Advanced Research in Electrical and Electronic Engineering
Print ISSN: 2349-5804; Online ISSN: 2349-5812 Volume 2, Number 2 October-December (2014) pp. 136-141

http://www.krishisanskriti.org/areee.html

Reduction of Bit Error Rate in MIMO-OFDM System using Two Phase Kalman Filter

Manpreet Kaur[1] and Gagandeep Kaur[2]

M.tech, Student Electronics and Communication Engg. Yadavindra College of Engineering, Guru Kashi Campus Punjabi University Patiala Talwandi Sabo (Bathinda)-151302, India.
[2]Yadavindra College of Engineering, Guru Kashi Campus Punjabi University Patiala Talwandi Sabo (Bathinda)-151302, India
E-mail: [1]manny.dhillon03@gmail.com, [2]ergagan84@gmail.com

Abstract: *MIMO-OFDM is one of the upcoming communication schemes, which present well-organized communication with multi-carrier modulation. MIMO-OFDM technique has been used in spatial diversity by multiple antennas at the transmitter and the receiver side. MIMO-OFDM (multiple input multiple output-orthogonal frequency division multiplexing), a new wireless broadband technology which has gained great popularity for its capability of high rate transmission and its strength against multi-path fading and other channel impairments. OFDM is a modulation technique that used for transmission the digital data to be professionally and constantly over a radio channel even in multipath environments. The main drawback of this approach is higher BER. In MIMO-OFDM systems channel estimation is also important character. For channel estimation there are number of methods which already designed for MIMO-OFDM systems. In the earlier period there are so many techniques had been designed for reduce BER in MIMO-OFDM systems. In this paper, a new proposing technique is used to minimize the BER in MIMO-OFDM system. In this paper proposing technique is Filtering technique. Under this procedure, a Two-phase KALMAN FILTER is used for reducing BER. Using Two-phase KALMAN FILTER, channel estimation is also done appropriately as compared with the true value.*

Keywords: *MIMO, OFDM, Kalman Filtering , Bit Error Rate, inter-carrier interference*

1. INTRODUCTION

MIMO is a wireless technique in which multiple antennas to transmit and receive the signals at the same time in the same frequency band. MIMO technique has advantage of the radio wave system called multipath. In multipath, the transmitted signal is faded by reflected from walls, ceilings, and additional objects and reached the receiving antenna multiple times. In which multipath signals are travelled through different paths. MIMO is one of the spatial diversity technique. Earlier multipath cause interference and it reduced the performances of wireless signals, but MIMO is the technique that takes the advantage of multipath behavior by using multiple antennas with a spatial diversity technique. In spatial diversity technique, it increases the performance and range of wireless system. In wireless system, MIMO technique increases the performances of the system by applying the to combined data streams arriving from different paths with different time interval due to multipath propagation, the ISI (Inter Symbol Interference) arrived in which one symbol interferes with the other subsequent symbol. Inter Symbol Interference is able to be removed with different kinds of equalizers.[1]

A well-known problem of OFDM system is its sensitivity to frequency offset between the transmitted and received signal which is caused by Doppler shift in the channel. This carrier frequency offset causes loss of orthogonality between sub-carriers and the signals transmitted on each carrier which are not independent of each other [2]. This leads to the inter-carrier interference (ICI) in OFDM. Researchers have proposed various methods to overcome the inter-carrier interference in OFDM systems. The previously approaches that have been used to reduce ICI are categorized as frequency-domain equalization, time-domain windowing, and the ICI self-cancellation (SC) scheme.

The first method to overcome the ICI is a self-cancellation scheme [3], in which redundant data is transmitted onto adjacent sub-carriers such that the ICI between adjacent sub-carriers cancels out each other at the receiver end. The second method is the windowing technique. The other techniques which are Maximum Likelihood (ML) estimation and the Extended Kalman Filter (EKF) method statistically estimate the frequency offset and correct the offset using the estimated value at the receiver. MIMO is technique that uses multiple antennas to transmit and receive the signals. The basic structure of MIMO is shown in Fig. 1, where T_n and R_n stands for the nth transmitter antenna and receiver antenna. In some cases, MISO is a system with multiple inputs and single output. On the other hand, a system with single input and multiple outputs is called SIMO. One of the initial MIMO to wireless communications applications came in mid 1980 with the get through developments by Jack Winters and Jack Saltz of Bell Laboratories [4].
They tried to send data from multiple users on the same frequency or time channel using multiple antennas equally at

