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Equalization Using Neural Network Applied for Multiple Access Technique in Differential Chaos Shift Keying

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Abstract: Using chaos for communication is a new field of research. Chaos communication has been studied for only a little more than a decade while traditional communication schemes have been developed for nearly a century. The hope was that for some application chaotic communication will prove to be better than traditional communication. In this study, a Multiple-access technique for use with Differential Chaos Shift Keying (MADCSK) is proposed and analyzed. A simple one-dimensional iterative map is used to generate the chaotic signals for all users and the average data rates for the users are identical. Bit-error rates are derived numerically for different number of users and computer simulations are performed to verify the results, we propose in this paper a novel method based on neural network, to improve the reception of MADCSK modulation. The Intersymbol Interference (ISI) degrades the performance of MADCSK systems through dispersive channels. We seek to correct this phenomenon by equalization techniques. Recently, neural networks become a solution for many problems in signal treatment. We choose RBF network to improve the performances of the signal and to correct the effect of channels.

Key words: MADCSK, RBF network, chaos, ISI, communication schemes

INTRODUCTION

A number of schemes have been proposed for communication using chaos over the past years. Regardless of the exact modulation method used, the transmitted signal must go through a physical channel which undesirably introduces distortion to the signal and adds noise to it.

Chaotic signals are useful for encoding information in spread spectrum communications (Heidari and Gillem, 1994) due to their continuous broadband feature. When a narrowband signal is spread over a much wider bandwidth, the average Power Spectral Density (PSD) becomes lower. As a consequence, the signal PSD becomes comparable with the background noise. Thus, without prior knowledge of the transmission system, it is not easy to detect the presence of the signal. Even if an unintended user detects the presence of the signal, in the case where coherent detection is required, it is very difficult to decode the data without prior knowledge of the encoding scheme. Recently, the application of chaotic signals in communications has received much attention.

Chaotic signals, by virtue of their wideband and deterministic nature, are well suited for carrying information in a spread-spectrum communication environment. The wideband feature allows the information to be spread over a wide frequency band, resulting in improved performance in multipath environments and antijamming capability.

Chaotic signals have several properties that make them attractive candidate for current communication (Farah *et al*., 2006; Rebh *et al*., 2007):

- Wideband spectrum.
- Waveform does not accurately repeat itself.
- Random-like appearance.
- Relatively simple analog hardware implementation.

During the last decade many chaos based communication schemes have been developed: Chaos synchronization (additive mixing, active passive decomposition), chaos shift keying (QCSK, SCSK), chaos control (symbolic dynamics), Chaos Pulse Position Modulation (CPPM), Chaotic Frequency Modulation (CFM) and more.

In this study, a Multiple-access technique for use with Differential Chaos Shift Keying (MADCSK) is proposed and analyzed. We try to correct the effect of

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User 1	R1.1	D1.1	R1.2	D1.2	R1.3	D1.3						
	F1.1		F1.2		F1.3							
User 2	R2.1	R2.2	D2.1	D2.2	R2.3	D2.4	D2.3	D2.4				
	F2.1				F2.2							
User 3	R3.1	R3.2	R3.3	D3.1	D3.2	D3.3	D3.4	D3.5	D3.6	D3.4	D3.5	D3.6
	F3.1						F3.2					

Fig.1: Process of transmission in multiple access DCSK system

PROAKIS channels in MADCSK system by using classic method and we propose a novel method based on neural network.

PRESENTATION OF MULTI-USER DCSK SYSTEM

For the communication systems based on chaos, some multiple access methods are proposed such as multiplexing chaotic signals, therefore, new methods of generation of spreading codes starting from chaotic functions applied to the conventional CDMA systems among of these methods the multiple access by DCSK which was introduced in (Yang and Chua, 1997).

In a multiple-access system, to avoid excessive interference and hence mis-detection, the separation between the reference and data samples must be different for different users. Here, we propose a multiple-access scheme where the separation between the reference and data samples differs for different users

Architecture of MA DCSK system: The separation between the references and the data must be different for various users to decrease the interferences in multiple accesses system; therefore we generate chaotic signals with varied initial conditions. Figure 1 proposes a multiple access method with chaotic sequences. For all users, the bit durations are first divided into 2 slots. For user 'i', '2i' consecutive slots are collected to form a frame. Hence, the slot duration (half of bit duration) is the same for all users but the frame periods are different for different users. In each frame of user 'i', the first 'i' slots (slots 1 to 'i') will be used to transmit 'i' reference samples while the remaining 'i' slots (slots i+1 to 2i) are used to transmit 'i' data samples (Lau *et al.*, 2002).

