Development of Optimal Performance Multiuser OFDM Network using Equalization and Filtering

Priyanka Yadav[1], Prof. Ruchi Thakur[2]

[1]M.Tech, Scholar, [2]Guide

Department of Computer Science and Engineering, SIRT, Bhopal

Abstract - The transmitted signal approach at the receiver by following different paths of various lengths in conventional wireless communication system. Since multiple renditions of the signal interference occurs, to recover the original information from received signal is a challenging job. The Fading and Interference effect of multi carrier multi user system can be reduced to build the capacity of a link. On the basis of information theory several techniques have been developed to achieve this goal. OFDM is a powerful modulation technique that is able to provide high data rate and can wipe out ISI. In this research work development of an optimal performance multiuser OFDM network using equalization and filtering is carried out in MATLAB platform. From the simulation outcome in MATLAB, it is observed that the QAM allows the BER to be improved even in a noisy channel with high bandwidth. Use of Averaging Filter and Zero forcing allows higher transmission capacity and reduce the probability of error. In proposed model results are analyzed and compared with existing results. The proposed modeling offers the optimal performance multiuser OFDM network in terms of BER.

Keywords - Zero Forcing and Square Error Equalization, Pulse Shaping Filter and Averaging Filter, BER, MIMO, OFDM.

I. INTRODUCTION

In a basic communication framework, the data are modulated onto a single carrier frequency. The accessible data transfer capacity is then completely possessed by every symbol. This sort of framework can lead to between symbol-interference (ISI) if there should arise an occurrence of frequency specific channel. The fundamental idea of OFDM is to separate the accessible range into a few symmetrical subchannels with the goal that each narrowband subchannel encounters practically level fading. Orthogonal frequency division multiplexing (OFDM) is turning into the chosen modulation procedure for wireless communications. OFDM can give vast data rates adequate heartiness to radio channel weaknesses. Many research focuses on the planet have specific groups working in the improvement of OFDM systems. In an OFDM conspire, an extensive number of symmetrical, covering, tight band sub-carriers are transmitted in parallel. These carriers partition the accessible transmission data transfer capacity. The partition of the sub-carriers is with the end goal that there is an extremely conservative spectral use. With OFDM, it is conceivable to have covering subchannels in the frequency domain, in this way expanding the transmission rate. The fascination of OFDM is predominantly a result of its method for taking care of the multipath interference at the receiver. Multipath phenomenon generates two impacts (a) Frequency specific fading and (b) Intersymbol interference (ISI).

The "flatness" seen by a narrowband channel beats the frequency selective fading. Then again, regulating symbols at a low rate makes the symbols any longer than channel impulse reaction and henceforth diminishes the ISI. Utilization of appropriate error rectifying codes gives more robustness against frequency selective fading. The addition of an additional guard interim between back to back OFDM symbols can decrease the impacts of ISI considerably more. The utilization of FFT strategy to execute modulation and demodulation capacities makes it computationally progressively productive. OFDM systems have gained an expanded enthusiasm amid the most recent years. It is utilized in the European digital broadcast radio framework, just as in wired condition, for example, asymmetric digital subscriber lines (ADSL). This strategy is utilized in digital endorser lines (DSL) to give high bit rate over a curved match of wires.

Wireless communications is a developing field, which has seen colossal development over the most recent quite a long while. The immense take-up rate of mobile telephone innovation, Wireless Local Area Networks (WLAN) and the exponential development of the Internet have brought about an expanded interest for new techniques for getting high limit wireless networks.

The orthogonal nature of the transmission is a consequence of the peak of each subcarrier relating to the nulls of all different subcarriers. At the point when this signal is identified utilizing a Discrete Fourier Transform (DFT) the spectrum isn't ceaseless as appeared in Figure 1.1 (a), however have discrete examples. The inspected spectrum is appeared as 'o's in the figure. In the event that the DFT is time synchronized, the frequency tests of the DFT compare to simply the peaks of the subcarriers, along these lines the covering frequency district between subcarriers does not influence the receiver. The deliberate peaks compare to the nulls for all different subcarriers, bringing about orthogonality between the subcarriers.

