

Orthogonal Frequency Division Multiplexing ICI Cancellation Technique

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ABSTRACT: The Orthogonal Frequency Division Multiplexing (OFDM) is the multicarrier technique which uses high data rate. A signal is divided into several orthogonal sub-carriers and these signals are orthogonal to each other. This results in inter-carrier interference (ICI) at the receiver end. To mitigate the ICI, different methods are introduced in the recent years like self-cancellation (SC), frequency-domain Equalization, etc. Here the parallel cancellation (PC) scheme is used to mitigate the ICI of Orthogonal Frequency Division Multiplexing systems.

KEYWORDS: Orthogonal Frequency Division Multiplexing (OFDM), Inter Carrier Interference (ICI), self-cancellation (SC), frequency-domain Equalization, parallel cancellation (PC).

I. INTRODUCTION

In the bandwidth efficient modulation technology and high data rate wireless applications orthogonal Frequency Division Multiplexing (OFDM) has become a key scheme, also known as multicarrier modulation (MCM) [1]. Multiplexing the Orthogonal Frequency Division (OFDM) is a special type of multi carrier modulation technique that is used to produce mutually orthogonal waveforms. A great number of orthogonal, overlapping, narrow-band sub-carriers are distributed in parallel in an OFDM system.

In order to do this the carriers must be mathematically orthogonal. Two signals are orthogonal if their dot product is zero. That is, if we take two signals multiply them together and if their integral over an interval is zero, then two signals are orthogonal in that interval. Since the carriers are all sine/cosine wave, we know that area under one period of a sine or a cosine wave is zero. This paper is organized as follows. Section 2 provides the literature survey on OFDM system developed in the recent year. Section 3 briefs the PC scheme. Section 4 shows the Simulation result. Section 5 presents conclusion.

II. LITERATURE SURVEY

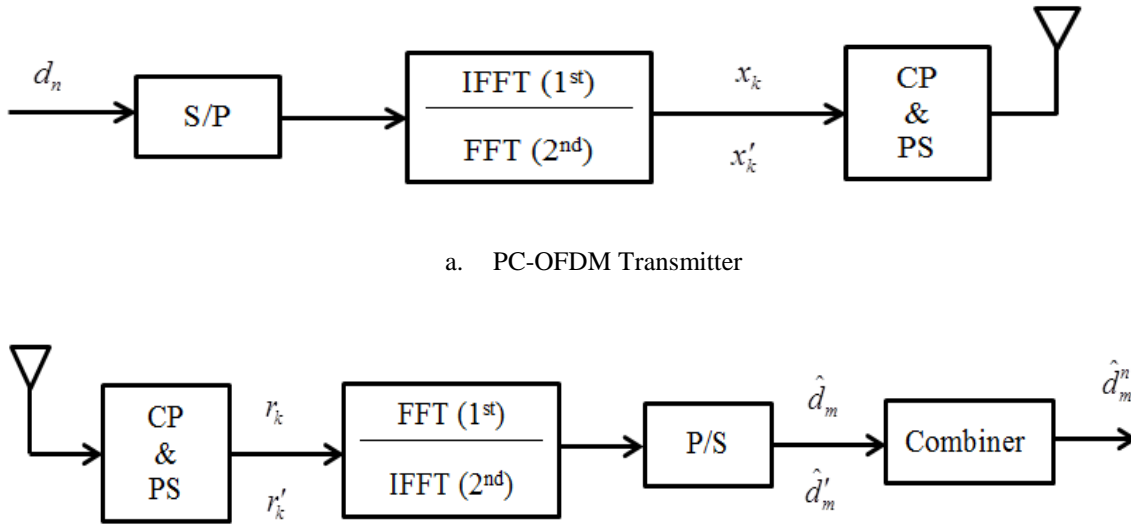
N. Sreekanth and Dr M. N. Giri Prasad [2] present the performance of OFDM systems in the presence of frequency offset between the transmitter and the receiver. Here they studied in terms of the Carrier-to-Interference ratio (CIR), which results from the frequency offset. This frequency offset degrades the overall performance of the OFDM system. This paper presents an ICI self-cancellation scheme for combating the impact of ICI on OFDM systems for different frequency offset values and different modulation techniques are used and compared with each other for ICI reduction.

