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Minimization of Ici Using Ofdm Techniques

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Abstract: *Orthogonal Frequency Division Multiplexing (OFDM) is an emerging broadband multicarrier modulation technique developed into a popular scheme for wideband digital communication, whether wireless or wired used in applications such as Digital Television, audio broadcasting, wireless networking and broadband internet access.OFDM has a well known limitation that is very sensitive to frequency error between transmitter and receiver local oscillator. This frequency offset results in Intercarrier Interference. In this paper, Inter Carrier Interference self cancellation scheme is studied for combating the effect of Inter Carrier Interference self. It shows that OFDM system with Intercarrier Interference self cancellation scheme perform much better than standard system.*
Key words*: Peak Average Power Ratio (PAPR), Fast Fourier Transform (FFT), Carrier to Interference Ratio (CIR), Inter symbol Interference (ISI), Orthogonal frequency Division multiplexing (OFDM).*

I. Introduction

OFDM is broad band multicarrier modulation technique having superior performance over older, more traditional single carrier modulation techniques as it meets high speed data requirement and operate in UHF and microwave spectrum. These carriers have different frequencies and are orthogonal to each other.

OFDM system is more sensitive to frequency synchronization error than single carrier system as it is multicarrier modulation technique. Which is well known limitation of OFDM. Further more, to preserve the ortogonality between sub-carriers, the amplifier should be linear. Also, OFDM system have a high PAPR or crest factor. Which require a large amplifier back off and a large number of bits in A/D and D/A design
Frequency offset is caused by mismatched due to Doppler shift movement. Due to this carrier frequency offset, causes loss of orthogonality between sub-carriers which leads to Intercarrier Interference.

There are various methods to combat the Intercarrier Interference in OFDM system. The existing approaches to combat Inter Carrier Interference in OFDM system can be categorized as Frequency domain equalization [1], Time domain equalization [2] and self cancellation technique.

This paper analyzes in detail, the effect of ICI and solution to combat ICI. This method is self cancellation scheme, this method maps the data to be transmitted on adjacent sub carriers such that ICI between adjacent sub-carriers to cancel out each other.

1.1 OFDM SYSTEM DESCRIPTION

In an OFDM system. The serial digital data stream to be transmitted is split into N slower symbol stream and eachismodulatedintoaseparatecarrierinallottedspectrum.Thesesub-carriers

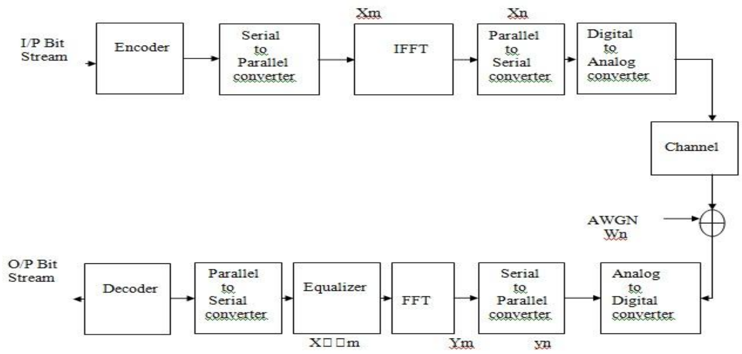

Fig.1: The Basic Block Diagram of OFDM System

are spaced by 1/NTs in frequency, where Ts is the symbol duration, N is total number of sub-carriers .

Fig.1 shows the block diagram of typical OFDM transceiver system. First, a S/P converter group the Input bit stream into group of log 2M bits, where M is the alphabets of size of digital modulation scheme employed on each sub carrier. A total of 'N' such symbol, Xm are created IFFT is then used to convert this

signal into time domain. In frequency domain before applying to IFFT, each of the discrete samples of IFFT corresponds to an individual sub carrier. Most of the subacrriers are modulated with data. The outer sub carriers are set to zero amplitude act as a frequency guard band before the nyquist frequency.
The OFDM symbol can be given as:-

$$x(n) = 1/N \sum_{m=0}^{N-1} Xme^{j2\pi nm/N} \; .....(1)$$

Xm- are base band symbols on each sub-carriers
Then an Analog time domain signal to be transmitted is created by D/A converter.
The receiver performs the reverse operation of transmitter.
The signal is converted back to discrete N- point sequence Y(n) , corresponding to each sub-carrier. Then using a FFT, the signal is analyzed in frequency domain .
The demodulated symbol stream is give by:

$$Y(m) = \sum_{n=0}^{N-1} y(n)e^{-j\frac{2\pi nm}{N}} + W(m) \; .....(2)$$

W(m) - is FFT of white Gaussian noise w(n) introduced in channel.

In order to achieve high speed data rates simultaneous transmission of data at lower rates on each of orthogonal sub carrier is done. Due to which distortion is induced in received signal by multi path delay result in ISI. To prevent the OFDM from ISI cyclic prefix are inserted between successive OFDM symbol. Due to its robustness to ISI and multipath distortion, it is used in various wireless applications and strandeous.