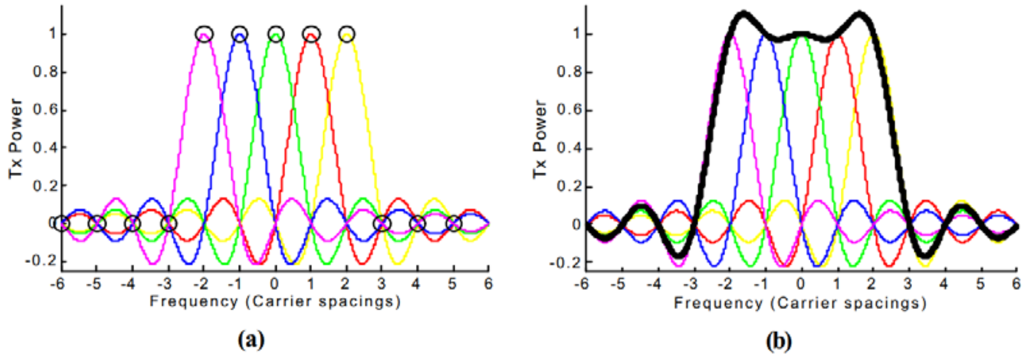

Figure: 1.1 Frequency response of the subcarrier in a 5 tone OFDM signal.

(a) shows the spectrum of each carrier, and the discrete frequency samples seen by an OFDM receiver. Note, each carrier is sinc, sin(x)/x, in shape. (b) Shows the overall combined response of the 5 subcarriers (thick black line).

II. MIMO SYSTEM MODEL

Consider a general N_T by N_R MIMO system with N_T transmit antennas and N_R receive antennas. There will be N_T by N_R uncorrelated paths between the transmitters and receivers. The complex channel gains between i^{th} receiver and j^{th} transmitter at a k^{th} STS is represented as $h_{ij,k}$ given by equation where α_{ij} are the amplitude gain and β_{ij} are the phase shift along these paths. The channel coefficients follow a Rayleigh distribution as given by equation. The block diagram for baseband transmission to baseband reception is presented in Figure 2.1.

$$h_{ijk} = \alpha_{ijk} e^{\beta ijk} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2.1)$$

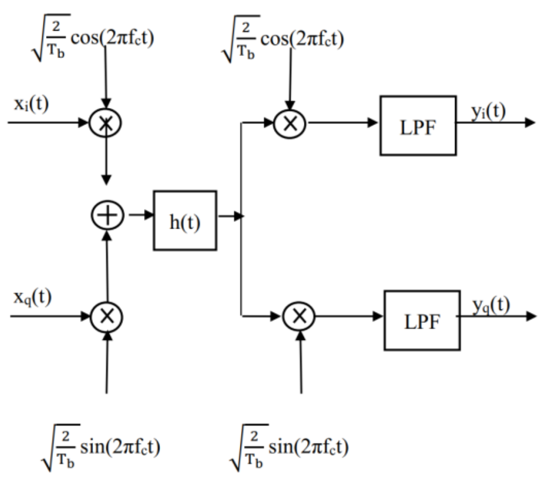

Fig. 2.1 Block Diagram for Baseband Transmission to Baseband Reception.

Here $x_i(t)$ and $x_q(t)$ are the in-phase and quadrature components of the baseband transmit signal and yi(t) and yq(t) are the baseband received signals. The linear model for the system is presented in below equation. A 2x2 MIMO system is presented in Figure 2.2.

$$\begin{bmatrix} y_{1,k} \\ y_{2,k} \end{bmatrix} = \begin{bmatrix} h_{11,k} & h_{12,k} \\ h_{21,k} & h_{22,k} \end{bmatrix} \begin{bmatrix} X_{1,k} \\ X_{2,k} \end{bmatrix} + \begin{bmatrix} n_{1,k} \\ n_{2,k} \end{bmatrix} \dots\dots\dots\dots\dots (2.2)$$

$$Y = HX + N \dots\dots\dots\dots\dots\dots\dots\dots (2.3)$$

X is a set of transmit signal vectors in the signal space defined by a set of basis functions. Y is the corresponding set of received signal vectors.

Noise at the receiver is modeled by an N_R X 1 column vector whose elements are zero-mean, i.i.d. complex Gaussian random variables with identical variances $(power)^2$.