Ri,j: Chaos reference sample for user 'i'
Di,j: Chaos data sample for user 'i'
Fi,j: Data frame for user 'i'

Figure (2) shows the transmitter for user 'i':

- If a binary symbol (+1) is to be transmitted in the slot i+1, the segment of the slot 1 will be repeated in i+1.
- Else, a reversed copy will be transmitted in slots (i+1).

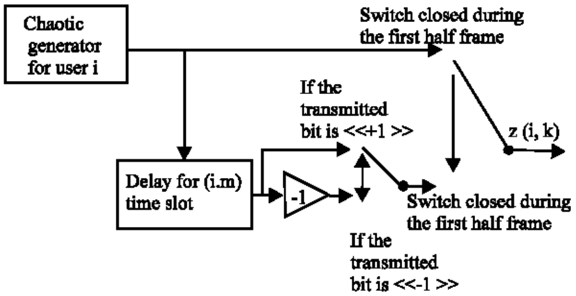

Fig. 2: Transmitter of user 'i' in MADCSK system

In the same way for the slot (i+2), the same one or a copy reversed of that with the slots 2 is sent and so on.

We used the following chaotic sequence with variation of the initial conditions each slot time for various users (Eq. 1):

$$x\ (k+1) = 4x^3\ (k)\ -3x\ (k) \qquad (1)$$

The modulated signal of user 'i' at the moment k will be equal to Eq. (2):

$$c(i,k)=\begin{cases} x(i,k) & \text{si} \quad 0<k<i \\ b.x(i,k) & \text{si} \quad i+1<k<2*i \end{cases} \qquad (2)$$

The signal z (k) to be emitted is the sum of the signals of all the users (Eq. (3)):

$$z(k) = \sum_{i=1}^{N}\sum_{k=1}^{2m} c\ (i,k) \qquad (3)$$

Detection of MA DCSK modulation: At the reception, the signal is firstly delayed of (i.m) slots of time (the duration of a half frame). The delayed signal will be correlated with the sum of signals of all the users. Therefore the correlation is done during the slots time of (i+1) with (2.i) for each frame.

The signal correlated will be send towards a detector of level. The operation of the recovery of the data starts by testing according to maximum of the sum of the correlation; if it is positive, therefore bit 1 will be

Table 1. Coefficients of PROAKIS channels

Channel (A)	0.04	-0.05	0.07-0	.21-	0.5	0.72	0.36	0	0.21	0.03	0.07
Channel (B)	0.407	0.815	0.407								
Channel (C)	0.227	0.46	0.688	0.460	0.227						

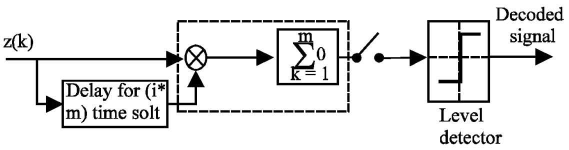

Fig. 3: Receiver of user ‘i’ in MADCSK system

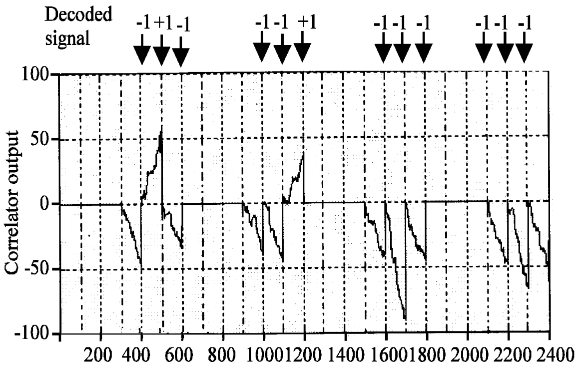

Fig. 4: Results of correlation (spreading factor m=100)

