International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622
NATIONAL CONFERENCE on Developments, Advances & Trends in Engineering Sciences
(NCDATES- 09th & 10th January 2015)

RESEARCH ARTICLE OPEN ACCESS

Optimization of Data Allocation in Of dm System

Mohammad Jabbirullah[1], Dr. A Srinivasula Reddy[2]
Department of Electronics & Communications Engineering[1,2]
CMR Engineering College,Kandlakoya(V),Medchal Road,Hyderabad-501401.

Abstract:
Orthogonal frequency division multiplexing (OFDM) systems in modern high data rate wireless communication is a very useful because of its multi carrier modulation technique. But one of the major disadvantages in OFDM systems is Intercarrier Interference (ICI) which may be cause for Doppler shift due to relative motion between transmitter and receiver local oscillator frequencies.ICI problem become more complicated when multipath fading is present which results in power leakage among subcarriers, degrading the overall system performance. In this paper an ICI self cancellation scheme is proposed for different frequency offset values. This also improves CIR performances without increase in system complexity. A sub optimal scheme utilizing sub optimal pair (λso, µso) is also proposed to completely eliminate requirement of CFO estimation. From the simulation results it is proved optimized data is allocated from the available resources in OFDM systems.

Key words: ICI self cancellation, OFDM, CIR, BER.

I. Introduction

Orthogonal Frequency Division Multiplexing (ODFM) systems are emerging schemes in the present wireless mobile communication system due to high spectral efficiency and robustness to multipath interference. It incorporates orthogonal sub carriers in the transmission system [1]. But OFDM system has two main disadvantages namely High peak to Average Power ratio and Intercarrier Interference (ICI). ICI mainly occurs due to frequency offset between transmitted and received signals, which may be caused by Doppler shift or by difference between transmitter and receiver local oscillator frequencies [2]. This frequency offset causes loss of orthogonality and then the signals transmitted on each carrier are not independent of each other.

This ICI can be reduced by decreasing the sensitivity of the OFDM systems towards the frequency offset errors. Many ICI self cancellation schemes have been proposed which use signal processing and frequency domain coding to reduce the amount of ICI generated as a result of frequency shifts with additional computational complexity. ICI self cancellation scheme proposed by Zhao [3] utilizes data allocation and combining pf (1,-1) on two adjacent subcarriers i.e same data is modulated at K^{th} and the subcarriers using (1-1) as data allocation are combined at receiver with weights 1 and -1. It is one of the most promising techniques to reduce ICI. But its performance at higher frequency offsets is degrading. Another technique called conjugate cancellation wa proposed by Yeh[4] in which OFDM symbol and its conjugate are multiplexed, transmitted and combined at the receiver to reduce the effect of ICI. A significant improvement in CIR at very low frequency offsets and its performance degrades as offset frequency value increases. Another method is Phase rotated conjugate cancellation [5] in which an optimal value is multiplied with OFDM symbol and its conjugate signal to be transmitted on different path. But it requires carrier frequency offset (CFO) estimation and feedback circuit which increases the system complexity.

Another scheme based on generalized data allocation (1, $\mu e^{j\theta}$) has been proposed in the literature [7] to improve CIR performance of ICI self cancellation system where µ is the optimal value and depends on the frequency offset. Therefore for every frequency offset a unique value of µ is to be multiplied with the data which again requires CFO estimation and feedback circuit. A symmetric symbol repeat ICI self cancellation scheme [6] was proposed by Sathanantham which utilizes data allocation and combining of (1,-1) at kth and N-1-kth subcarrier. It has better CIR performance and its performance in frequency selective fading channel found to be better than ICI self cancellation proposed previously.

In this paper, we have proposed an optimum data allocation scheme for SSR ICI cancellation scheme to improve the CIR performance. The scheme is based on SSR ICI self cancellation scheme, in which a data is modulated at two symmetrically placed subcarriers i.e. kth and N-1-

kth utilizes a data allocation of (1,λ) to improve CIR performance.To further reduce the effect of ICI, received modulated data signal at kth and N-1-kth subcarriers are combined with weights 1 and -μ. The λ and μ are the optimal values resulting in maximum CIR. The optimum values of λ and μ are the function of normalized frequency offset i.e. for every normalized frequency offset, there exist an unique value of λ and μ.This process requires continuous CFO estimation. To overcome this problem, we have proposed a suboptimal approach to find suboptimal values (λ*so*, μ*so*). The obtained sub-optimal values are independent of normalized frequency offset. Thus, the proposed scheme does not require any CFO estimation or feedback circuitry and hence eliminates the requirement of complex the hardware circuitry.