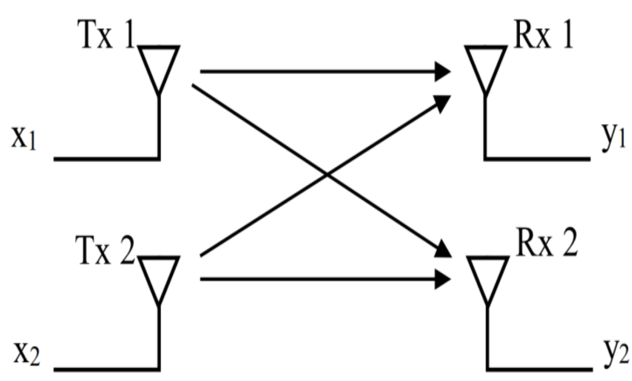

Fig. 2.2 A 2X2 MIMO System.

III. PROPOSED METHODOLOGY

This work proposed a development of optimal performance multiuser OFDM network using equalization and filtering approach. Fig.3.1 shows the block diagram of proposed approach implemented and simulated on MATLAB Environment. As demonstrated in Fig. 3.1 input information signal is modulated by 8/16/32/64 QAM modulation block then the modulated signal is converted in parallel stream using serial to parallel converter. An inverse transform (OFDM modulation) is applied on signal stream and again converted in its actual serial form. An AWGN MIMO channel with noise is used in proposed model to propagate modulated transmitted signal. At the receiver end Reverse OFDM (OFDM demodulation) transform is applied on received signal. After that equalization and filtering is applied on received demodulated signal. Combine the received signal with respective data. Apply median filtering along with moving average filtering to get actual information output. Operation and functionality of fundamental blocks of proposed model are given as follows.

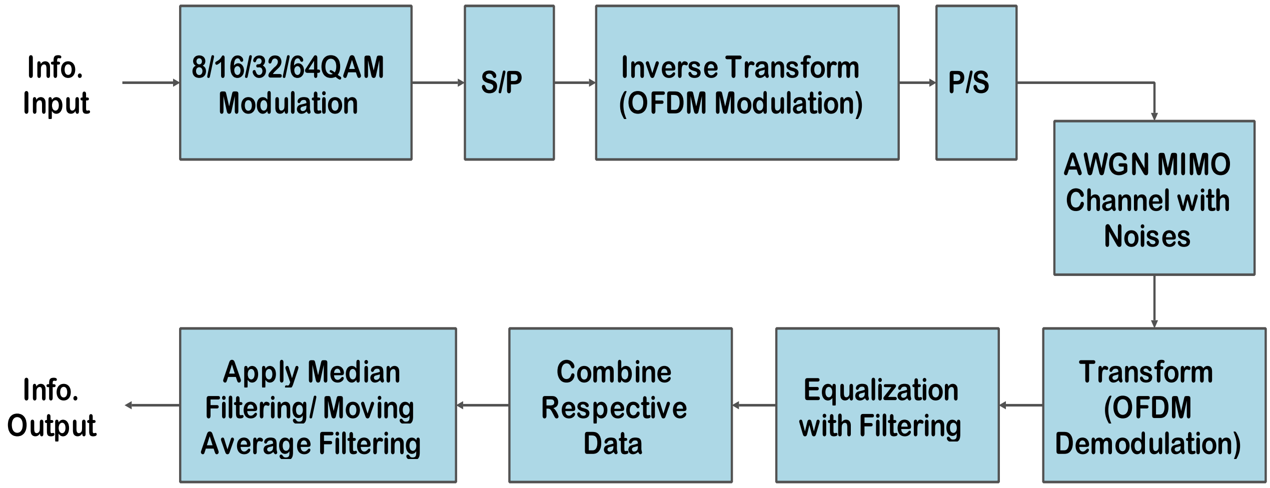

Fig.3.1 Block Diagram of Proposed Methodology.

a. QAM Modulation

For higher data rates, PSK has limitations. QAM provides the higher throughput rate required for data transfers by combining ASK and PSK. Two different signals are sent simultaneously on the same carrier frequency. The result of this combination provides two variable (amplitude and phase of the signal) to assign binary values. As the number of states is increasing, greater throughput is achieved. The number of states used in QAM ranges from 8 to 64 in practical systems making data throughput to 100 Mbps rate in WLAN and very high speed digital subscriber line (VHDSL) systems. As the complexity of QAM increases, the possibility.

M-QAM has been simulated in Matlab. M used in the simulation is 4, 16 and 64. Different QAM results summary is given in the simulation results. As the M value increases in order to maintain good BER, SNR also needs to be increased appropriately for each QAM points. In QAM, the margins are low between signal constellation points. Hence, any imbalances or impediments in the channel or overall system can make the BER to grow. To contain BER low, it is required to send higher power.

b. Equalization

The effect of Inter Symbol Interference (ISI) in multipath time varying dispersive channel is more severe than noise associated with the system. One method to abate this ISI is by implementing equalization or channel inversion at the receiver. Effectively the equalizers are used to decouple the multiple sub-streams in the received sequence. The process of equalization involves realization of a filter w such that (z) is approximately equal to $H^{-1}(z)$.

