mean squared values are unity, i.e., $E(x_k) = 0$ and $E(x_k^2)$

C. The MU OFDM-DCSK Transmitter

In this section we will present the MU OFDM-DCSK design. The aim of the proposed system is to reduce the hardware complexity of the MC-DCSK proposed to increase the data rate, to reduce the transmitted bit energy, to operate in multi-user scenario, to benefit from the properties of OFDM modulation and to perform without any need to RF delay circuits or complex channel estimators.

The structure of the modulator and the transmitted signal are shown in Fig. 2 and Fig. 3. In this system, we consider N_t subcarriers among which N subcarriers at the central spectrum are used for transmission and the remaining $N_t - N$ subcarriers which are located at the two edges of the spectrum form the guard band and the unused subcarriers N_u. In our scheme and for P users, PN_P frequencies out of N subcarriers are used to transmit the P different reference signals. The edges and the center of the spectrum are allocated to transmit the reference signals of different users and the remaining NS frequencies are shared to transmit the spread data. As shown in Fig. 3, the distribution of the reference signal over the predefined private frequencies follows the comb-type pattern design. In fact, the comb-type design allows the receiver to have a fast adaptation to the channel when this lattice changes in time from one OFDM symbol to another. It is important to note that different uncorrelated reference signals of P users are used in the same fashion as pilot signals spreading codes of the OFDM-DCSK system. Therefore, with this design, only the reference signals (i.e pilots) of different users are separated in the frequency domain to allow multiple access communications. As shown in Fig. 3, the spreading operation is done in the time domain. This will require β number of IFFT operations to transmit the M spread bits with a spreading factor of β. In addition, since each user shares a part of his bandwidth with the other users, this reduces the total required bandwidth but increases MAI. However, MAI can be reduced by increasing the spreading factor value. As shown in Fig. 3, the OFDM-DCSK symbol duration Ts is given by

$$T_s = N\beta T_c \qquad (3)$$

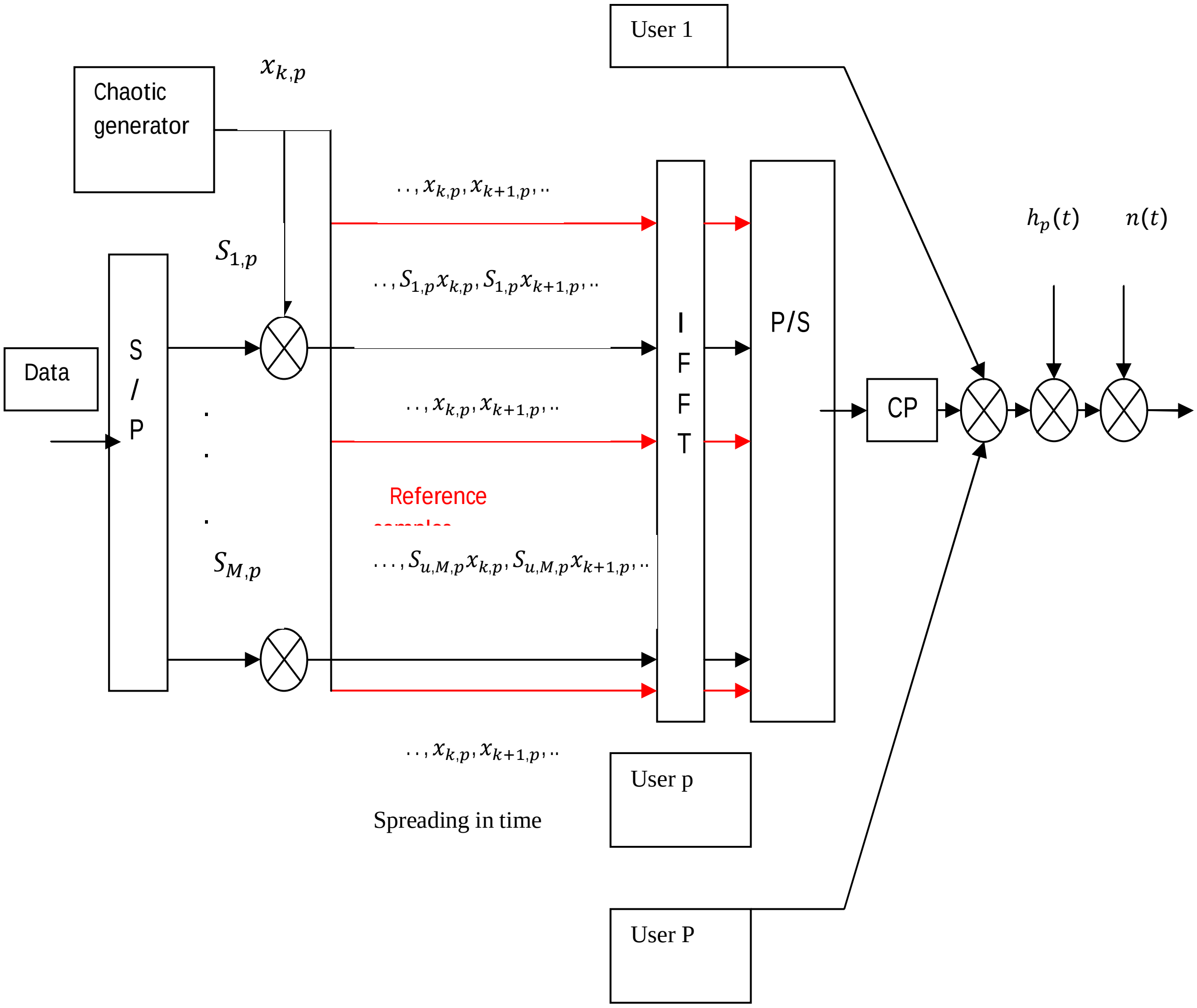
Where $T_{OFDM} = NT_C$ is the time duration of OFDM symbol. After each IFFT operation the parallel signal is converted into a serial sequence and a cyclic prefix is added to eliminate the inter symbol interference and to allow a simpler frequency domain processing. Hence, the OFDM-DCSK system benefits from the non-coherent advantages of DCSK and the spectral high data rate of OFDM modulation.