Amandeep Kaur and Garima Saini [3] proposed zero-padded conjugate transmission with adaptive receiver to cancel out the effect of ICI. This proposed system is analysed in terms of BER for BPSK, QPSK and 16-QAM modulation schemes. After the simulation result it is found that the performance of proposed scheme is BER better than CC, PRCC and standard OFDM. Silky Pareyani and Prabhat Patel [4] propose a new ICI self-cancellation scheme. This proposed scheme gives better BER performance than the ASR and SCSR self-cancellation schemes in AWGN channel in the simulation result. In this system data transmitted over four different subcarriers which affect the efficiency of bandwidth, hence the OFDM system using the proposed ICI self-cancellation scheme performs much better than the standard OFDM system.

Pello Ochandiano et al. [5] present a novel FG-based detector for wireless mobile OFDM systems. This system enables exploitation of the frequency diversity available in the received signal affected by ICI. This signal detection system allows high speed joint detection and decoding providing excellent performance at high mobility scenarios. This proposed system analysed over a TU6 channel model using LDPC codes. When the proposed FG detector was compared to the traditional BCJR receiver, the proposed is better suited to large FFT sizes.

III. PC-OFDM SCHEME

Figure 1 shows the proposed PC-OFDM scheme, this system is contains two parts; a. PC-OFDM Transmitter (a regular OFDMsystem with an IFFT processing) and PC-OFDM receiver (with an FFTprocessing).



a. PC-OFDM Transmitter

b. PC-OFDM Receiver
Figure 1 PC-OFDM Scheme

a. PC-OFDM Transmitter [1]

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 Signal Mapper. In IFFT, the frequency domain OFDM symbols are converted into time domain OFDM symbols. After this, Guard interval is inserted in each OFDM symbol to eliminate inter symbol interference (ISI). All the OFDM symbols are taken as input to parallel to serial block. 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. At the transmitter, the lower branch requires a FFT operation as defined

$$x_k = \sum_{n=0}^{N-1} d_n e^{-j\frac{2\pi}{N}kn} \quad k=0,1,2,3,\dots,N-1$$

b. PC-OFDM Receiver[1]

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. ICI cancelling demodulation is performed on these OFDM symbols. At the receiver, the lower branch requires an IFFT as follows.

$$\hat{d}'_m = \frac{1}{N} \sum_{k=0}^{N-1} r'_k e^{j\frac{2\pi mk}{N}}$$

$$\hat{d}'_m = \frac{1}{N} \sum_{n=0}^{N-1} \sum_{k=0}^{N-1} d_n H'_n e^{j\frac{2\pi(-n+\epsilon)k}{N}} e^{j\frac{2\pi mk}{N}}$$

$$\hat{d}'_m = H'_m v_0 d_m + \sum_{n=0, n \neq m}^{N-1} H'_n v_{n-m} d_n \quad m=0,1,2,\dots$$



Where,

$$v_{n-m} = \frac{e^{j\pi \frac{N-1}{N}(m-n+\varepsilon)} \sin[\pi(m-n+\varepsilon)]}{N \sin[(\pi/N)(m-n+\varepsilon)]} \Big|_{(n-m) \bmod N}$$

Note r_k represents the 2nd received signal, and \hat{d}_m is the output of the IFFT.

III. SIMULATION RESULT

SF-, SFPC-OFDM systems are all two-branch systems. It is assumed that the channel responses, h_1 and h_2 , are known at the receiver and remain constant for two adjacent subcarriers. The maximum Doppler spread, f_D , to subcarrier frequency spacing ratio.