The demand for future higher data rate communications always provides the impetus for this research. It is obvious that a parallel system is capable of carrying more information than a cascade system, simply because it uses a variety of frequency bands. However, the significant advantage of OFDM is that it is robust in frequency-selective channels, which result from either multipath fadings or other communication interferences. In order to deal with frequency-selective fading's, the transmitted OFDM signals are divided into many sub-channels so that those sub-channels can be considered frequency- flat approximately as the number of the sub-channel *N* is large enough. Hence the OFDM signals will suffer channel distortion less than the conventional modulated signals.

The rest of the paper is organized as follows. Section II describes the OFDM system Section III describes AWPN channel Section IV describes ICI self cancellation scheme. Section V describes the proposed scheme including the method to calculate sub-optimal values. Simulation results are presented in Section VI and we conclude in Section VII.

II. Ofdm System

Orthogonal Frequency Division Multiplexing (OFDM) is a special form of multi carrier modulation technique which is used to generate waveforms that are mutually orthogonal. In an OFDM scheme, a large number of orthogonal, overlapping, narrow band sub-carriers are transmitted in parallel. These carriers divide the available transmission bandwidth. The separation of the sub-carriers is such that there is a very compact spectral utilization. With OFDM, it is possible to have overlapping sub channels in the frequency domain, thus increasing the transmission rate. In order to avoid a large number of modulators and filters at the transmitter and complementary filters and demodulators at the receiver, it is desirable to be able to use modern digital signal processing techniques, such as fast Fourier transform (FFT). The major advantages of OFDM are its ability to convert a frequency selective fading channel into several nearly flat fading channels and high spectral efficiency. However, one of the main disadvantages of OFDM is its sensitivity against carrier frequency offset which causes attenuation and rotation of subcarriers, and intercarrier interference (ICI). Figure 2.1 shows the block diagram of a typical OFDM transceiver. The transmitter section converts digital data to be transmitted, into a mapping of subcarrier amplitude and phase. It then transforms this spectral representation of the data into the time domain using an Inverse Discrete Fourier Transform (IDFT). The Inverse Fast Fourier Transform (IFFT) performs the same operations as an IDFT, except that it is much more computationally efficiency, and so is used in all practical systems. In order to transmit the OFDM signal the calculated time domain signal is then mixed up to the required frequency. The receiver performs the reverse operation of the transmitter, mixing the RF signal to base band for processing, then using a Fast Fourier Transform (FFT) to analyze the signal in the frequency domain. The amplitude and phase of the subcarriers is then picked out and converted back to digital data. The IFFT and the FFT are complementary function and the most appropriate term depends on whether the signal is being received or generated. In cases where the signal is independent of this distinction then the term FFT and IFFT is used interchangeably. The high data rate serial input bit stream is fed into serial to parallel converter to get low data rate output parallel bit stream. Input bit stream is taken as binary data. The low data rate parallel bit stream is modulated in