As shown in Fig.2, the chaotic sequence $X_p = [x_{i,p}, \ldots . x_{k,p}, \ldots, x_{\beta,p}]$ is transmitted over NP frequencies which are used as reference signal and spreading code for the M bits of user p.

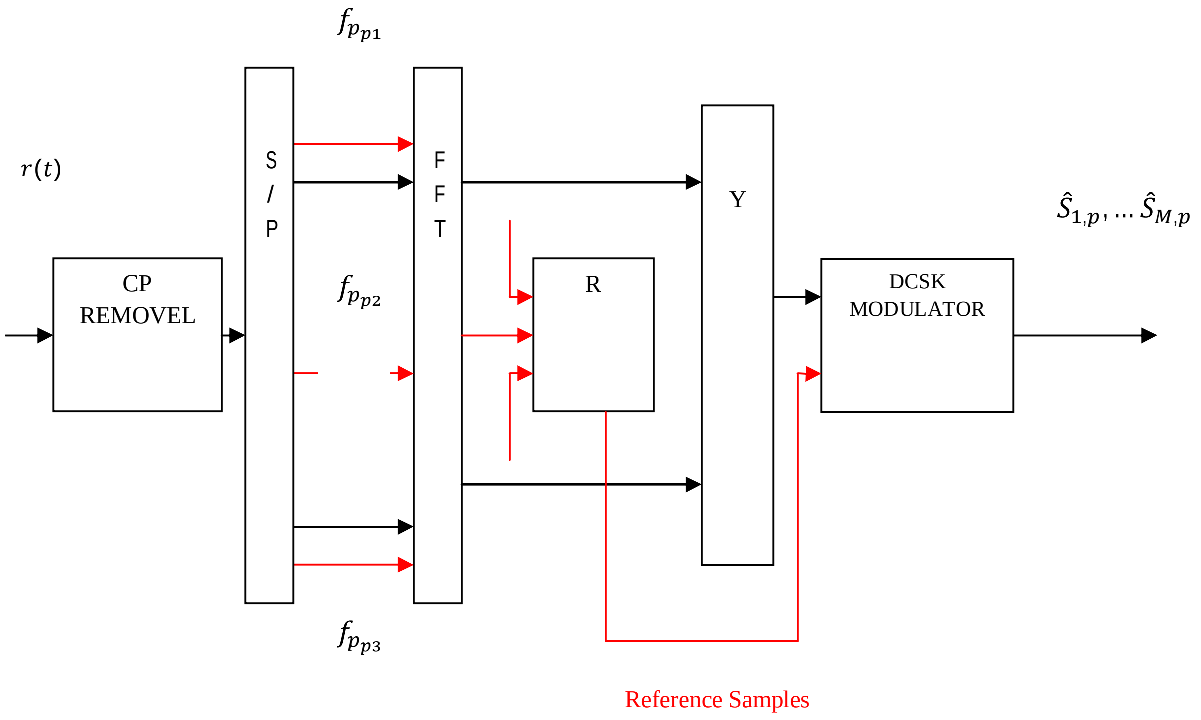
Hence, the M bits stream of user p are spread due to multiplication in time with the same chaotic spreading code$x_p(t)$.

