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Performance Comparison of OFDM System with Different Modulation Schemes Using ISP Pulse Shaping Technique

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ABSTRACT: Amazing advancement has been built up in wireless communication system because of achievement of OFDM system. In spite it's many favorable advantages, performance of OFDM system is ruined because of the CFO (Carrier recurrence offset).Doppler shift and frequency mismatch are responsibility of presenting CFO which is overwhelm the orthogonally between the subcarriers and generate ICI. In this paper evolution of CFO-OFDM system using ISP is assessed with different modulation schemes (BPSK, QPSK, 8-PSK, 16-PSK) in term of BER. A result acquired by simulation demonstrates that CFO-OFDM using ISP with BPSK gives better performance compared to other modulation scheme. MATLAB software has been used for simulation result.

KEYWORDS: Carrier Frequency Offset Orthogonal Frequency Division Multiplexing (CFO-OFDM), Improved Sinc Power pulse (ISP), Inter Carrier Interferences (ICI), Signal to Noise Ratio (SNR), Bit Error Rate (BER),Binary shift keying(BPSK), Quadrature shift keying(QPSK), Phase shift keying(PSK).

I. INTRODUCTION

It has been proven that Orthogonal Frequency Division Multiplexing (OFDM) system has reached high data speed transmission in wireless environment due to its ability to decompose a wideband frequency selective fading channel in to several parallel narrow band flat fading channels [1],[2].Multi-path delay spread tolerance, immunity to frequency selective fading channels, high spectral efficiency, efficient modulation and demodulation techniques and robust to impulse noise are the foremost advantages of OFDM system [3],[4]. OFDM technique has potential of increasing the data rate in band limited channel. However, inter-carrier interferences (ICI) and high peak to average power ratio (PAPR) are main downsides of OFDM system [2],[3].

A considerable research has been accomplished for diminishing the two significant restrictions of OFDM system and to boost up the overall performance of the system. One of the impairment is sensitivity of OFDM system against carrier frequency offset which obliterates the orthogonality amongst subcarriers and causes inter-carrier interferences (ICI) [2],[3],[4],[5],[6],[7],[8]. Several methods have been offered to reduce ICI, Frequency domain equalization, windowing at the receiver, ICI self-cancellation and use of pulse shaping [9]. Another one is the large variation in envelope of OFDM signal, which causes high peak-to-average power ratio (PAPR) [2],[3].

Simulation results show that introducing CFO degrades the performance and introducing ISP pulse shaping technique improved the performance with using different modulation scheme Also it has been observed that ISP pulse shape with BPSK modulation provides better performance in comparison of other modulation schemes.

In this paper, Section 2 introduces OFDM System model with Effect of CFO and different modulation schemes with ISP pulse shaping functions is listed in Section 3. Section 4 includes simulation results. Lastly, Section 5 concludes the paper.

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II. SYSTEM MODEL

OFDM communication system with pulse shaping function has been shown in Figure 1. In this system QPSK constellation is used to map binary information. The high speed serial data stream is split up in to a set of low speed sub streams and modulated onto the orthogonal carriers through Inverse Fast Fourier transform (IFFT). Signal s (t) which is represented as in (2.1) is transmitted through the channel with ISP pulse shaping functions [2].

OFDM block with pulse-shaping is represented as:

$$s(t) = e^{j2\pi f_c t} \sum_{k=0}^{N-1} D_k \, p(t) e^{j2\pi f_k t} \qquad (2.1)$$

Where j=$\sqrt{-1}$, Number of subcarrier is N, Carrier frequency of OFDM system is f_c, Subcarrier frequency of the K_{th} subcarrier is f_k, Where $k = 0, 1\ldots N-1$, Time limited pulse shaping function is p (t). Transmitted symbol is D_k which is assumed to have zero mean and normalized average symbol energy. Also we consider that all data symbols are uncorrelated [10, 11] i.e.:

$$E[D_k D^*_m] = \begin{cases} 1, & k = m, k, m = 0,1,\ldots,N-1 \\ 0, & k \neq m, k, m = 0,1,\ldots,N-1 \end{cases} \qquad (2.2)$$

