International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

Performance of ICI Cancellation in OFDM System Using Different Reduction Techniques

M. Tejeswara Rao[1], **I. Krishna Rao**[2]

[1, 2] Department of Electronics and Communication, Vignan's Institute of Information Technology, Visakhapatnam, India

Abstract: ***Orthogonal frequency division multiplexing (OFDM) is used in many wireless broadband communication systems because it is a simple and scalable solution to inter symbol interference caused by a multipath channel. OFDM is emerging as preferred modulation scheme in modern high data rate wireless communication systems. A well known problem of OFDM system is 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 subcarriers and the signal transmitted on each carrier are not independent of each other, leading to inter carrier interference (ICI).In this paper the effect of ICI have analyzed and different techniques has been used to reduce the ICI effect. The first method is a self cancellation scheme and other one is using an extended kalman filter. We also analyze the ICI without reduction***.

Keywords: Extended Kalman Filter (EKF), OFDM, ICI, AWGN, BER

1. Introduction

Multiple access schemes are used to allow many mobile users to share simultaneously a finite amount of radio spectrum. Orthogonal frequency division multiplexing (OFDM) is used in many wireless broadband communication systems because it is a simple and scalable solution to inter symbol interference caused by a multipath channel. It is used in wireless local area networks (WLAN) and wireless metropolitan area networks (WMAN) including IEEE802.11a/g and worldwide interoperability for microwave access (Wi-MAX). As a promising technique, OFDM has been widely applied in modern wireless communications due to its high spectral efficiency and low susceptibility to the multipath propagation. Very recently the use of OFDM in optical systems has attracted increasing interest. ICI self-cancellation is a scheme that was introduced by Yuping Zhao and Sven-Gustav Haggman in 2001 in to combat and suppress ICI in OFDM systems. The increase of bit rates in digital mobile radio communication systems , the intersymbol interference (ISI) and channel deep fading become big problems in conventional single carrier systems. A proposal to use Orthogonal Frequency Division Multiplexing (OFDM) in radio mobile environment has been analyzed [8].Since a long symbol interval is used, the system has strong ability to combat channel deep fading, and the ISI can be mitigated by means of guard intervals. In an OFDM system, the whole available bandwidth is divided into N small parts, and a block of N data symbols are modulated on N corresponding subcarriers which are orthogonal to each other. The spectra of the subcarriers are over lapping; therefore precise frequency recovering is needed. However, in the mobile radio environment [4], the relative movement between transmitter and receiver causes Doppler frequency shifts, in addition the carriers can never be perfectly synchronized. However, one of the well known problems in the OFDM applied systems is its sensitivity to the frequency offset caused by the mismatch of local oscillators, Doppler frequency drift and sampling clock offset. Without the estimation and adjustment for the frequency offset in the received signal, the effect of inter carrier interference (ICI) will degrade the system performance. In the proposed schemes, different data allocation which is used to modulate one data symbol onto the next subcarrier with predefined weighting coefficients to mitigate the phase error. In the following section, the effect of inter carrier interference (ICI) in the OFDM systems is introduced.

2. OFDM System Description and ICI Problem

An OFDM system at least contains the function of parallel transmission, signal modulation and IFFT/FFT [1-2]. Fig. 1 illustrates the block diagram of the baseband, discrete-time FFT-based OFDM systems. Each parallel data is mapped with *M*-ary PSK scheme and, then, those data are modulated by an IFFT on N-parallel subcarriers. With a cyclic prefix [1-3], the complete OFDM symbol is transmitted over a discrete-time channel. At the receiver, the data are retrieved by a FFT and, then, demapped with corresponding scheme to obtain the estimated data.

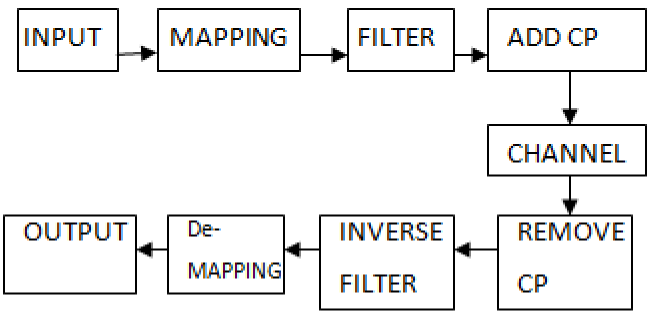


Figure 1: Block Daigram of OFDM

In OFDM systems, the transmitted signal in time domain could be expressed as

$$x(n) = \frac{1}{N}\sum_{l=0}^{N-1} X(l)e^{j2\pi ln/N}$$

where $x(n)$ denotes the nth sample of the OFDM transmitted signal, $X(l)$ denotes the modulated symbol within the lth subcarrier and N is the number of the subcarriers. Assuming the channel frequency offset normalized by the subcarrier frequency spacing denotes as ε and, then, the received signal in time domain could be written as $y(n) = [x(n) + w(n)]e^{j2\pi n\varepsilon/N}$