$$x_p(t) = \sum_{k=1}^{\beta} x_{k,p} g(t - kT_c) \qquad (4)$$

Where β the spreading is factor, $g(t)$ is the shaping filter which is assumed to be rectangular in this paper and T_c is the chip duration.



(a) Transmitter Structure of User



(b) Receiver Structure of User P

Fig,2. Block diagram of MU OFDM-DCSK system

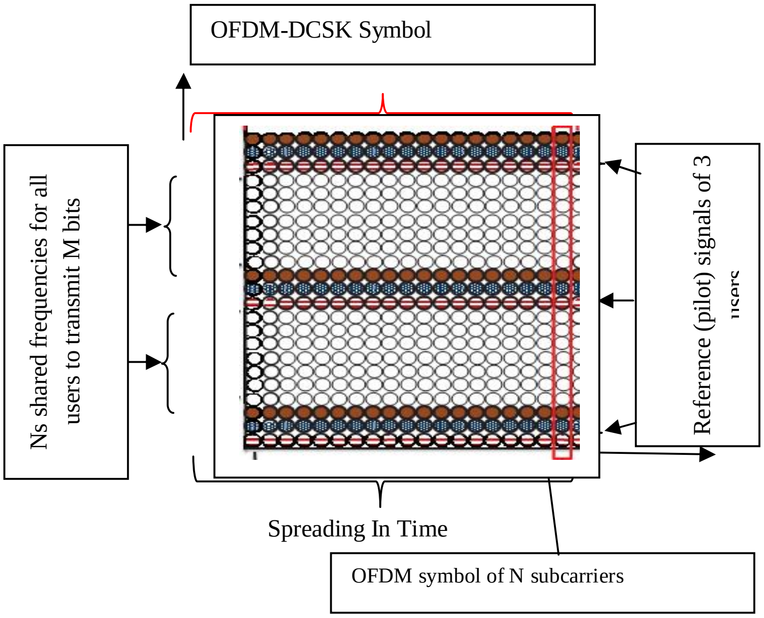


Fig.3. Signal structure with comb-type reference sequences for the pth user

For simplicity, the insertion and removal of cyclic guard prefix or postfix is used in this system with period but not expressed in our mathematical equations. Therefore, the transmitted signal of the pth user of OFDM-DCSK system is given by

$$e_p(t) = \sum_{v=1}^{N_P}\sum_{k=1}^{\beta} x_{k,p} e^{2\pi j f P p_{p_v}(t-kT_c)} g(t-kT_c) +$$

$$\sum_{\substack{i=1\\ i\neq p}}^{M}\sum_{k=1}^{\beta} x_{k,p} s_{i,p} e^{2\pi j f s_{p_i}(t-kT_c)} g(t-kT_c) \qquad (5)$$

where $e_p(t)$ represents the transmitted OFDM symbol of user p, $f_{p_{pv}}$ is its νth private frequency used to transmit the reference chaotic signal $x_{k,p}$, N_P is the number of private frequencies per user, fs_{p_i} is the i^{th} shared public frequency of the $N_S = (N - PN_P)$ remaining public frequencies to transmit the i th bit of the M block of bits. Hence, the maximal number of transmitted bits per user must be equal to the number of shared frequencies NS, (i.e. M $\leq N_S$). As described mathematically in the above formula, the spreading operation is done in time domain where β number of IFFT operations are required to transmit an OFDM-DCSK symbol of N_P reference signals with M spread bits. Finally, for a given number of users P, the maximum number of allowed subcarriers to transmit the data would be

$$N_S = N_t - N_{cp} - PN_P \qquad (6)$$

Where N_{cp} and N_P represent the number subcarriers dedicated to transmit the cyclic prefix and the pilot signal respectively and N_u represents the number of unused subcarriers which is defined according to the used standards (i.e.$N = N_t - N_{cp} - N_U$). It is assumed that the OFDM-DCSK signal is transmitted over a multipath fading channel, the equivalent impulse response of the channel for the pth user is

$$h_p(t) = \sum_{l=1}^{L_p}\sum_{k=1}^{\beta} \alpha_{p.l.\left\lceil\frac{KNT_c}{T_h}\right\rceil}(t)\delta(\tau - \tau_{p,l}) \qquad (7)$$