the transmitter and receiver. In view of the fact that, several academics and engineers have made important contributions in the field of MIMO. Energy-efficiency analysis of MIMO system is significant topic in MIMO research. Earlier multipath caused interference and slow down the wireless signals, but in the MIMO technology take the advantages of multipath actions by using multiple antennas on transmitter and the receiver side through spatial diversity technique. By using spatial diversity technique, the performance and range will be increase. MIMO makes antennas work superior by applying them to combine the data streams incoming from different paths with different time interval. Which will increase the receiver signal capturing power due to multipath propagation, the ISI (Inter Symbol Interference) occurred in which one symbol interferes with the other subsequent symbol? Therefore, different kinds of equalizers can be used to improve ISI [5]. At present, MIMO technology has aroused interest because of its feasible applications in digital television, wireless local area networks, metropolitan area networks and mobile communication.

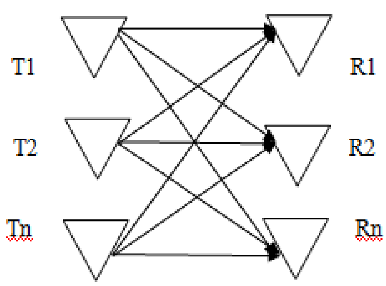

Fig. 1: MIMO structure.

Aim of this paper is to improve the BER in MIMO-OFDM system. In this paper, analysis the BER performance of MIMO-OFDM system using Two phase Kalman filter. In Modern communication system, the BER and signal-to-noise ratio (SNR) is the very important parameter.

The rest of the paper is prepared as follows. In section II, MIMO-OFDM system with Two phase Kalman filter structure scheme is presented. In section III the simulation results and its discussion are given in this section. Finally, the section IV concludes the paper.

2. YSTEM STRUCTURE

In this section, the simulated model structure with simulation parameter for implemented the system.

A. MIMO-OFDM System Model

The Block diagram of MIMO-OFDM system is shown in Fig. 2. At the transmitter side, a serial data bit stream is mapped to a symbol stream by a modulator. Then, this serial symbol stream is converted into parallel sub-streams. Next, pilot symbols for the channel estimation are inserted into these parallel sub-streams, in the frequency-domain, prior to the OFDM modulation. The OFDM modulation is then implemented by performing the inverse discrete Fourier transform (IDFT). Each transmits antenna sends independent OFDM symbols. The use of cyclic prefix is to reduce the effect of ISI. After that bits are converted from parallel to serial and given to the antenna.

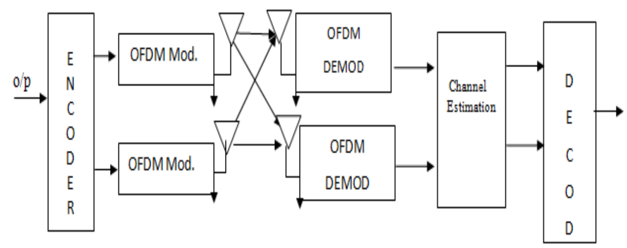

Fig. 2: Block Diagram of MIMO-OFDM System model.

At the receiver side the bits are converted from serial to parallel after getting from the antenna. Then cyclic prefix is removed which is added at the transmitter side and then OFDM modulation again is performed in which DFT is performed. After this the channel estimation block comes in order to estimate the channel accurately. At last De-mapping is done in order to get the desired output [6].

B. Two phase Kalman Filter

In basic communication systems, filtering is a important factor. While radio communication signals are repeatedly corrupted with noise, a high-quality filtering algorithm is necessary to remove the noise from electromagnetic signals as retaining the useful information. Therefore the Kalman filtering is an valuable scheme to filter impurities in linear systems. The Kalman filter is an most favorable estimator infers parameters of interest from indirect, imprecise and unsure explanation. A Kalman filter is linear, discrete time, finite time-varying system to calculate the state estimate to reduced the mean-square error.

A basically the kalman filter consists of a set of mathematical equations that provides an efficient computational means to estimate the state of a process that minimizes the mean of the squared error. It procedure recursively on streams of noisy input data to generate statistically best results the filter is controlling in several aspects: it supports estimations of past, present, and still future states, and still when the accurate nature of the modeled system is unidentified [7]. In Fig. 3 is explained the general filtering process with Kalman filter.