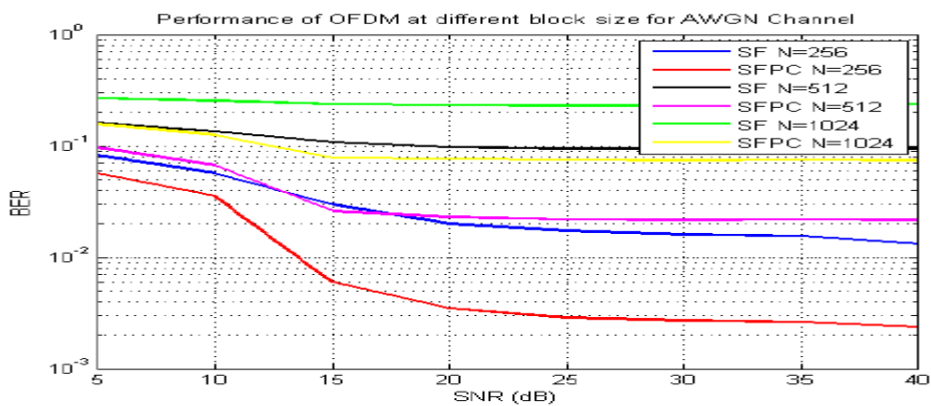


Figure 2 The BER comparison of SF- and SFPC- OFDM system with different Block sizes, constant Doppler frequency

Table 1 Results of ICI mitigation at different block size

SR.NO	Technique	Block size		
		256	512	1024
1	SF min	0.014857	0.086363	0.020349
2	SF max	0.15102	0.22178	0.32347
3	SFPC min	0.0023395	0.018566	0.067082
4	SFPC max	0.16243	0.23869	0.32345

is chosen as 0.0244 ($f_D = 50$ Hz) and 0.0488 ($f_D = 100$ Hz) in SUI channel parameters with a fixed OFDM block size $N = 512$. In Figure 3, the BER of the SFPC scheme outperforms that of the PC and SF schemes, while the BER of the SF scheme is better than that of the PC scheme. The lower f_D , the better BER performance of all.

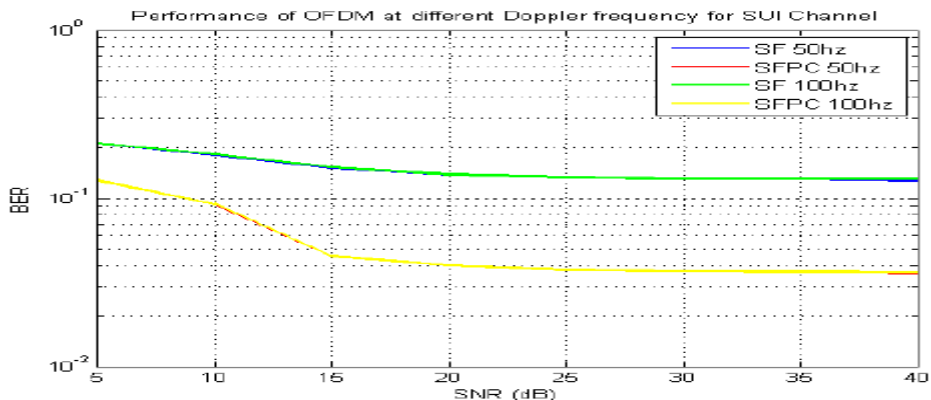


Figure 3 BER comparison of SF- and SFPC- OFDM schemes for different Doppler Shift



The Table 2 and Table 3 shows the result, the minimum value for SF-OFDM ranges from 0.012863 (f=50HZ) to 0.12755 (f=100Hz) and maximum value ranges from 0.27345 (f=50HZ) to 0.28762 (f=100Hz). The minimum value for SFPC-OFDM ranges from 0.03475 (f=50HZ) to 0.03475 (f=100Hz) and maximum value ranges from 0.287343 (f=50HZ) to 0.27765 (f=100Hz). The result is calculated on the basis of 5 iterations.