Where $T_{h,p} = X_p NT_C$ is the time where the channel coefficient α p is maintained constant during the transition of X_p OFDM symbols of user p and [·] is the ceiling operator. In our paper the complex channel coefficients are zero mean and follow Rayleigh distribution given by

$$F(\alpha|\sigma) = \frac{\alpha}{\sigma^2} e^{-\frac{\alpha^2}{2\sigma^2}}, \quad \alpha \geq 0, \qquad (8)$$

Where $\alpha > 0$ is the scaling factor of the distribution representing the root mean square value of the received voltage signal before envelope detection. The received MU OFDM-DCSK signal over the wireless channel is given by

$$r(t) = \sum_{p=1}^{P} h_p(t) \otimes e_p(t) + n(t)$$

Where P is the total number of users, ⊗ is the convolution operator and n(t) is a circularly symmetric complex Gaussian noise with zero mean and power spectral density of N_0.

4. SIMULATION RESULTS

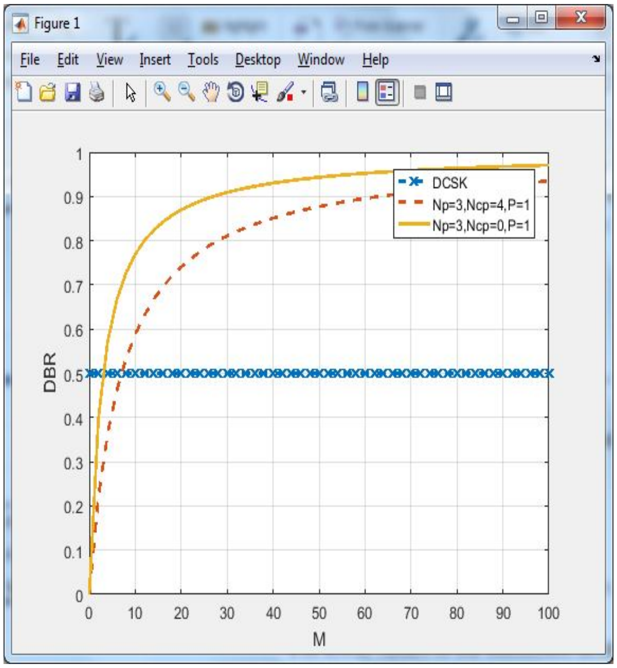


Fig. 4. DBR versus number of data subcarriers M.

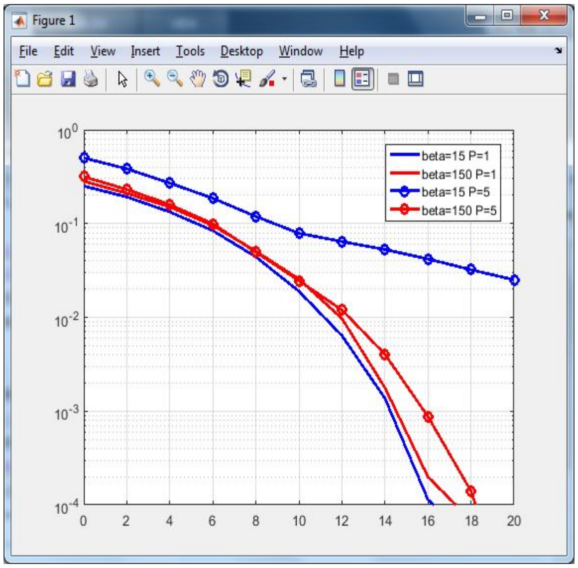


Fig. 5. Simulation and analytical BER performance over AWGN channel of MU OFDM-DCSK system for different spreading factor values (Different beta and p values)