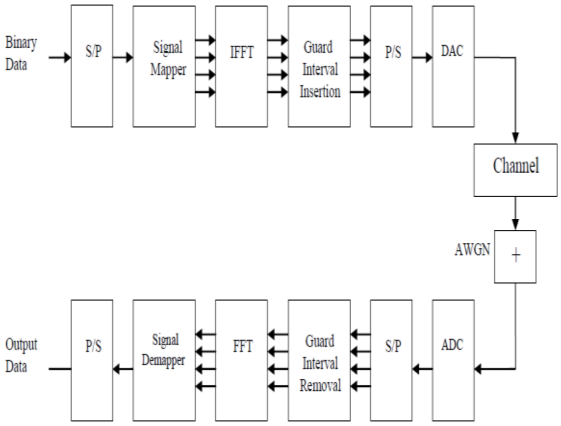

Fig: 1 OFDM SYSTEM

Signal Mapper. Modulation can be BPSK, QPSK,QAM etc. The modulated data are served as input to inverse fast Fourier transform so that each subcarrier is assigned with a specific frequency. The frequencies selected are orthogonal frequencies. In this block, orthogonality in subcarriers is introduced. In IFFT, the frequency domain OFDM symbols are converted into time domain OFDM symbols. Guard interval is introduced in each OFDM symbol to eliminate inter symbol interference (ISI). All the OFDM symbols are taken as input to parallel to serial data. These OFDM symbols constitute a frame. A number of frames can be regarded as one OFDM signal. This OFDM signal is allowed to pass through digital to analog converter (DAC). In DAC the OFDM signal is fed to RF power amplifier for transmission. Then the signal is allowed to pass through additive white Gaussian noise channel (AWGN channel). At the receiver part, the received OFDM signal is fed to analog to digital converter (ADC) and is taken as input to serial to parallel converter. In these parallel OFDM symbols, Guard interval is removed and it is allowed to pass through Fast Fourier transform. Here the time domain OFDM symbols are converted into frequency domain. After this it is fed into Signal Demapper for demodulation purpose. And finally the low data rate parallel bit stream is converted into high data rate serial bit stream which is in form of binary.

The discrete time OFDM symbol at the transmitter can be expressed as

$$x[n] = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X(k)\, e^{j2\pi nk/N}, n = 0,1,2,\dots, N-1 \qquad (1)$$

where N is total numbers of subcarriers and X(k) denotes the modulated data symbol transmitted on kth subcarrier. Due to AWGN channel and frequency offset, the received OFDM signal can be written as

$$y[n] = x[n]e^{j\frac{2\pi\varepsilon n}{N}} + w[n], \quad n = 0,1,2,\dots, N-1 \qquad (2)$$

where ε is the normalized frequency offset and w[n] is the sample of additive white Gaussian noise. The received data signal on kth subcarrier can be written as

$$Y(k) = X(k)S(0) + \sum_{l=0, l\neq k}^{N-1} X(l)S(l-k) + W(k), \quad k = 0,1,\dots,N-1 \qquad (3)$$

Where $W(k)$ is the *k th* sample of DFT of additive noise. The sequence $S(l-k)$ is defined as the ICI coefficient between *k th* and *lth* subcarriers, which can be expressed as

$$S(l-k) = e^{\left(j\pi(l+\varepsilon-k)\left(1-\frac{1}{N}\right)\right)} \frac{\sin(\pi(l+\varepsilon-k))}{N\sin\left(\frac{\pi}{N}(l+\varepsilon-k)\right)} \qquad (4)$$

The CIR at the *k th* subcarrier can be written as

$$CIR_o = \frac{|S(k)|^2}{\sum_{l=0, l\neq k}^{N-1} |S(l-k)|^2} \qquad (5)$$

III. Awpn Channel

Noise exists in all communications systems operating over an analog physical channel, such as radio. The main sources are thermal background noise, and electrical noise in the receiver amplifiers, and inter-cellular interference. In addition to this noise can also be generated internally to the communications system as a result of Inter-Symbol Interference (ISI), Inter-Carrier Interference (ICI), and Inter- Modulation Distortion (IMD). These sources of noise decrease the Signal to Noise Ratio (SNR), ultimately limiting the spectral efficiency of the system. Noise, in all its forms, is the main detrimental effect in most radio communication systems. It is therefore important to study the effects of noise on the communications error rate and some of the tradeoffs that exists between the level of noise and system spectral efficiency. Most types of noise present in radio communication systems can be modeled accurately using Additive White Gaussian Noise (AWGN). This noise has a uniform spectral density (making it white), and a Gaussian distribution in amplitude (this is also referred to as a normal distribution). Thermal and electrical noise from amplification, primarily have white Gaussian noise properties, allowing them to be modeled accurately with AWGN. OFDM signals have a flat spectral density and a Gaussian amplitude distribution provided that the number of carriers is large (greater than about 20 subcarriers), because of this the inter-cellular interference from other OFDM systems have AWGN properties. For the same reason ICI, ISI, and IMD also have AWGN properties for OFDM signals. In the study of communication systems, the classical (ideal) additive white Gaussian noise (AWGN) channel, with statistically independent Gaussian noise samples corrupting data samples free of inter symbol interference (ISI), is the usual starting point for understanding basic performance relationships. An AWGN channel adds white Gaussian noise to the signal that passes through it.