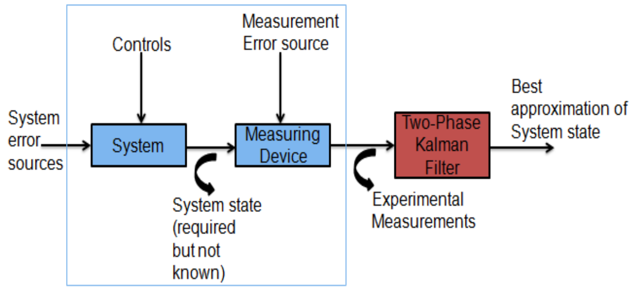

Fig. 3: General filtering process with Kalman filter.

C. Proposed Model

The simulation proposed model for MIMO-OFDM system is shown in Fig. 4. It is expected that the proposed system will improve the network with reduction of error rate and the interference ratio. The basic terms related to the system include:

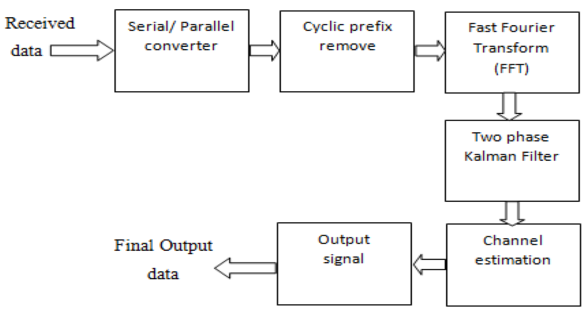

Fig. 4: Block Diagram of proposed model.

1) *ICI :-* A well-known problem of MIMO OFDM, however, is its sensitivity to frequency offset between the transmitted and received signals, which may be caused by Doppler shift in the channel, or by the difference between the transmitter and receiver local oscillator frequencies. This carrier frequency offset causes loss of orthogonality between sub-carriers and the signals transmitted on each carrier are not independent of each other, leading to inter-carrier interference. Researchers have proposed various methods to contest the ICI in OFDM systems [8]. The existing approaches that have been developed to reduce ICI can be categorized as, frequency-domain equalization, time-domain windowing and the ICI self-cancellation (SC) scheme. In addition, statistical approaches have also been explored to estimate and cancel ICI. Kalman based Statistical approach is used to In this work improve the Kalman Filter.
2) *PAPR:-* High peak-to-average-power ratio (PAPR) has been cited as one of the drawbacks of OFDM modulation format. In the RF systems, the major problem resides in the power amplifiers at the transmitter end, where the amplifier gain will saturate at high input power. One of the ways to avoid the relatively "peaky" OFDM signal is to operate the power amplifier at the so-called heavy "back-off" system, where the signal power is much lower than the amplifier saturation power. Unfortunately, this requires an excess large saturation power for the power amplifier , which certainly leads to low power efficiency. In the optical systems, interestingly enough, the optical power amplifier (predominately an Erbium-doped-amplifier today) is ideally linear regardless of its input signal power due to its slow response time in the order of millisecond. Nevertheless, the PAPR still poses a challenge for optical fiber communications due to the nonlinearity in the optical fiber. In this PAPR is analyzed by using Kalman Filter based Statistical analysis and based on obtained value the Phase variation is performed to control the PAPR.
3) *FFT/IFFT (Fast Fourier and Inverse Fast Fourier Transformation):-* FFT is used to perform Frequency domain transformation [9]. And IFFT is used to convert OFDM sub-channels into time domain. OFDM sub-channels are converted into time domain using IFFT because it generates distinct samples of waveforms with frequency satisfying orthogonality conditions. IFFT modulates each of the sub-channels into a precise orthogonal carrier.
4) *Carrier Frequency Offset:-* OFDM requires high degree of synchronisation to maintain sub-channel orthogonality. So, performance level depends on the accuracy in estimating Carrier Frequency Offset. Basically, CFO is the difference in carrier frequency at transmitter side and the receiver side. In wireless communication using OFDM due to mobility of the users, more accurate frequency offset control is needed to ensure that subcarriers are orthogonal. CFO estimation is needed because of the difference in frequencies of transmitter and receiver, which if not estimated can cause large bit errors in the received signals [2].
5) *Kalman Filtering:-* In radio communication systems, filtering is a desirable factor. As radio communication signals are often corrupted with noise, a good filtering algorithm is required to remove noise from electromagnetic signals while retaining the useful information. Kalman Filtering [10] is an effective method to filter impurities in linear systems. The kalman filter basically consists of a set of mathematical equations that provides an efficient computational means to estimate the state of a process that minimizes the mean of the squared error. It operates recursively on streams of noisy input data to produce statistically optimal results The filter is very powerful in several aspects: it supports estimations of past, present, and even future states, and it can do so even when the precise nature of the modeled system is unknown.