where $w(k)$ denotes an additive white Gaussian noise. Therefore, the corresponding frequency domain response can be obtained by FFT, which gives

$$Y(k) = X(k)S(0) + \sum_{\substack{i=0 \\ i=k}}^{N-1} X(l)S(1-k) + n(k)$$

The sequence $S(l\text{-}k)$ is defined as the ICI coefficient between lth and kth subcarriers, which can be expressed as

$$s(l-k) = \frac{\sin(\pi(l-k+\varepsilon))}{N\sin(\frac{\pi}{N}(l-k+\varepsilon))}\exp\left(j\pi\left(1-\frac{1}{N}\right)(l-k+\varepsilon)\right)$$

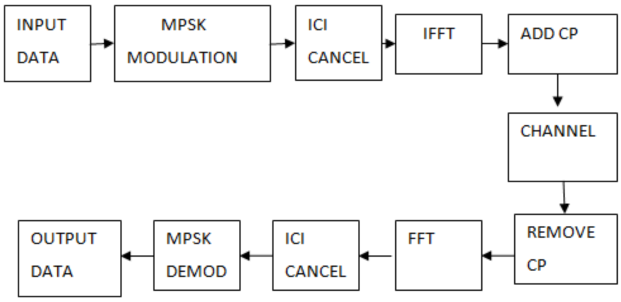
3. Extended Kalman Filtering to OFDM System

A state-space model of the discrete Kalman filter is defined as
$z(n)=a(n)\,d(n)+v(n)$

In this model, the observation $z(n)$ has a linear relationship with the desired value $d(n)$. By using the discrete Kalman filter, $d(n)$ can be recursively estimated based on the observation of $z(n)$ and the updated estimation in each recursion is optimum in the minimum mean square sense. Hence the normalized frequency offset$\mathcal{E}(n)$ can be estimated in a recursive procedure similar to the discrete Kalman filter. As linear approximation is involved in the derivation, the filter is called the extended Kalman filter(EKF). The derivation of the EKF is omitted in this report for the sake of brevity. The EKF provides a trajectory of estimation for$\mathcal{E}(n)$ .The error in each update decreases and the estimate becomes closer to the ideal value during iterations. However it has been proved that EKF is a very useful method of obtaining good estimates of the system state. Hence it has motivated us to explore the performance of EKF in ICI cancellation in an OFDM system. In the following estimation using the EKF, it is assumed that the channel is slowly time varying so that the time-variant channel impulse response can be approximated to be quasi-static transmission of one OFDM frame. Hence the frequency offset is considered to be constant during a frame. The preamble preceding each frame can thus be utilized as a training sequence for estimation of the frequency offset imposed on the symbols in this frame. Furthermore, in the estimation, channel is assumed to be flat-fading and ideal channel estimation is available at the receiver. Therefore in the derivation and simulation,one-tap equalization is temporarily suppressed.

4. ICI Cancellation

There are two stages in the EKF scheme to mitigate the ICI effect: the offset estimation scheme and the offset correction scheme. The main reason for ICI is the normalized frequency offset. So first we have to estimate using EKF algorithm and then we have to correct using offset model.



ICI cancellation is done using different techniques in OFDM. The cyclic prefix is used here by varying filtering purposes. This ICI reduction is done by kalman filtering ,self cancellation and without any cancellation of ICI. The existing approaches that have been developed to reduce ICI can be categorized as frequency-domain equalization, time –windowing and the ICI self cancellation scheme. It is seen that the difference of ICI coefficient between two consecutive sub carrier $S(l\text{-}k)$ and $S(l+1\text{-}k)$ is very small. Hence the idea of self-cancellation is generated. The main idea is to modulate one data symbol onto a group of sub carriers with predefined weighting coefficients. By doing so, the ICI signals generated within a group can be self-cancelled each other . Thus it is called self-cancellation method. Two ways of self-cancellation are data conversion and data conjugate.

5. Proposed Scheme

In this paper we compare both the techniques of extended kalman filter and self cancellation techniques for the reduction of ICI .And we also compare these techniques with the actual ICI reduction without any cancellation. Using Matlab software tool the output waveform are compare with their BER and CIR. In this paper we conclude that extended kalman filtering in OFDM is efficient than all other cancellation techniques.