IV. Ici Self Cancellation Scheme.

In ICI self cancellation scheme [6], the data symbol to be transmitted at the k *th* subcarrier is repeated at *N*-1-*kth* the subcarrier with opposite polarity, i.e.

$$X(N-1) = -X(0), \ldots, X(N-1-k) = -X(k) \qquad (6)$$

The block diagram of the proposed ICI self cancellation scheme is depicted in Fig. 2. The received data signal at the *k th* subcarrier is thus given by

$$Y'(k) = \sum_{l=0}^{\frac{N}{2}-1} X(l)S((l-k) - S(N-1-l-k)) + W(k) \qquad (7)$$

Combining the received data at k th and N-1-kth subcarriers,we have

$$Y''(k) = Y'(k) - Y'(N-1-k) \qquad (8)$$

Using (7) and (8)

$$Y''(k) = \sum_{l=0}^{\frac{N}{2}-1} X(l)[S(l-k) - S(N-1-l-k) - S(l+k+1-N) + S(k-l) + W(k)$$

$$-W(N-1-k) \qquad ; \qquad k = 0,1,2,\ldots,\frac{N}{2}-1 \qquad (9)$$

Thus, CIR of conventional SSR ICI self cancellation scheme can be written as

$$CIR_c = \frac{|-S(-N-1-2k) + 2S(0) - S(1-N+2k)|^2}{\sum_{l=0, l\neq k}^{\frac{N}{2}-1} |-S(l-k) - S(N-1-l-k) - S(l+k+1-N) + S(k-l)|^2} \qquad (10)$$

V. Proposed Scheme

In the proposed scheme at the transmitter a data allocation (1,λ) is utilized at *kth* and *N*-1-*kth* subcarriers .i.e.

$$X(N-1) = -\lambda X(0), X(N-2) = -\lambda X(1), \ldots, X(N-1-k) = -\lambda X(k) \qquad (11)$$

Hence, the received data signal at the *k th* subcarrier is

$$Y'(k) = \sum_{l=0}^{\frac{N}{2}-1} X(l)S((l-k) - \lambda S(N-1-l-k)) + W(k) \qquad (12)$$

After Combining the received data at *k th* and *N* -1-*kth*, subcarriers with weight 1 and –μ we have

$$Y''(k) = Y'(k) - \mu Y'(N-1-k) \qquad (13)$$

$$Y''(k) = \sum_{l=0}^{\frac{N}{2}-1} X(l)[S(l-k) - \lambda S(N-1-l-k) - \mu S(l+k+1-N)$$

$$+\mu\lambda S(k-l)] + W(k) - \mu W(N-1-k) \quad k = 0,1,\ldots,\frac{N}{2}-1 \qquad (14)$$

Thus, CIR of proposed optimal SSR ICI self cancellation scheme is given by

$$CIR_p = \frac{|-\mu S(2k+1-N) + (1+\lambda\mu)S(0) - \lambda S(N-1-2k)|^2}{\sum_{l=0,,l\neq k}^{\frac{N}{2}-1} |-\mu S(l-N+k+1) + S(l-k) - \lambda S(N-1-l-k) + \mu\lambda S(l-k)|^2} \qquad (15)$$

The optimal values of λ and μ have been found by using an optimization technique known as Nelder Mead Simplex Algorithm [8].

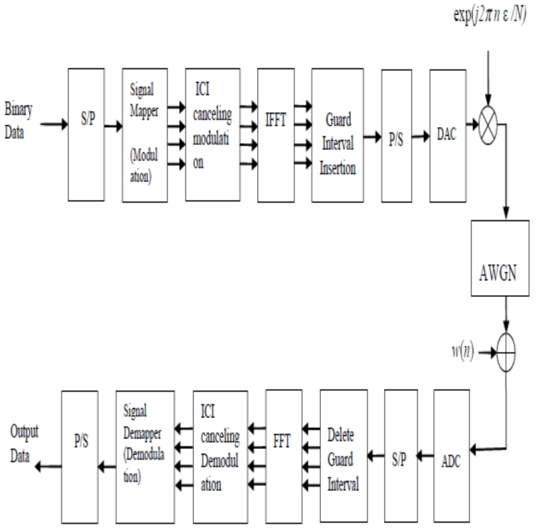

Fig: 2 ICI Self Cancellation Scheme

The optimum values of λ and μ are calculated for ε Є [0.03,0.25] at a very small interval of ε, which results in maximum CIR for the given ε. Thus for every ε , we have a unique optimal value λ and μ and these are denoted by (λ*o* , μ*o*). The optimum values (λ*o* , μ*o*) are to be used for data allocation and combining the data at *kth* and *N*-1-*kth* subcarriers to maximize the CIR of the OFDM system. But, this will require a continuous CFO estimation.