In this technique, the idea of cyclic slots and Correlated Channel Mapping are used through the Kalman Filter. The Kalman Filter technique at receiver side proposed model shown in above Fig. 4. In this Kalman Filter technique a two phase Kalman Filter is used after performing the FFT at receiver side. But the preliminary steps are not change in proposed model, these steps are mostly same for MIMO OFDM system.

3. RESULTS AND DISCUSSION

In section II, The MIMO-OFDM system with Two phase Kalman filter. Which is implemented using MATLAB and observed the bit error rate (BER) at different values of signal-to-noise ratio (E_b/N_0).

The proposed work is implemented presently performed after the FFT functional blocks at the receiver side. Then performed the channel mapping and estimation. If the channel mapping is not mapped properly some filtration is performed so that the mapping will be done accurately.

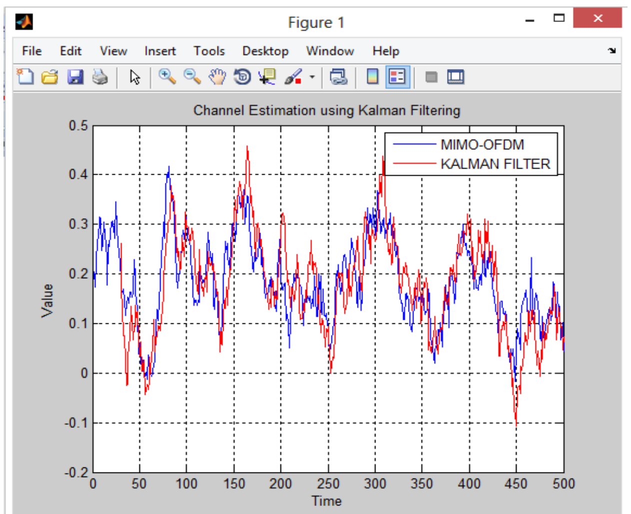

Fig. 5: Channel estimation using Kalman Filter.

Fig. 5. shows that the channel estimation is done by using the Kalman Filter, and its values are shown in Table 1. In which the channel estimation observed and compared the Kalman Filter estimate with the true value. It clearly observed that the Kalman Filter estimate is better than the true value.

Table 1: Different value of ber with respect to time.

Time (seconds)	System used to calculate BER (dB)	
	Standard MIMO-OFDM system	MIMO-OFDM with KALMAN filter
0	0	0
50	0.06	0.03
100	0.32	0.29
150	0.29	0.31
200	0.19	0.27
250	0.95	0.94
300	0.28	0.26
350	0.14	0.11
400	0.24	0.28
450	0.04	-0.1
500	0.04	0.07

In Fig. 6 it shows that the BER calculated in standard MIMO OFDM system. In this graph BER shown as red line.

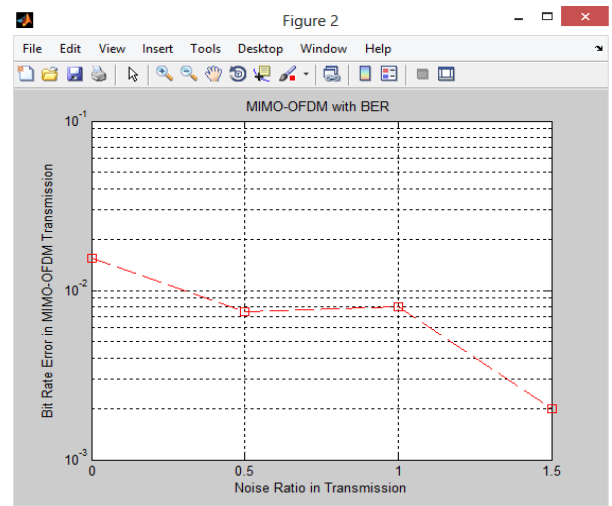

Fig. 6: Bit error rate in MIMO-OFDM transmission

In Fig. 7 shows the BER calculated in MIMO OFDM system with Kalman Filter. In this graph BER shown as blue line.