Where D^*_m is the complex conjugate of D_k.To ensure the orthogonality of subcarrier, it is very important to satisfied the below equation for OFDM system [10, 11]. The subcarrier frequency is

$$f_k = \frac{k}{T_s}; \qquad k = 0,1,\ldots..N-1$$

$$f_k - f_m = \frac{k-m}{T_s}, \qquad k, m = 0,1,\ldots...., N-1 \qquad (2.3)$$

For maintaining orthogonality between subcarriers, the minimum required subcarrier frequency spacing is $1/T_s$. The received signal at the receiver can be represented as:

$$r(t) = s(t) \otimes h(t) + w(t) \qquad (2.4)$$

In above equation convolution is denoted by $\otimes$, h (t) is the channel impulse response and the additive white Gaussian noise is represented by w (t) which process with zero mean and variance $N_0/2$ per dimension.

For this work we assume that the channel is ideal, i.e., h (t) = $\delta(t)$ in order to investigate the effect of the frequency offset only on the ICI performance. At the receiver, the received signal r' (t) becomes:

$$r'(t) = e^{j2\pi\Delta f_c t + \theta} \sum_{k=0}^{N-1} D_k \, p(t) e^{j2\pi f_k t} + w(t) e^{j2\pi(-f_c + \Delta f)t + \theta} \qquad (2.5)$$

Where θ is the phase error and Δf is the carrier frequency offset between transmitter and receiver oscillators.

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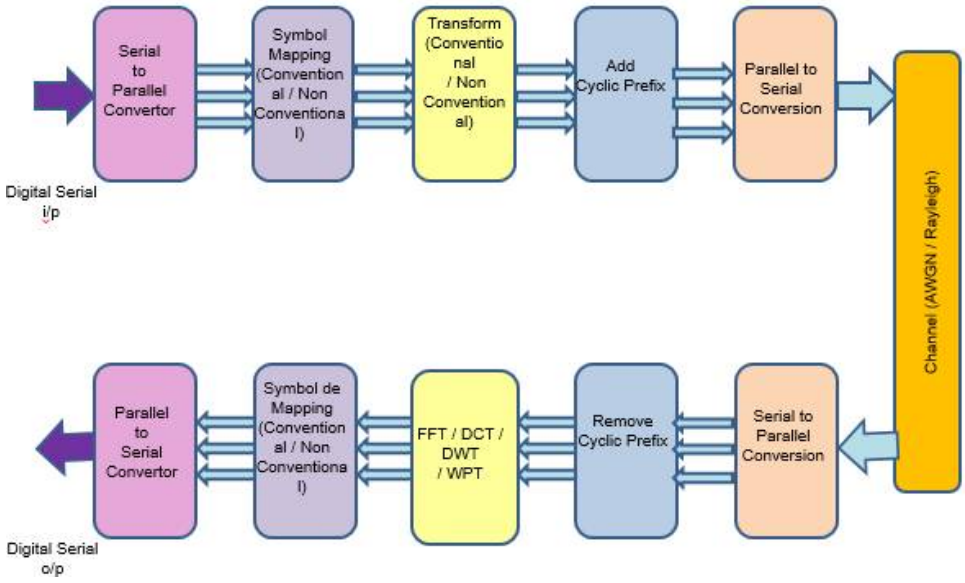

Figure 1 Simulation block diagram of OFDM System

III. PULSE SHAPING FUNCTION WITH DIFFERENT MODULATION SCHEMES

In the OFDM spectrum each carrier is represented by main lobe with a number of side lobes having lower amplitudes. Since peak power is associated with main lobe and ICI power is associated with side lobes, so the intention of pulse shaping function is to increase the width of main lobe and/or reduce the amplitude of sidelobes [10]. Proper pulse shaping techniques makes a digital communication system possible to transmit data within a limited BW with minimum ISI [12, 13].

The performance of OFDM system depends on several factors, such as the modulation schemes used, the amount of multipath, and the level of noise in the signal. Different modulation schemes are used like BPSK.QPSK, 8-PSK and 16-PSK

Digital modulation provides more information capacity, compatibility with digital data services, higher data security, better quality communications, and quicker system availability. The type of modulation used depends on the type of the communication channel. The type of modulation used depends on the type of the communication channel. Bit rate and symbol rate term gives us understanding and comparison of different modulation format efficiencies, the signal bandwidth for the communications channel needed depends on the symbol rate, not on the bit rate.