Zero Forcing Equalizer is used in this work. A Zero Forcing equalizer is formulated to render the least square estimate of the transmit signal vector. It is shown that, the Zero Forcing equalizer is the pseudo-inverse of the channel matrix. Hence, the zero forcing equalizer is purely a function of the channel state or the channel matrix.

c. Moving Average Filter

The Moving average filter is a basic Low Pass FIR (Finite Impulse Response) filter ordinarily utilized for smoothing a variety of tested data/signal. It takes L tests of contribution at once and takes the normal of those L-tests and delivers a solitary output point. It is a straightforward LPF (Low Pass Filter) structure that comes helpful for researchers and specialists to filter undesirable noisy segment from the intended data. As the filter length builds (the parameter L) the smoothness of the output signal, increments, while the sharp advances in the data are made progressively obtuse. This implies that this filter has excellent time domain response but a poor frequency response.

Fig. 3.2 shows the simulation flow of proposed work in MATLAB.

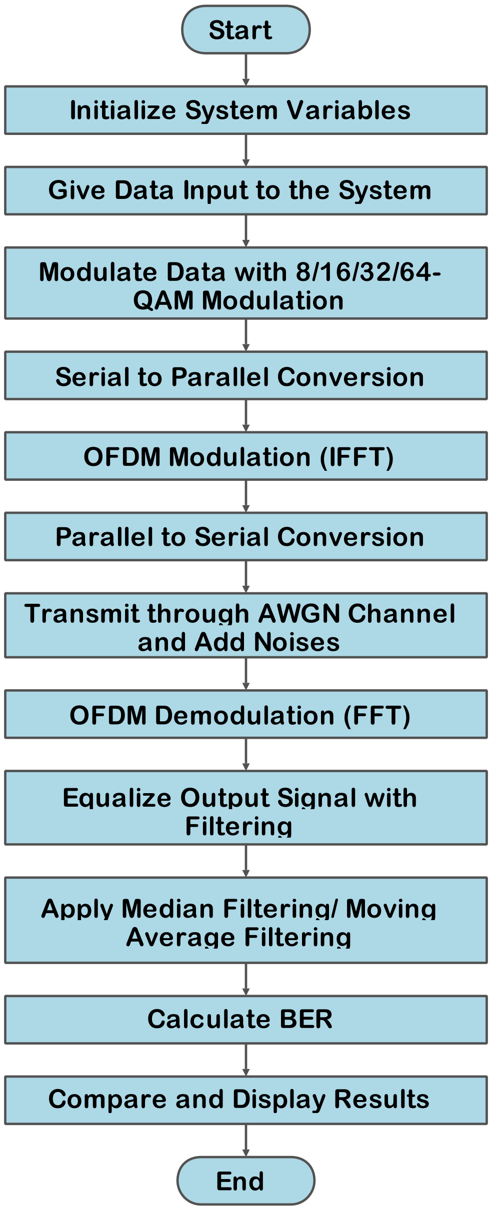

Fig.3.2 Flow chart of Proposed System Algorithm.

IV. SIMULATION RESULTS

In simulation of proposed work consider the performance of the ZF equalizers in cases of various transmitter and receiver conditions. To simulate proposed work various antenna configurations are considered. The antenna configuration considered for the simulation of this work for deferent QAM modulation. Using 8-QAM Modulation, 16-QAM Modulation ,32-QAM Modulation and 64-QAM Modulation for 2 transmitter and 2 receiver antenna configuration, A comparative study of performance of equalizers in these cases is presented based on SNR and BER of the output streams from the equalizer for cases of transmitter and receiver.

Fig. 4.1 Shows the Multi User OFDM Wireless Network with Tx=2 (Number of transmitters) and Rx=2 (Number of receivers) using 8-QAM modulation scheme. BER for different schemes like ZF-OSIC,MMSE-OSIC,ZF-OSIC+Averaging filtering, MMSE-OSIC+Averaging filtering, ZF-OSIC+Pulse shaping filter is illustrated with different colors.