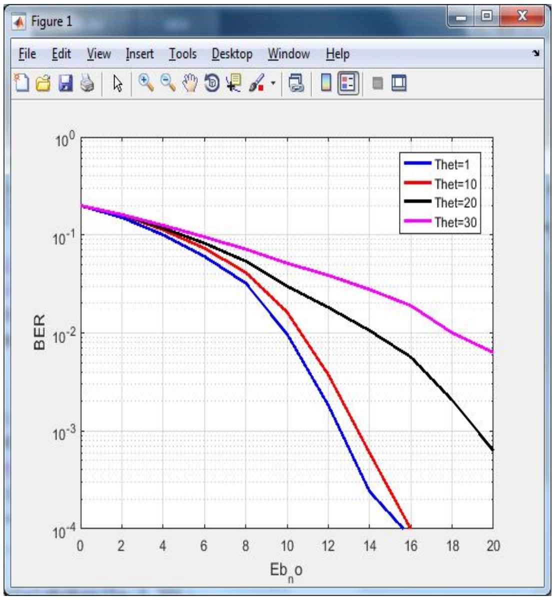


Fig. 6. Simulation and analytical BER performance over AWGN channel of MU OFDM-DCSK system for different theta values (theta=1,10,20,30)

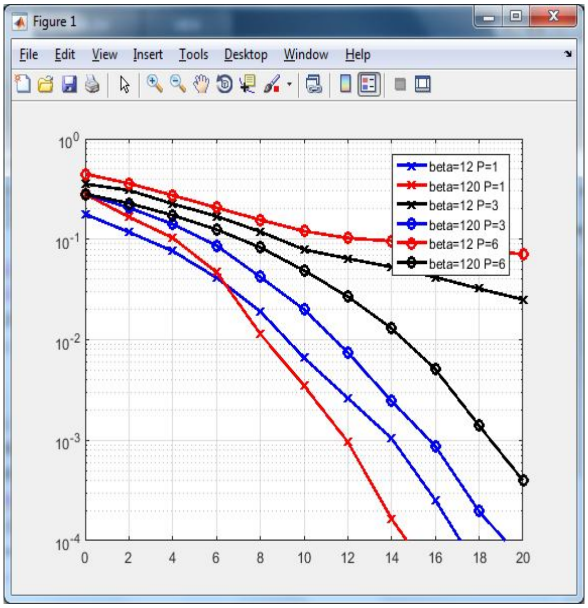


Fig. 7. Simulation and analytical BER performance of MU OFDM-DCSK for β = 12, 120, M = 49, Nt = 128 in multipath Rayleigh fading channels with L p = 3, χ = 3, and equal average power gain.

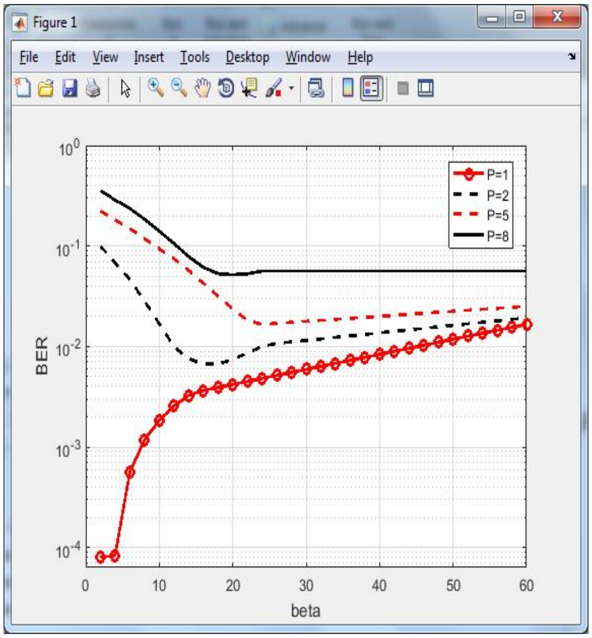


Fig. 8. BER values against the spreading factor β for Eb/N0 = 12 dB, Nt = 128 and M = 49.