- **BPSK:** One of the simplest forms of digital modulation is binary or Bi-Phase Shift Keying (BPSK). The phase of a constant amplitude carrier signal moves between zero and 180 degrees. So they are chosen is that they have a correlation coefficient of -1, which leads to the minimum error probability [14].

Used as pilot carrier in all type of cellular scheme (wimax, wifi .e.g.) constellation is shown in figure 2

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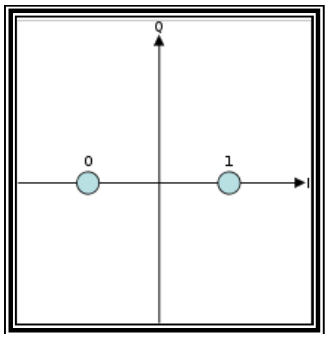

Figure 2: BPSK constellation

- **QPSK:** Quadrature means that the signal shifts between phase states which are separated by 90 degrees. This gives maximum phase-separation between adjacent points and thus the best immunity to corruption. The signal shifts in increments of 90 degrees from 45 to 135, –45, or –135 degrees.

` All constellation points have same energy on circle. Only two I values and two Q values are needed and this gives two bits per symbol. There are four states because $2^2 = 4$. It is therefore a more bandwidth-efficient type of Modulation than BPSK, For QPSK theoretical bandwidth efficiency is 2 bit/second/Hz potentially twice as efficient.

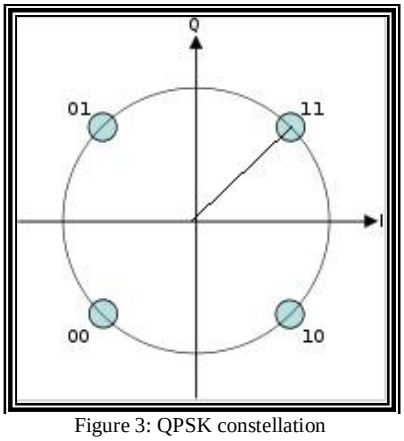

Figure 3: QPSK constellation

In this section ISP pulse shaping functions have been introduced with different modulation schemes and its Fourier transforms are given, as [2, 3, 4, 7, 10, and 13].

The pulse shaping functions is

$$P_{ISP}(f) = \exp(-a(fT)^2)\sin c^n(fT) \qquad (3.1)$$

To adjust the amplitude of improved sinc power pulse design parameter ‘a’ is used in equation (3.1), the degree of sinc power pulse is ‘n’. [2, 3, 6, 7, 10].

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IV. SIMULATION RESULTS

To demonstrate the performance enhancement of shaping the CFO-OFDM system, the simulation results have been done by using different modulation scheme with ISP time-limited pulse shaping function which have been mentioned in section 3.

4.1 Impulse response of ISP pulse with values of a (0.5, 1).

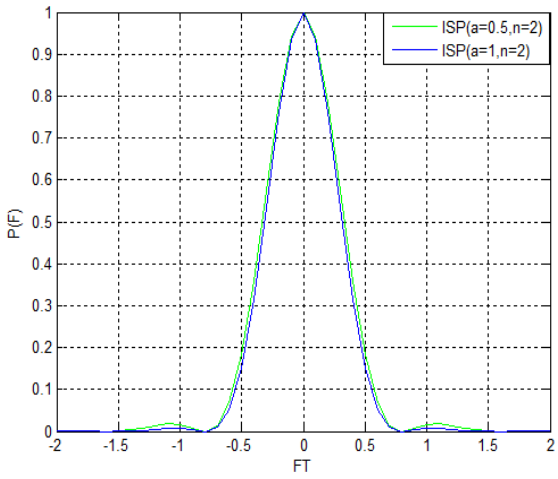

Figure 4 Impulse response of ISP pulse shape.

ISP pulse is depicted in Figure 4 with values of 'a' (0.5, 1) where the amplitude of ISP pulse is adjusted by varying a design parameter 'a' and *n* is the degree of the sinc function. As the value of design parameter 'a' increases from 0.5 to 1, the width of the main lobe is further reducing up to some extent. But after that for very large values of a, ISP pulse shape become to a very narrow pulse shape which is not preferred for the system having frequency offset.