6. Simulation Results

Using MATLAB software we obtain different simulation outputs using kalman filter for ICI reduction. Similarly without self cancellations by different techniques in the OFDM system are also obtained. Comparison for all these schemes are done here.

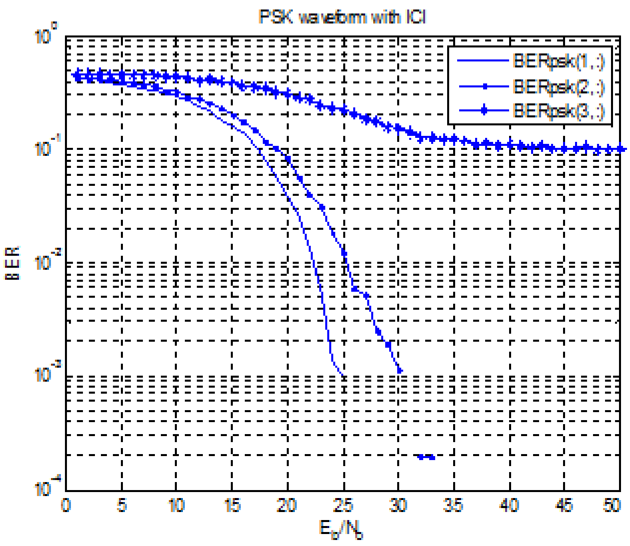


Figure: PSK waveform with ICI

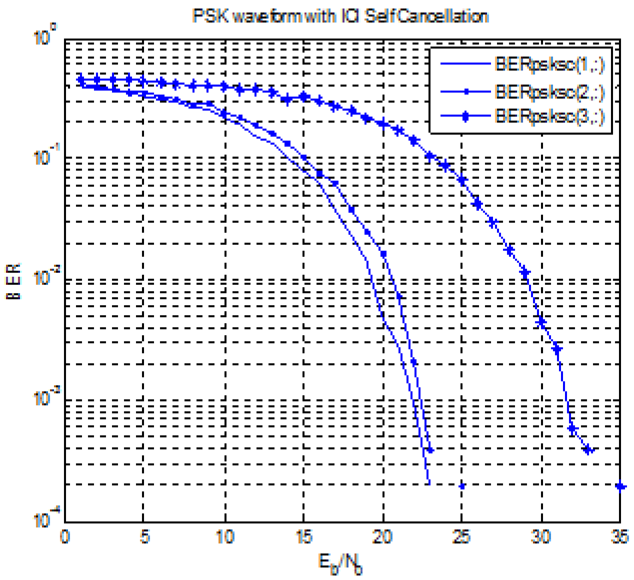


Figure: PSK waveform with ICI self Cancellation

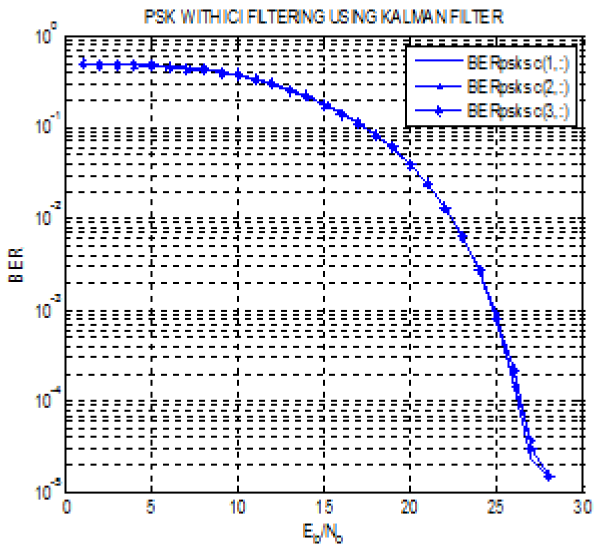


Figure: PSK with ICI filtering using Kalman Filter

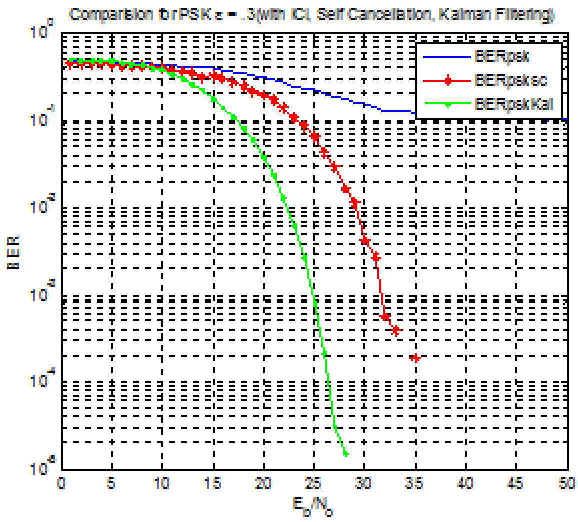


Figure: Comparison for PSK with different Schemes.