For each pair of (λ*o* , μ*o*) , the CIR has been calculated, which forms a CIR matrix as shown

$$CIR_p(\varepsilon,\lambda_o,\mu_o) = \begin{bmatrix} CIR_p(\varepsilon_1,\lambda_{o1},\mu_{o1}) & \cdots & \cdots & CIR_p(\varepsilon_v,\lambda_{o1},\mu_{o1}) \\ \vdots & \ddots & & \vdots \\ \vdots & & \ddots & \vdots \\ \vdots & & \ddots & \vdots \\ CIR_p(\varepsilon_1,\lambda_{ov},\mu_{ov}) & \cdots & \cdots & CIR_p(\varepsilon_v,\lambda_{ov},\mu_{ov}) \end{bmatrix} \qquad (16)$$

Here, *CIRp* (ε1,λ*o*1,μ *o*1) corresponds to maximum value of CIR for ε1 , and *CIRp* (ε2 ,λ*o*2 ,μ*o*2) corresponds to maximum CIR for ε1 and so on and

$$v = \frac{(\varepsilon_H - \varepsilon_L)}{\Delta\varepsilon} + 1 \qquad (17)$$

where, ε *H* and ε *L* are the lowest and the highest possible values of the normalized frequency offset.

Here, we have considered ε*H* =0.25 and ε*L* = 0.03. To avoid the problem of continuous ε estimation, sub-optimal (λ*so* , µ*so*) amongst all (λ*o* , µ*o*) has been found by using the following criterion as

$$(\lambda_{so},\mu_{so}) = \max_{\lambda_o,\mu_o}\left[p - \frac{\sum_{j=1}^{p}(p - CIR(\varepsilon_j,\lambda_o,\mu_o))}{v} \right] \qquad (18)$$

In the above expression, *p* represents the maximum CIR of a particular row of the matrix given by (14) and the second term represents the mean deviation of the CIR of that row from the peak (*p*) of that row. Thus irrespective of the value of ε, (λ*so* , µ*so*) can be used for data allocation and combining to get a sub-optimal CIR performance.

In the proposed scheme, Δε is taken as 0.25 and thus V = 8. Applying the above described algorithms, optimal values are λ*o* =1.926and µ*o* =.0151.sub-optimal values are λ*so* =0.6164 and µ*so* =1.0351. This optimization and sub-optimization technique can be applied for any range as required.

VI. Simulation Results

In this paper, we have considered an OFDM system with *N*= 64 subcarriers and QPSK modulation scheme is used to modulate each of the subcarriers. The simulation model of the OFDM system is shown in Fig.2. The computer simulation using MATLAB are performed to evaluate CIR and BER performance. Fig. 3 shows the CIR performance of standard OFDM system, SSR ICI self-cancellation [6], Proposed SSR ICI self cancellation using optimal & sub-optimal approach. Fig. 4 shows BER performance of the standard OFDM system, conventional SSR ICI self cancellation and the proposed SSR ICI self cancellation using sub-optimal approach.

As seen from Fig. 3 the CIR performance of the proposed optimal approach is about30dB better than the conventional SSR ICI self cancellation scheme. However, the proposed sub-optimal approach also provides better CIR scheme performance over conventional SSR ICI self cancellation scheme, proposed suboptimal approach provides a gain of more than 12dB at ε=0.15 over conventional SSR ICI self cancellation scheme.

The CIR performance of proposed SSR ICI self cancellation scheme is slightly worse than conventional SSR ICI self cancellation scheme for ε Є [0.03,0.08] . The BER performance of the proposed SSR ICI self cancellation scheme is very much improved in comparison to standard OFDM system and very close to conventional SSR ICI self cancellation scheme. Figure 5 represents phase representation at which the data is transmitted. Figure 6 represents modulated data w.r.t quadrature and in phase after final transmission of data.