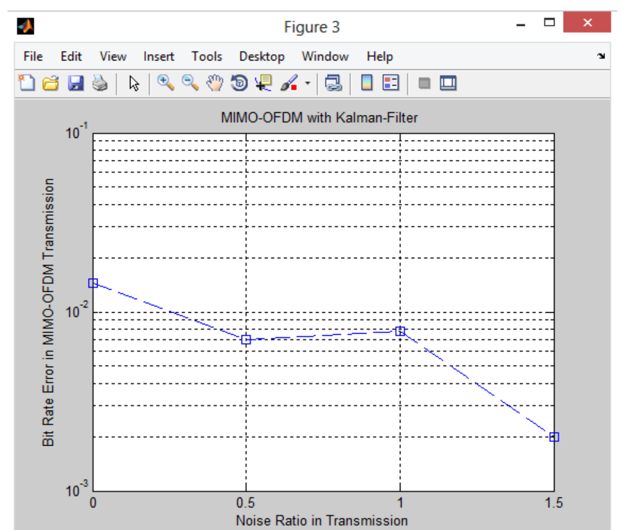

Fig. 7: Bit error rate in MIMO-OFDM transmission using KALMAN Filter.

Fig. 8. shows the comparison of the standard MIMO-OFDM system with MIMO-OFDM using Kalman Filter technique. From this graph, it clearly described that the BER in standard MIMO OFDM system is high as compared to the MIMO OFDM using Kalman Filter.

In Table 2 shows the Comparison of the standard MIMO-OFDM system with MIMO-OFDM using Kalman Filter.

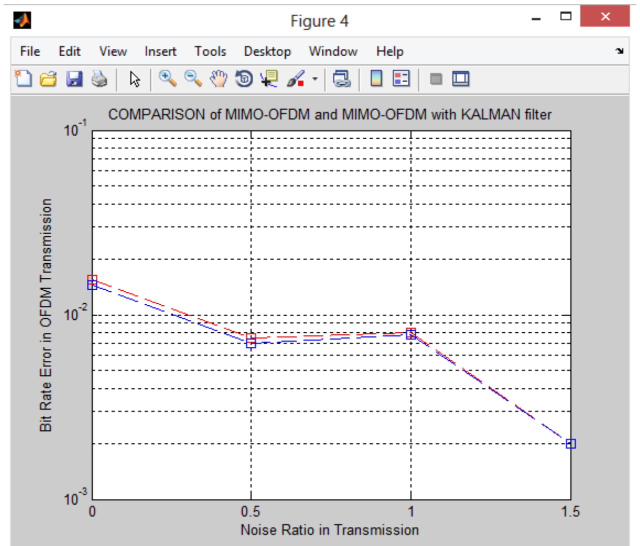

Fig. 8: Comparison between SNR versus BER in MIMO-OFDM and with KALMAN filter.

Table 2: Ber virsus signal-to-noise ratio in mimo-ofdm and mimo-ofdm with kalman filter.

Signal-to-noise ratio (Eb/N0)	System used to calculate BER (dB)	
	Standard MIMO-OFDM system	MIMO-OFDM with KALMAN filter
0	10-1.81	10-1.84
0.5	10-2.13	10-2.16
1	10-2.10	10-2.11
1.5	10-2.70	10-2.70

Therefore, the two phase Kalman Filter technique reduced the bit error rate in MIMO OFDM system and it give the better result as compared to the traditional MIMO OFDM technique.

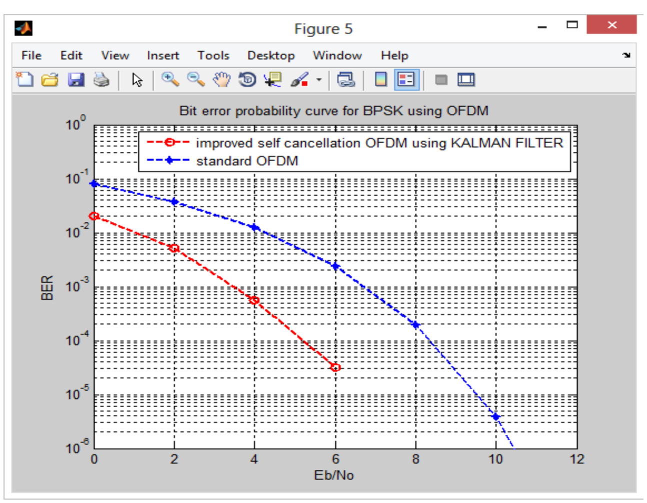

Fig. 9: Bit error rate probability between standard OFDM and OFDM using Kalman Filter.