II. Analysis Of Inter-Carrier Interference

The main disadvantage of OFDM is that it requires very accurate frequency synchronization between the transmitter and receiver, with frequency deviation the sub carrier will no longer be orthogonal, normally referred as frequency offset. The frequency offset can be caused by Doppler shift due to difference between the frequency of the local oscillator at the transmitter and receiver causing Intercarrier Interference.

$$\exp(j2\pi n\varepsilon/N) \quad w(n)$$

$$X(m) \xrightarrow{IFFT} x(n) \rightarrow \oplus \rightarrow \oplus \rightarrow y(n)$$

Fig.2: Frequency Offset Model

Fig.2 shows the frequency offset model as a multiplicative factor introduced in channel.
The received signal is given by

$$y(n) = x(n)e^{j\frac{2\pi n\varepsilon}{N}} + w(n) \; ....(3)$$

Where, w(n)-AWGN introduced in channel.
N- total number of sub-carriers.
$\varepsilon -$ normalized frequency offset & given as $\varepsilon = \Delta FNTs$
Where ΔF is the frequency difference between transmitted and received carrier frequency
Ts- sub-carrier symbol period
By considering the received symbol Y(k) on the Kth sub-carrier the effect of this frequency offset can be well understood. $y(k) = x(k)S(0) + \sum_{l=0,1-k}^{N-1} X(l)S(l-k) + n_k$

k =0, 1, 2 …N-1

Where N-total number of sub-carrier X(k) is the transmitted symbol for Kth sub-carrier, S(l-k) – are complex coefficient for the ICI component in the received signal.

2.1 Ici Self - Cancellation Scheme

ICI self cancellation scheme was introduced by Yuping Zhao and Sven-Gustav Haggman in 2001 to suppress ICI in OFDM .The main idea of this scheme is that data is mapped onto the group of sub carrier with predefined coefficient .This cancels the component of ICI within group of sub carriers due to linear variation in weighting coefficient. The complex coefficient is given by-

$$S(l-k) = \frac{\sin(\pi(l+\varepsilon-k))}{N\sin(\pi(l+\varepsilon-k)/N)} \exp(j\pi(1-\frac{1}{N})(l+\varepsilon-k) \; .....(4)$$

2.1.1 Ici Canceling Modulation

In ICI self-cancellation, the transmitted signal be constrained such that X(1)=-X(0), X(3) =-X(2),…X(N-1) =-X(N-2).
Using equation of complex coefficient, this assignment of transmitted symbol allow the signal on sub carrier k and k+l to written as [13, 8]

$$Y'(k) = \sum_{\substack{l=0 \\ l=even}}^{N-2} X(l)[S(l-k) - S(l+1-k) + n_k \quad .....(5)$$

$$Y''(k+1) = \sum_{\substack{l=0 \\ l=even}}^{N-2} X(l)[S(l-k-1) - S(l-k) - n_{k+1} \quad .....(6)$$

and the ICI coefficient S'(l-k) is denoted as

S′(l-k)=S(l-k)-S(l+1-k)….(7)

2.1.2 Ici Canceling Demodulation

ICI modulation introduces redundancy in the received signal since each pair of sub carriers transmit only one data symbol. This redundancy can be exploited to improve the system power performance, while it surely decreases the bandwidth efficiency. To take advantage of this redundancy, the received signal at the (k + 1) the sub carrier,

Where k is even, is subtracted from the kth sub carrier. This is expressed mathematically as

Y″(k) =Y′(k)-Y′(k+1) …..(8)

$$= \sum_{l=0,2,4.}^{N-2} X(l)[-S(l-k-1) + 2S(l-k) - S(l+k+1)] + n_k + n_{k-1} \quad ....(9)$$

Subsequently, the ICI coefficients for this received signal becomes

S " (*l*-k) = – S (*l*-k-1) + 2S (*l*-k) – S (*l*-k+1) …..(10)

When compared to the two previous ICI coefficients |S (*l*-k)| for the standard OFDM system and |S'(*l*-k)| for the ICI canceling modulation, |S"(*l*-k)| has the smallest ICI coefficients, for the majority of (l-k) values, followed by |S' (*l*-k)| and |S (*l*-k)|.

The reduction of the ICI signal levels in the ICI self-cancellation scheme leads to a higher CIR. The theoretical CIR is given by

$$CIR = \frac{\left| -S(-1) + 2S(0) - S(1) \right|^2}{\sum_{l=2,4,6..}^{N-1} \left| -S(l-1) + 2S(l) - S(l+1) \right|^2} \quad ......(11)$$

III. Conclusion

In this paper, the effect of frequency error between transmitter and receiver local oscillator on performance of OFDM system is studied in terms of Carrier to Interference Ratio and Bit Error Rate performance. The ICI self cancellation technique was proposed to combat ICI by canceling higher order components.

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