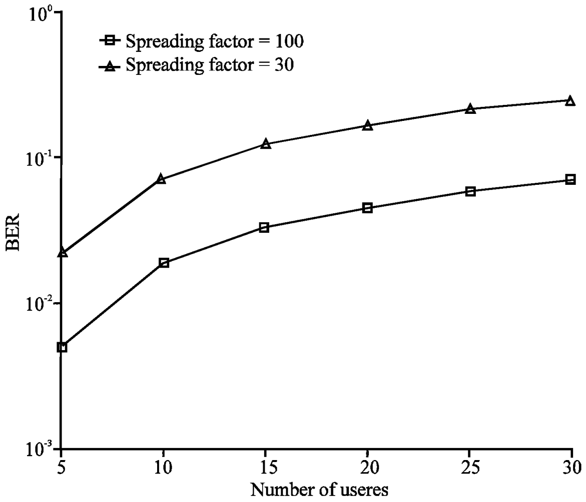

Fig. 5: Performances of MADCSK system

regenerated and else bit 0 will be regenerated. Figure 3 illustrates the process of reception for user i at instant k. Figure 4 shows a form of wave transmitted of the correlation for three users for spreading factor m = 100.

Simulations have been carried out to confirm the feasibility of the proposed multiple-access scheme and to verify the foregoing numerical analysis. Spreading factors 30 and 100 are used. The number of users in the system is with different initial conditions. 1000 symbols are first sent from each user. Then, the number of errors received by each user and the average number of errors among all users arenoted. Figure 5 shows typical results obtained, we note that when the spreading factor is higher the performances of signal are better.

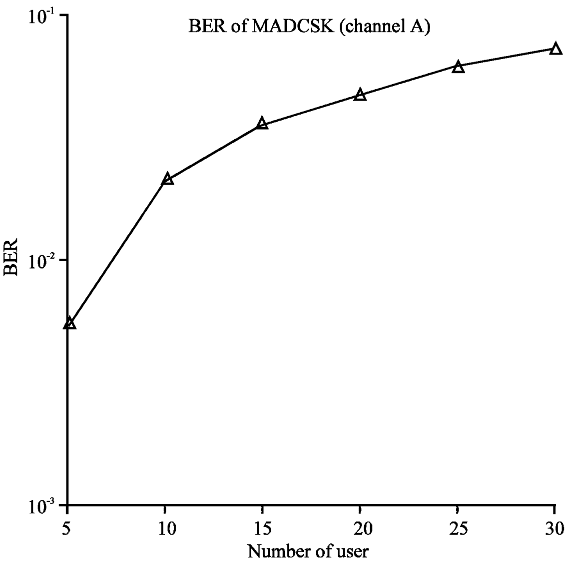

Fig. 6: Performances of MADCSK system (channel A)

Channel effect in MADCSK modulation: We present in this section the effect of PROAKIS channels on MADCSK system, Table 1 gives coefficients of these channels.

Figure 6-8 gives the performances of MADCSK system for diffecrents channel (A, B and C). Figure 9 show the Number of errors received in MADCSK system when we use C channel.

We propose in the following section a novel method based on neural network, the aim of neural network is to reduce the effect of channels. This network work with tow process: the training phase and the testing phase.

PRESENTATION OF NEURAL NETWORK PROPOSED

In Fig. 10 we give communication system using RBN equalizer (Jiuchao *et al.*, 2004) we study in this study

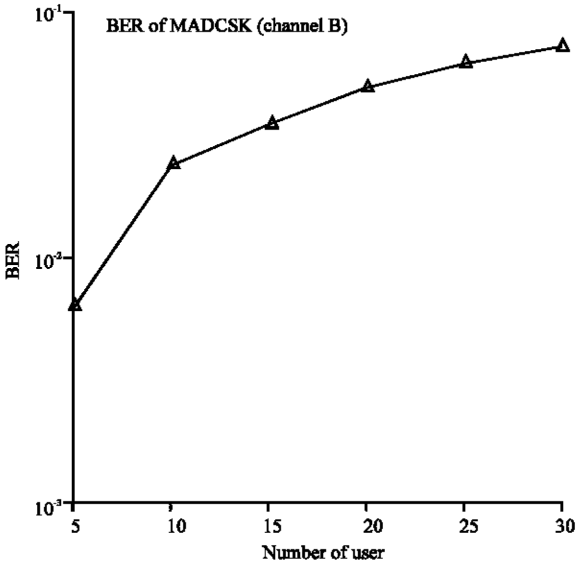

Fig. 7: Performances of MADCSK system (channel B)