As shown in Fig. 9, it described the BER probability curve between the standard OFDM system and OFDM system using Kalman Filter in self cancellation. Its BER values calculated are shown in Table 3. In Two-phase Kalman filter the bit error rate (BER) easily reduce and improves the performance of Signal-to-Noise Ratio. Reduction in BER found to be satisfactory when compared with previous work. By simulation, Two-phase Kalman Filter used in OFDM system gives better results for self cancellation as compared to standard OFDM system, it can be seen that as increasing the value of Signal-to- Noise Ratio the value of the Bit Error Rate (BER) decreases.

Table 3: Ber virsus signal-to-noise ratio in mimo-ofdm and mimo-ofdm with kalman filter for self cancellation.

Signal-to-noise ratio (Eb/N0)	System used to calculate BER (dB)	
	Standard MIMO-OFDM system	MIMO-OFDM with KALMAN filter
0	10-1.70	10-1.10
2	10-2.30	10-1.42
4	10-3.3	10-1.90
6	10-4.50	10-2.6
8	0	10-3.72
10	0	10-5.4
12	0	0

4. CONCLUSION

The MIMO-OFDM is the efficient technology for data transfer at higher bit rate. Due to the nature of MIMO higher bit error rate had reduce the efficiency of the network. In this dissertation, filtering technique is purposed this technique is the mathematically technique in which two-phase Kalman filter for reducing the bit error rate. This filtering technique is a mathematically technique in which Kalman filter is used for improving the performance.

The simulation results shows that, the Two-phase Kalman filter technique is more efficient as compared to the MIMO-OFDM systems and provide better bit error rate performance. Channel estimation is also improved with the help of Kalman filter and the simulation results shows that in Kalman Filter estimate is better.

The future scope is that BER can be minimized by using other types of filter like adaptive filter and wiener filter. Using other types of modulation, the BER can be calculated in Two-phase Kalman filter.

REFERENCES

[1] Theodore S. Rappaport, "Wireless Principles and Practice", Prentice-Hall, India.

[2] J. Armstrong, “Analysis of new and existing methods of reducing intercarrier interference due to carrier frequency offset in OFDM,” IEEE Transactions on Communications, vol. 47, no. 3, pp. 365–369, March 1999.

[3] Zhao and S. Haggman, "Intercarrier interference self cancellation scheme for OFDM mobile communication systems," IEEE Transactions on Communications, vol. 49, pp. 1185–1191, July 2001.

[4] L.J. Cimini, Jr., "Analysis and simulation of a digital mobile channel using orthogonal frequency division multiplexing," IEEE Trans. on Communications. vol. COM-33, No. 7, pp. 665-675, July 1985.

[5] Hongwei Yang, "A road to future broadband wireless access: MIMO-OFDM Based air interface," IEEE Communications Magazine., vol. 43, pp. 53-60, Jan. 2005.

[6] Mitalee Agrawal (2011), "BER Analysis of MIMO-OFDM systrem for AWGN & Rayleigh Fading Channel", Inter. J. of Comp. Appl. (0975-8887), vol 34, pp 33-37, Nov 2011.

[7] M. Huang, X. Chen, L. Xiao, S. Zhou and J. Wang, "Kalman filter based channel estimation for OFDM in time-varying channels", IET Communication., pp.795 801, 2007.

[8] Heung-Gyoon Ryu, Yingshan Li, and Jin-Soo Park, "An Improved ICI Reduction Method in OFDM Communication System" IEEE Trans., vol. 51, pp. 395-400, Sept. 2005.

[9] A. L.intini, "Orthogonal frequency division multiplexing networks for wireless networks", Electrical and Computer Engineering Department, University of California, Santa Barbar, December 2000.

[10] Jia TU, "Turbo Equalization based on a New Kalman Filter for OFDM over Doubly-Selective Channels", IEEE Inter. Confer. ICCCAS, pp. 237-241, May 2008.