7. Conclusion

In this paper, the performance of OFDM systems in the presence of frequency offset between the transmitter and the receiver has been studied in terms of the Carrier-to-Interference ratio (CIR) and the bit error rate (BER) performance. Inter-carrier interference (ICI) which results from the frequency offset degrades the performance of the OFDM system. Two methods were explored in this project for mitigation of the ICI. The ICI self-cancellation (SC) scheme was proposed in previous publication. The extended Kalman filtering (EKF) method for estimation and cancellation of the frequency offset has been investigated in this project, and compared with basic OFDM and self cancellation. The choice of which method to employ depends on the specific application. For example, self cancellation does not require very complex hardware or software for implementation. However, it is not bandwidth efficient as there is a redundancy of 2 for each carrier. On the other hand, the EKF method does not reduce bandwidth efficiency as the frequency offset can be estimated from the preamble of the data sequence in each OFDM frame. However, it has the most complex implementation of the other methods. In addition, this method requires a training sequence to be sent before the data symbols for estimation of the frequency offset. The preambles are used as the training sequence for estimation of the frequency offset.

In this paper, the simulations were performed in an AWGN channel. This model can be easily adapted to a flat fading channel with perfect channel estimation. Further work can be done by performing simulations to investigate the performance of these ICI cancellation schemes in multipath fading channels without perfect channel information at the receiver. In this case, the multipath fading may hamper the performance of these ICI cancellation schemes. Kalman filtering is the efficient scheme in reduction of ICI. Other schemes are compared with all the other techniques and we conclude that ICI reduction is done well in kalman filter scheme.

References

[1] R.W. Chang, ”Synthesis of Band-Limited Orthogonal Signals for Multichannel Data Transmission”, Bell Syst. Tech. J., vol.45, pp. 1775-1796, Dec. 1966.
[2] B.R. Salzberg, “Performance of an efficient parallel data transmission system”, IEEE Transactions on Communications. Technol., vol. COM-15, pp. 805-813, Dec. 1967.
[3] S.B. Weinstein and P.M. Ebert, “Data transmission by frequency-division multiplexing using the discrete Fourier transform”, IEEE Trans. Communications. Technol., vol. COM-19, pp. 628-634, Oct. 1971.
[4] L. J. Cimini: "Analysis and Simulation of a Digital Mobile Channel Using Orthogonal Frequency Division Multiplexing." IEEE Trans. Comm. Vol. com-33, No. 7, July, 1985.
[5] R. Steele: "Mobile Radio Communications". Pentech Press. 1992, London.
[6] Y.Zhao and S.G.Haggman, “Inter carrier interference self cancellation scheme for OFDM mobile communication systems,” IEEE Trans. on Comm., vol. 49, pp. 1185-1191, July 2001.
[7] Y. Zhao, J.-D. Leclercq and S.-G. Haggman, “Inter carrier interference compression in OFDM communication systems by using correlative coding,” IEEE Commun. Lett., vol. 2, pp. 214–216, Aug. 1998.
[8] Y. Zhao and S.-G. Haggman, “Sensitivity to Doppler shift and carrier frequency errors in OFDM systems—the consequences and solutions,” in Proc. IEEE 46th Vehicular Technology Conf., Atlanta, GA, Apr. 28–May1, 1996, pp. 1564–1568.
[9] J. G. Proakis, Digital Communications, 2nd Ed. New York: McGraw-Hill, 1989.
[10] “A general coding method to minimize inter carrier interference in OFDM mobile communication systems,” in Proc. Int. Wireless and Telecommunications Symp./Exhibition (IWTS’97), vol. 1, Shah Alam, Malaysia, May 14–16, 1997, pp. 231–235.

Author Profile

Mr.M.Tejeswara Rao has obtained B.E degree from College of Engineering ,GITAM affiliated to ANDHRA UNIVERSITY . Now he is pursuing Master Degree in Department of Electronics & Communications, Vignan's institute of Information Technology, Visakhapatnam. He is interested in the fields of signal processing and wireless communication.

Mr. I. Krishna Rao obtained his B.Tech.degree from Sivaji University, in the year 1990. He obtained his M.Tech. degree from Rajasthan Deemed University, in the year 2007. He has 10 years experience in teaching. Presently working as a Professor in the department of ECE, VIIT, Visakhapatnam. He own 9 papers in various National and International conferences and journals.