4.2 Frequency Spectrum of ISP pulse

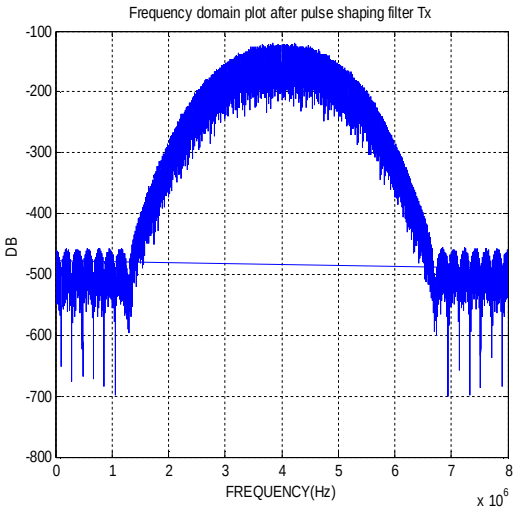

Figure 5 Spectrum performance using ISP

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Frequency Spectrum of ISP pulse has been shown in figure 5.From the simulation result it can be observed that ISP is showing better spectrum because width of main lobe is increases and the amplitude of side lobes is reduces .So ultimately its reduces ICI and ISP is more spectrum efficient in comparison of without pulse shaping technique.

4.3 BER of OFDM system

Simulation parameters which have been used are as follows:
FFT size: 64; No. of subcarriers: 52; No. of Symbols: 10000 and 2 bits per symbol. Channel: AWGN. Cyclic prefix duration: 0.8µs. SNR: 1 to 25.Modulation scheme: BPSK

4.3.1 BER comparison of OFDM system without CFO and without ISP

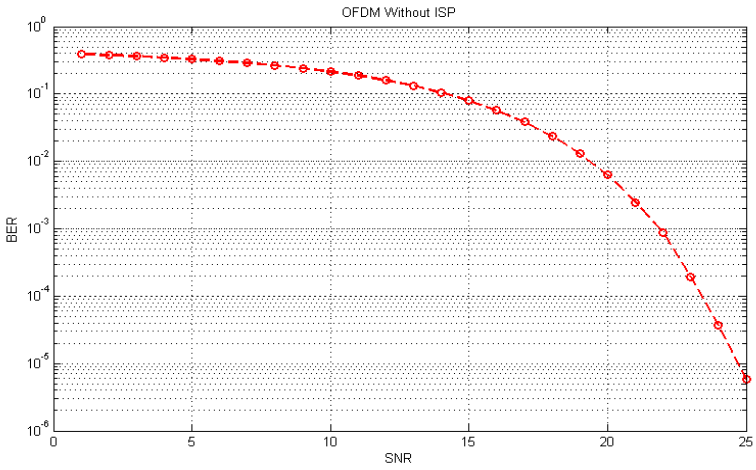

Figure 6: BER Comparison of OFDM without CFO and ISP

The OFDM without CFO and without ISP has been shown in Figure 6, where the BER is shown as a function of SNR.

4.3.2 BER comparison of OFDM with CFO without ISP

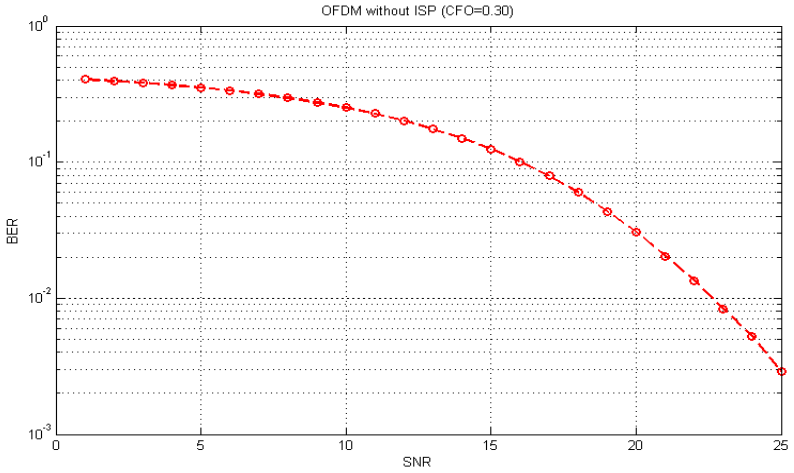

Figure 7. BER improvement of OFDM system with CFO without ISP technique

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It is observed that from figure 7 BER without ISP pulse shaping technique the BER performance is degrade with CFO-OFDM system.