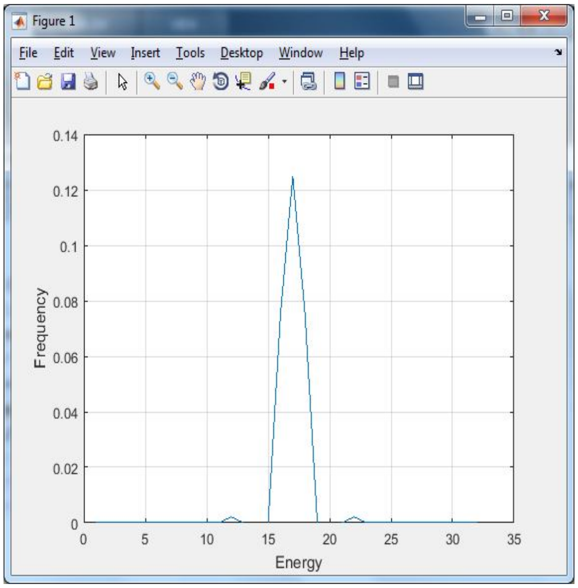


Fig. 9. Performance of system using Energy versus frequency graph

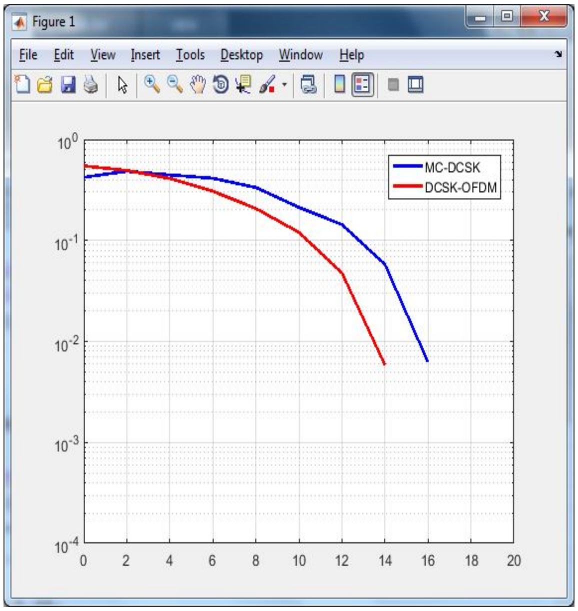


Fig10. BER performance of existing and Proposed method

For extension

As extension there is use of SUI modeling. With the help of which proposed results get improved. In SUI modeling there is consideration of different transmission parameters such as antenna diversity, antenna correlation, antenna gain.

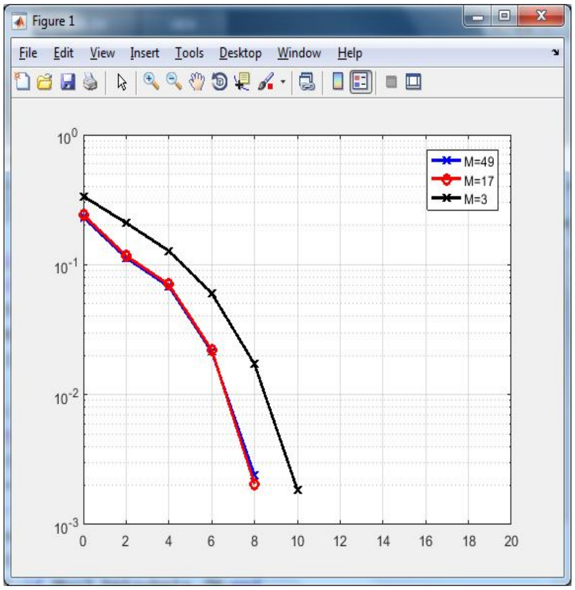


Fig. 11 BER performance of the extension work

5. CONCLUSION

In this paper we successfully proposed the multi-user OFDM-DCSK which is recent technique used to overcome the drawback of the OFDM. This new development of OFDM aims to get increasing the spectral and energy efficiencies, allowing multiple access transmission, reducing complexity by using IFFT/FFT operations instead of parallel matched filters as in MC-DCSK and solving the RF delay line problem faced in conventional DCSK schemes. The main objective of this development is to assign N_P private subcarriers to each user and leave the remaining $N_S = N – PN_P$ subcarriers as shared public subcarriers. The private subcarriers are used to transmit the reference signals of the users, while the public subcarriers are shared with other users to carry data. For any individual user, only NP replicas of the chaotic reference signal are used to transmit M bits, instead of using M reference signals as done in DCSK system (Np << M). The energy efficiency of the proposed work is analyzed and a DBR is derived with the help of it. Our results shows us that given condition of M > 50 subcarriers, the energy loss in transmitting the reference signal is less than 10% of the total bit energy. The performance of the planned system is studied and bit error rate expressions for AWGN and multipath Rayleigh weakening channels area unit derived. Simulation results being matched to theoretical BER expressions affirm our derivation approach. Additionally, the obtained results highlight the importance of the comb-type style to use the time diversity of wireless channels. To check the performance of the planned system to it of DCSK, MC-DCSK and OFDM-DCSK, the simulated BERs area unit premeditated wherever results show a performance of PAPR is within the planned system compared to rival systems. Considering the requirement and demand of future wireless communications to multiuser communications at reduced information measure and energy prices, the planned OFDM-DCSK system as promising.

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