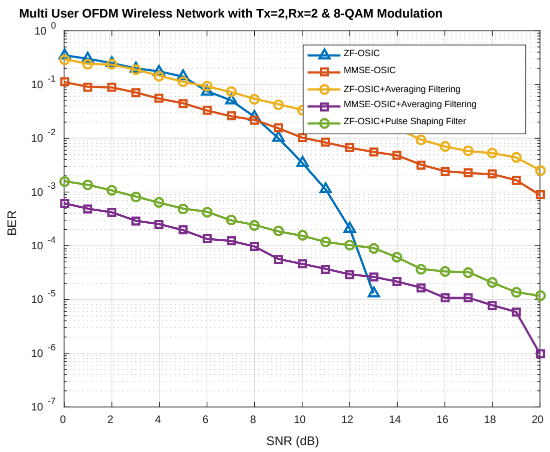

Fig. 4.1 Multi User OFDM Wireless Network using 8-QAM Modulation.

Fig. 4.2 Shows the Multi User OFDM Wireless Network with Tx=2 (Number of transmitters) and Rx=2 (Number of receivers) using 16-QAM modulation scheme. BER for different schemes like ZF-OSIC,MMSE-OSIC,ZF-OSIC+Averaging filtering, MMSE-OSIC+Averaging filtering, ZF-OSIC+Pulse shaping filter is illustrated with different colors.

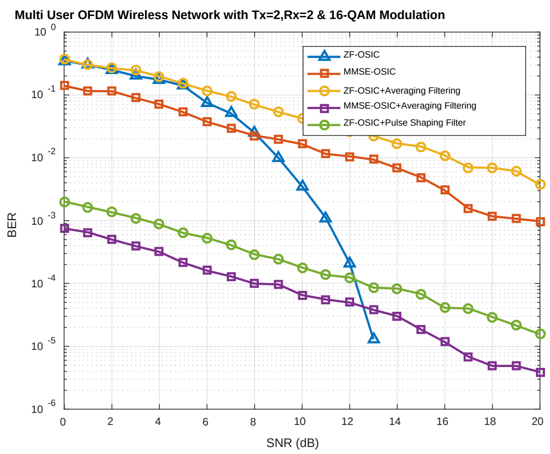

Fig. 4.2 Multi User OFDM Wireless Network using 16-QAM Modulation.

Fig. 4.3 Shows the Multi User OFDM Wireless Network with Tx=2 (Number of transmitters) and Rx=2 (Number of receivers) using 34-QAM modulation scheme. BER for different schemes like ZF-OSIC,MMSE-OSIC,ZF-OSIC+Averaging filtering, MMSE-OSIC+Averaging filtering, ZF-OSIC+Pulse shaping filter is illustrated with different colors.

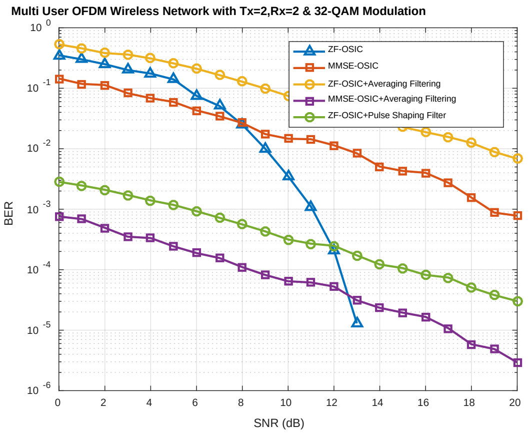

Fig. 4.3 Multi User OFDM Wireless Network using 32-QAM Modulation.

Fig. 4.4 Shows the Multi User OFDM Wireless Network with Tx=2 (Number of transmitters) and Rx=2 (Number of receivers) using 64-QAM modulation scheme. BER for different schemes like ZF-OSIC,MMSE-OSIC,ZF-OSIC+Averaging filtering, MMSE-OSIC+Averaging filtering, ZF-OSIC+Pulse shaping filter is illustrated with different colors.

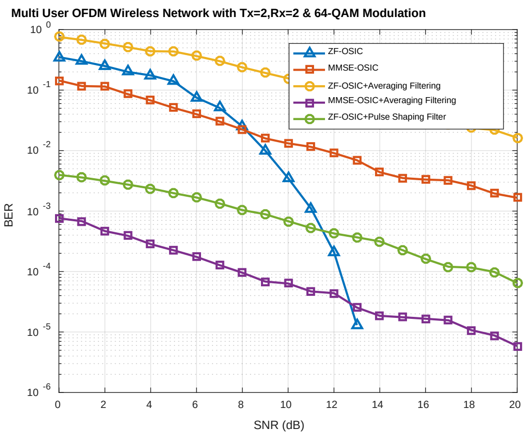

Fig. 4.4 Multi User OFDM Wireless Network using 64-QAM Modulation.