4.3.3 BER comparison of OFDM with different modulation schemes without CFO using ISP

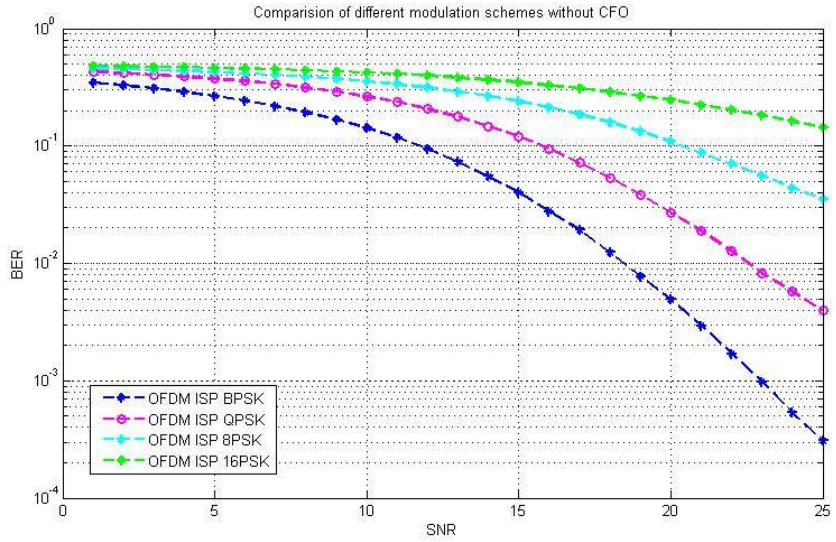

Fig 8 BER improvement of OFDM system without CFO using ISP technique

It has been observed from figure 8 BER of BPSK modulation is less compared to other modulation schemes without CFO.

4.3.4 BER comparison of OFDM with different modulation schemes and CFO using ISP

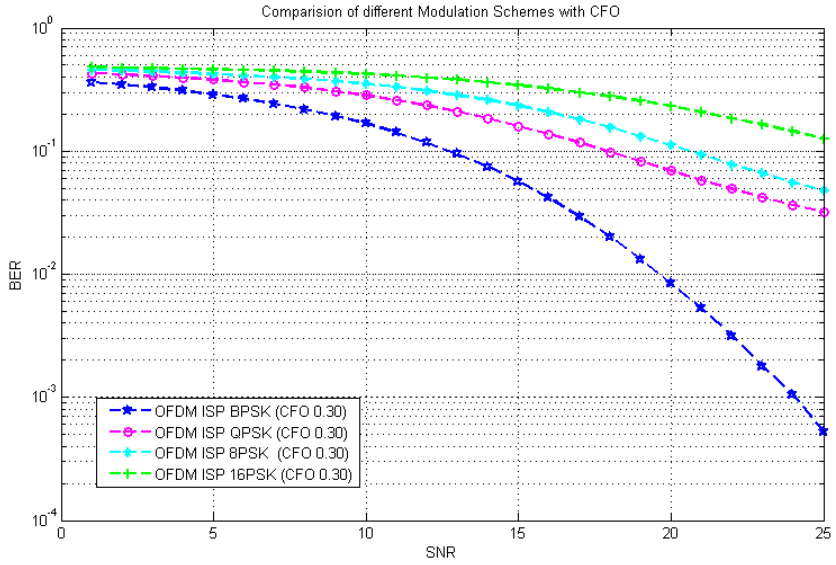

Fig 9 BER improvement of OFDM system with CFO using ISP technique

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OFDM system with different modulation schemes and CFO using ISP pulse shaping function as depicted in figure 9.It has been observed that the BER performance degrades by approximately 3 dB with BPSK and CFO by using ISP pulse shaping.

V. CONCLUSION

In this paper, the performance of CFO-OFDM system with different modulation scheme using ISP pulse shaping technique has been evaluated in terms of SNR and BER. From the simulation results it has been observed that Introducing CFO degrades the performance and shaping the OFDM system by ISP pulse with BPSK provide better performance compared to other modulation schemes.

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