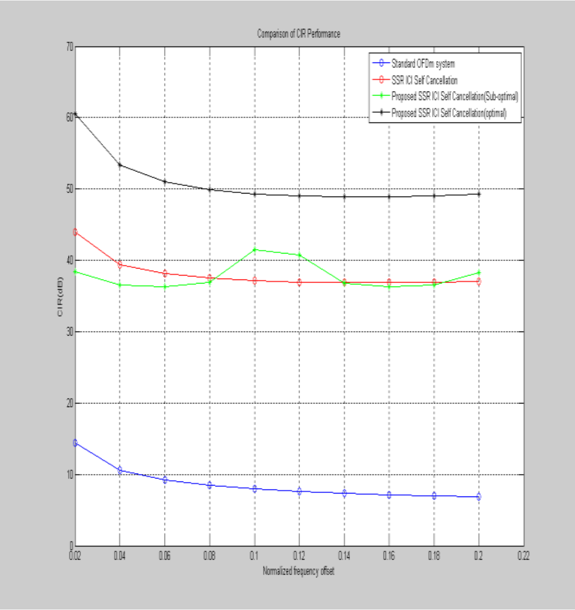

Fig 3: CIR performance comparison of various ICI self cancellation scheme

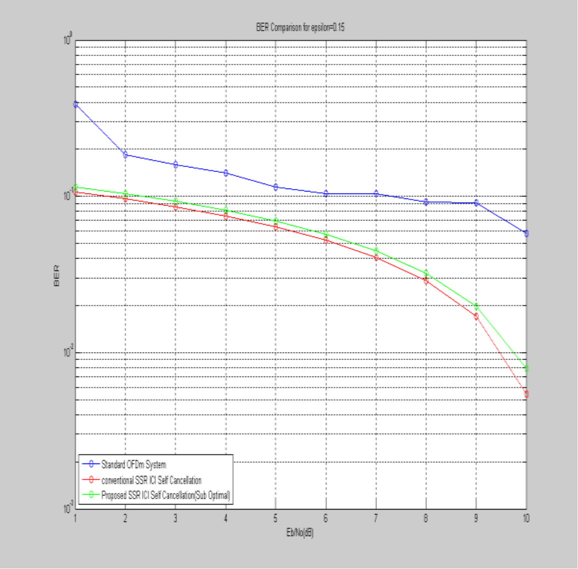

Fig 4: BER Performance Comparison

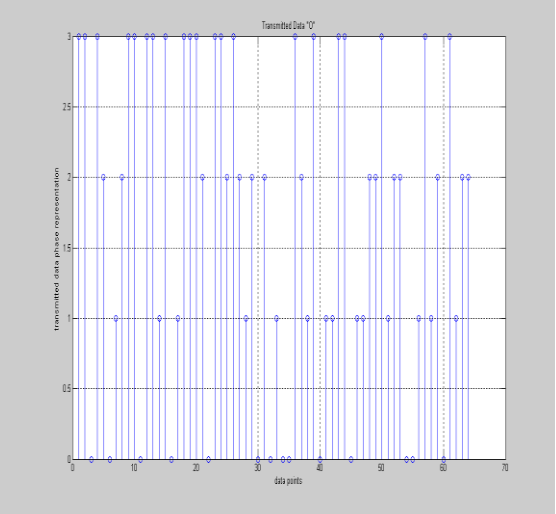

Fig 5: Phase Representation Of Data Transmitted

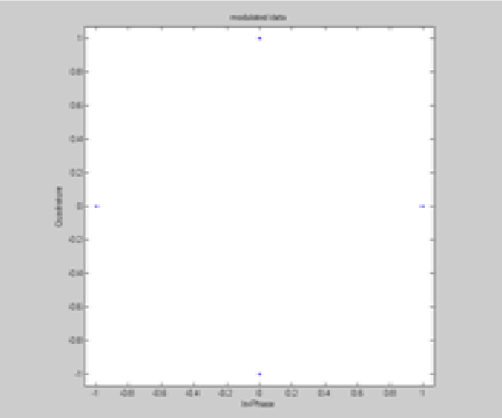

Fig 6: Final Modulated Data

VII. Conclusion

One of the main disadvantages of OFDM is its sensitivity against carrier frequency offset which causes attenuation and rotation of subcarriers, and inter carrier interference (ICI). So, ICI mitigation techniques are essential in improving the performance of an OFDM system in an environment which induces frequency offset error in the transmitted signal. This work investigates an ICI self-cancellation scheme for combating the impact of ICI on OFDM systems for different frequency offset values. Different modulation techniques are considered for ICI reduction and compared with each other for their performances. It is also suitable for multipath fading channels. It is less complex and effective. The proposed scheme provides significant CIR improvement, which has been studied theoretically and by simulations. Under the condition of the same bandwidth efficiency and larger frequency offsets, the proposed OFDM system using the ICI self-cancellation scheme performs much better than standard OFDM systems. In addition, since no channel equalization is needed for reducing ICI, the proposed scheme is therefore easy to implement without increasing system complexity.