V. CONCLUSION AND FUTURE SCOPE

In this work a theoretical framework to of a communication system development of optimal performance multiuser OFDM network using equalization and filtering approach to predict the performance of the equalizers is proposed and verified. The model is checked for consistency by verifying its performance for 2X2 MIMO antenna configuration for 8QAM, 16QAM, 32 QAM and 64QAM modulation. Further, the performance is studied for a case in which one of the communication entities is mounted. The effect of antennas is studied. The proposed model is seen to have reduced complexity and computation, smart choice of transmits power and optimal placement of antennas. In the background of the challenging conditions that demand robust solutions for effective communication.

The following are the some of the interesting extensions of the present work: (1) An interesting topic for future research is to perform more extensive performance comparisons between FFT based OFDM. (2) The proposed OFDM system is working well for AWGN channel; it can be tested to Rayleigh fading channels.

REFERENCES

[1] G. Kaddoum, "Design and Performance Analysis of a Multiuser OFDM Based Differential Chaos Shift Keying Communication System," in IEEE Transactions on Communications, vol. 64, no. 1, pp. 249-260, Jan. 2016.

[2] Y. Tanigawa, Y. Kozai and T. Saba, "A physical layer security scheme employing imaginary receiver for multiuser MIMO-OFDM systems," 2017 IEEE International Conference on Communications (ICC), Paris, 2017, pp. 1-6.

[3] T. Murakami, K. Ujihara, Y. Takatori, M. Mizoguchi and F. Maehara, "Downlink multiuser MIMO-OFDM transmission using simple receive antenna selection," 2016 International Symposium on Antennas and Propagation (ISAP), Okinawa, 2016, pp. 604-605.

[4] P. Xu, J. Wang, J. Wang and F. Qi, "Analysis and Design of Channel Estimation in Multicell Multiuser MIMO OFDM Systems," in IEEE Transactions on Vehicular Technology, vol. 64, no. 2, pp. 610-620, Feb. 2015.

[5] M. Kirutiga, K. Narayan and A. Chinmayi, "Correlation delay shift keying based Chaos MIMO communication system," 2015 International Conference on Communications and Signal Processing (ICCSP), Melmaruvathur, 2015, pp. 1690-1694.

[6] G. Kaddoum and F. Gagnon, "Lower bound on the bit error rate of a decode-and-forward relay network under chaos shift keying communication system," in IET Communications, vol. 8, no. 2, pp. 227-232, 23 January 2014.

[7] S. Yoon, J. Lee and H. Ryu, "Chaos communication system using MIMO technique," 16th International

Conference on Advanced Communication Technology, Pyeongchang, 2014, pp. 579-583.

[8] G. Kaddoum, F. Richardson and F. Gagnon, "Design and Analysis of a Multi-Carrier Differential Chaos Shift Keying Communication System," in IEEE Transactions on Communications, vol. 61, no. 8, pp. 3281-3291, August 2013.

[9] T. S. Rappaport, Wireless Communications: Principles and Practice. Englewood Cliffs, NJ, USA: Prentice-Hall, 1996.

[10] L. Hanzo, T. Keller, M. Muenster, and B.-J. Choi, OFDM and MC-CDMA for Broadband Multi-User Communications, WLANs and Broadcasting. Hoboken, NJ, USA: Wiley, 2003.

[11] R. V. Nee and R. Prasad, OFDM for Wireless Multimedia Communications, 1st ed. Norwood, MA, USA: Artech House, 2000.

[12] S. Kondo and B. Milstein, “Performance of multicarrier DS-CDMA systems,” IEEE Trans. Commun., vol. 44, no. 2, pp. 238–246, Feb. 1996.

[13] F. C. M. Lau and C. K. Tse, Chaos-Based Digital Communication Systems. New York, NY, USA: Springer, 2003.

[14] A. P. Kurian, S. Puthusserypady, and S. M. Htut, “Performance enhance- ment of DS-CDMA system using chaotic complex spreading sequence,” IEEE Trans. Wireless Commun., vol. 4, no. 3, pp. 984–989, May 2005.