Table 2 Observation table for SF- and SFPC-OFDM with SUI channel

Sr. no.	PARAMETERS	SPECIFICATION
1	Iterations	100
2	Block size	512
3	Doppler frequency	50 and 100
4	Time spread	1
5	No. of multipath	12

• BER v/s SNR Observation at Different Block Size for SUI Channel

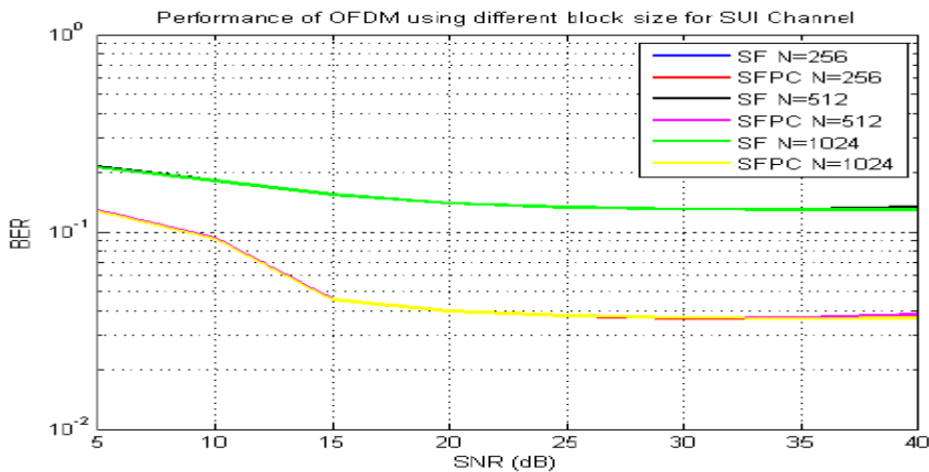


Figure 4 BER comparison of SF- and SFPC- OFDM schemes for different Block sizes in SUI channel

The results are shown in Figure 4 SF- and SFPC- OFDM method have been tested using simulations on the basis of their bit error rate (BER). In order to investigate the performances of OFDM an accurate channel model needs to be considered. Usually all the wireless channels are characterized by path loss (including shadowing), multipath delay spread, fading characteristics, Doppler spread, and co-channel and adjacent channel interference. Ricean distribution can be used for characterization of narrow band received signal fading. In this distribution the key parameter is the K-factor, which is defined as the ratio of the fixed component power and the scatter component power.

Figure 4 shows the average BER comparison with the maximum Doppler frequency f_D , equal to 100 Hz. Both the SF and SFPC schemes are compared with three different OFDM block size, N=256, 512, and 1024. Table 4 and Table 5 shows the parameter and results for the BER for different block size at constant frequency 100 hz. They are known or estimated accurately at the receiver, and the corresponding complex channel gain remains constant between adjacent subcarriers in one OFDM symbol. The Table 5 shows the result, the minimum value for SF-OFDM ranges from 0.12939 (N=256) to 0.27595 (N=1024) and maximum value ranges from 0.27664 (N=256) to 0.32347 (N=1024).

The minimum value for SFPC-OFDM ranges from 0.03632 (N=256) to 0.036145 (N=1024) and maximum value ranges from 0.27664 (N=256) to 0.27601 (N=1024). The result is calculated on the basis of 5 iterations.

Table 3 Results of SUI channel at different Doppler Frequencies

SR.NO	Technique	Doppler frequency	
		50	100
1	SF min	0.012863	0.12755
2	SF max	0.27345	0.28762
3	SFPC min	0.03475	0.036045
4	SFPC max	0.287343	0.27765



Table 4 Table for SF- and SFPC-OFDM

SR. NO.	Parameters	Specification
1	Iterations	100
2	Doppler frequency	100
3	Time spread	1
4	No. of multipath	12

Table 5 Results of SUI Channel at different block size

SR.NO	Technique	Block size		
		256	512	1024
1	SF min	0.12939	0.12889	0.12861
2	SF max	0.27664	0.27588	0.27595
3	SFPC min	0.03632	0.036204	0.036145
4	SFPC max	0.27664	0.2757	0.27601

IV. CONCLUSION

By keeping useful properties of both the SF (robust to OFDM symbol size) and PC (ICI cancellation) schemes, the SFPC outperforms regular SF-OFDM and PC-OFDM systems in mobile channels without increasing system complexity. This SFPC-OFDM has a significantly lower error or due to the ICI parallel cancelling scheme in both slow and fast frequency selective fading channels. Since this SFPC is very simple, it may serve as the enhanced function with almost no additional cost in hardware and software when it is combined with other channel coding scheme to mitigate ICI and improve BER performance in mobile channels with residual frequency offset, timing offset, or Doppler velocity.

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