Although the bandwidth efficiency of the scheme is reduced by half due to the redundant symbols, it can be solved by increasing the number of subcarriers or using larger signal alphabet size and it is less complex as compared to the other frequency offset estimation and correction schemes. For increased accuracy wavelets can also be used for ICI analysis and reduction.

REFERENCES

[1] Y.Wu and W. Y. Zou, “Orthogonal frequency division multiplexing: A multicarrier modualtion scheme”, IEEE Transaction on Consumer Electronics, vol. 41, no. 3,pp 392-399, Aug. 1995.

[2] P.H.Moose, “ A Technique for orthogonal frequency division multiple - xing frequency offset correction,’’IEEE Trans. Commun., vol.42, pp 2908-2914, Oct. 1994.

[3] Y. Zhao and S.G. Haggman, “Intercarrier Interference Self-Cancellation Scheme for OFDM Mobile Communication Systems’’,IEEE Trans.Commun., vol. 49, no. 7, pp. 1185-1191, Jul. 2001.

[4] H.-G. Yeh, Y.-K. Chang, and B. Hassibi, “A scheme for cancelling intercarrier interference using conjugate transmission in multicarrier communication systems," IEEE Trans. Wireless Communication., vol. 6, no. 1, pp. 3-7, Jan. 2007.

[5] Chin-Liang Wang and Yu-Chih Huang, “Intercarrier Interference Cancellation Using General Phase Rotated Conjugate Transmission for OFDM Systems” IEEE Transactions on communications, vol. 58, no. 3, pp. 812-819, March 2010.

[6] K.Sathanantham , R.M.A.P.Rajatheva and Slimane Ben Slimane “Analysis of OFDM in the Presence of Frequency Offset and a Method to Reduce Performane Degradation” Global Telecommunications Conference, 2000. GLOBECOM '00. IEEE,vol. 1,pp. 72-76, 2000.

[7] Yu Fu and Chi Chung Ko, “A New ICI Self –Cancellation Scheme for OFDM Systems based on a Generalized Signal Mapper”, 5th International Symposium on Wireless Personal Multimedia Communications, vol. 3, pp. 995-999, Oct. 2002.

[8] J. H. Mathews, K. K. Fink, Numerical Methods using Matlab, 4th edition, Prentice-Hall Inc. , 2004.
[9] Ochiai, H. and Imai, H.; “MDPSK-OFDM with highly power-efficient block codes for frequency-selective fading channels” Vehicular Technology, IEEE Transactions on, vol. 49 Issue: 1, pp. 74 –82, Jan. 2000
[10] Cimini, L.J., Jr. and Sollenberger, N.R.; “Peak-to-average power ratio reduction of an OFDM signal using partial transmit sequences”, IEEE Communications Letters, vol. 4, Issue: 3, pp. 86 –88. Mar. 2000
[11] Breiling, H.; Muller-Weinfurtner, S.H.; Huber, J.B.; “SLM peak-power reduction without explicit side information”, IEEE Communications Letters, vol. 5 Issue: 6, pp. 239 –241, Jun.2001
[12] Ochiai, H. and Imai, H.; “Performance of the deliberate clipping with adaptive symbol selection for strictly band-limited OFDM systems ”, Selected Areas in Communications, IEEE Journal on, vol. 18, Issue: 11, pp. 2270 –2277, Nov 2000
[13] Nikookar, H. and Lidsheim, K.S.; “Random phase updating algorithm for OFDM transmission with low PAPR”, Broadcasting, IEEE Transactions on, vol. 48 Issue: 2, pp. 123 –128, Jun. 2002.
[14] Heung-Gyoon Ryu and Kyoung-Jae Youn; “A new PAPR reduction scheme: SPW (subblock phase weighting)” Consumer Electronics, IEEE Transactions on, vol. 48 Issue: 1, pp. 81 – 89, Feb 2002.