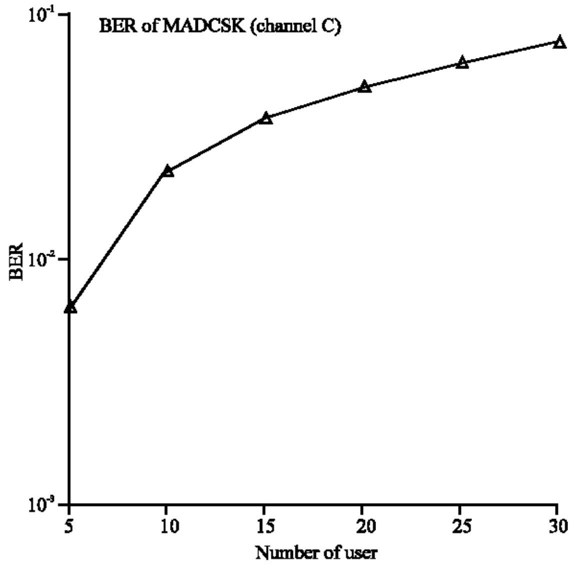

Fig. 8: Performances of MADCSK system (channel C)

RBN Equalizer. We present a model of communication system using neural network for equalization.

Several Neural Network classes are described in the literature (Broomhead and Love, 1988; Ciochoki and Unbehauen, 1993; Jodouin, 1994) in which the reader could find all the basic information. Among them, the better-known are the multilayer Perceptron, Kohonen network, Σ_Π (Sigma-Pi) network and the Radial Basis Function network. Each of them is better adapted for a particular application. We decided to use RBF Neural Networks (Ciochoki and Unbehauen, 1993; Park and Sanderg, 1993) because we are in recognition problem. Radial basis networks can be used to approximate functions. Our network has two layers. The first layer has radial basis neurons (transfer function is radial basis) and calculates its weighted inputs with Euclidean distance weight function. The second layer has neurons with linear transfer functions and calculates a layer's net input by combining its weighted inputs and biases. Both layers have biases (Chen *et al.*, 1993; Jiuchao *et al.*, 2004).

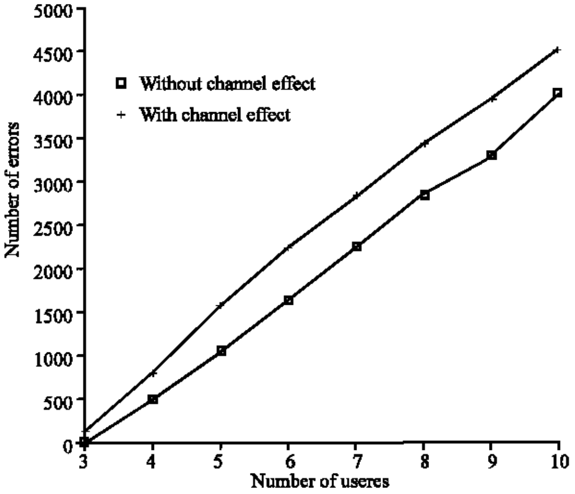

Fig. 9: Number of errors received in MADCSK system (channel C), (200000 symbols transmitted)

A conventional RBF features 2 layers (the input layer and the output layer). Generally, the network outputz^ k () is given at step k by Eq. 4 which corresponds to the weighted linear combination of the outputs of each neuron number I.

$$\hat{z}(k) = \sum_{i=1}^{L} w_i d_i (X_k) \qquad (4)$$

Where w_i is the weighting coefficient of the considered neuron i. The output of each neuron is the result of a function which measures the distance d_i between the input vector X and the center C_i (or the kernel) of the neuron i. (Eq. 5)

$$di(X) = f(r) = f(\|X\_Ci\|) \qquad (5)$$

Practically, the functions which compute the distance d(X) are the following:

$f(r) = r$,
$f(r) = r^2$

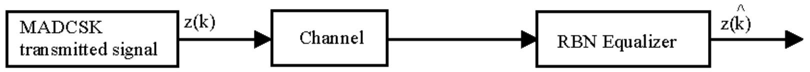

Fig. 10: Chaos-based communication system using RBN Equalizer

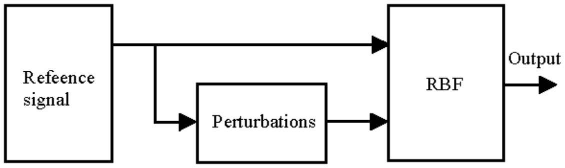

Fig. 11: Test procedure

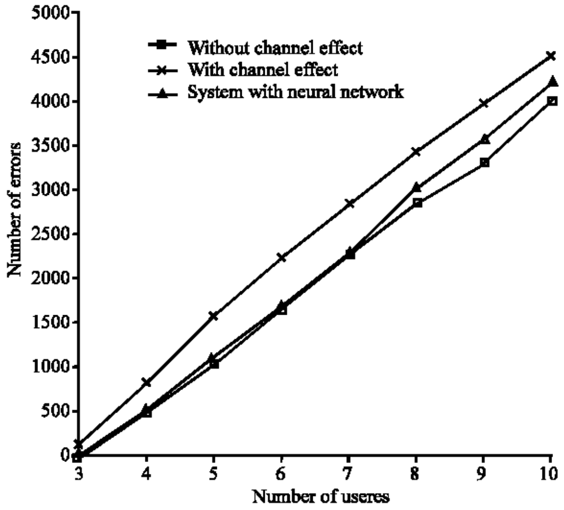

Fig.12: Test of neural network for channel C

and $f(r) = \exp(-r^2/\sigma^2 r$ classification.

The behavior of the network comprises two phases. The first is known as the training phase: Consisting in the adaptation of the weights of the neurons. The second phase corresponds to the recognition phase.

In training phase we work with PROAKIS channels (A, B and C), the output of our network must be the signal z (k) without considering the effect of channels.

In testing phases, we test also with PROAKIS channels and we introduce Gaussian perturbations to references signals (Fig. 11).

Figure 12 show the result of the network proposed, for C Channel, we remark that our neural network proposed have a better estimation of the signal transmitted.

CONCLUSION

In this study, we have proposed a Multiple-Access Scheme for Use with Differential Chaos Shift Keying (MADCSK). To decode the signals, non coherent receiver has also been designed and the access scheme of different users has been described. We have presented the effect of noise and channel for MADCSK system, computer simulation has been showing to valid our work. A neural network has been proposed as a solution to reduce the channel effect. The perspective of our research is to improve the detection method in order to reduce the intersymbol interferences effect and to optimize the equalization algorithm in order to implement it in specific circuit.

REFERENCES

Ben Farah, M.A., A. Kachouri, M. Samet. 2006. New Application of DCSK Modulation In Secure Communication System, International Conference on Design and Test of Integrated Systems in nanoscale technology (DTIS'06), Tunis, Tunisia.

Broomhead, D.S. and D. Love, 1998. Multivariable Functional Interpolation and Adaptive Networks, Complex Sys., 2: 321-355.

Chen, S., B. Mulgrew and P.M. Grant, 1993. A clustering teaching for digital communications channel equalization using radial basis function networks, IEEE Transactions on Neural Networks.

Ciochocki, A. and R. Unbehauen, 1993. Neural Networks for Optimization and Signal Processing, Wiley and Sons, New York.

Heidari-bateni, G. and C.D. McGillem, 1994. A chaotic direct-sequence spread-spectrum communication system. IEEE Transactions on Communications.

Jiuchao Feng, Chi K. Tse and Francis C.M. Lau, 2004. Reconstruction of chaotic signals with application to channel equalization in chaos-based communication systems, International Journal of Communication. System.

Jiuchao Feng, Chi K. Tse and Francis C.M. Lau, 2004. Reconstruction of chaotic signals with application to channel equalization in chaos-based communication systems, International Journal of Communication System.

Jodouin, J.F., 1994. Les réseaux neuromimétiques, Hermès, Collection informatique, Paris.

Lau, F.C.M., M.M. Yip, C.K. Tse and S.F. Hau, 2002. A Multiple-Access Technique for Differential Chaos-Shift Keying".IEEE Transaction on Circuits and System, Vol. 49: 1.

Park, J. and I.W. Sanderg, 1993. Approximation and Radial Basic Function Networks, Neural Computation, 5: 305-316.

Rebh, N., M.A. Ben Farah, A. Kachouri and M. Samet, 2007. Evaluation des performances de la modulation DCSK: Analyse de l'effet du bruit dans la transmissiond'image, Septièmes journées scientifiques des jeunes chercheurs en Génie Electrique et Informatique (GEI 2007) Monastir Tunisie.

Yang, T. and L.O. Chua, 1997. Chaotic digital Code-Division Multiple-Access (CDMA) communication systems, International Journal of Bifurcation Chaos.