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Carrier Interference Ratio Analysis & Cancellation scheme For OFDM System Affected by Frequency Offset or Phase Offset

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Abstract-In the OFDM symbol inter-carrier interference (ICI) introduces frequency offset Or phase Offset. The evaluation of impact of frequency offset resulting inter-carrier interference (ICI) while receiving OFDM Modulated symbol. We will first discuss the OFDM transmission and reception, frequency offset. Later we will define the loss of Orthogonality and resulting signal to noise ratio (SNR) loss due to the presence of frequency offset .

Key Words: OFDM, ICI, SNR, frequency offset

I. INTRODUCTION

OFDM stands for Orthogonal Frequency Division Modulation is a wideband wireless digital communication technique. OFDM can supports the video as well as audio h without any inter symbol interference (ISI).It is a high spectral efficiency transmission scheme .OFDM system is very sensitive to synchronization errors such as frequency offset and phase offset from the receiver oscillator circuit which causes inter-carrier interference (ICI). In the OFDM technique total transmission bandwidth is divided into a number of orthogonal subcarriers then they are applied to the parallel arrangement of narrowband orthogonal signals for transferring the wideband signals.

It is well known that the original OFDM principles proposed by Chang in 1966 and successfully achieved a patent in January 1970. In 1971, Weinstein and Ebert proposed a modified OFDM system in which the generation of orthogonal subcarrier waveforms is carried out with the help of mathematical operations that is Discrete Fourier Transform (DFT) and Inverse Discrete Fourier Transform (IDFT) in place of group of sinusoidal generators. This two mathematical operations are used to transform signal between time and frequency domain. In the transmitter baseband signals were modulated by the IDFT and then demodulated in the receiver by the DFT. Hence, all subcarriers were overlapped with others in the frequency domain, while the DFT modulation still assures their orthogonality.

This paper focuses on the signal processing methods to overcome the effect of Inter-carrier interference (ICI) due to frequency or phase offset from the receiver oscillator of OFDM system. To reduce the ICI effect, the same information symbol is placed on the adjacent subcarriers. The main approach is estimation and compensation of frequency offset or phase offset while the other one is that to use the signal processing techniques in the transmitter for cancelling the effect of frequency or phase offset**.**

The purpose of this project is to investigate how OFDM performs in an Additive White Gaussian Noise (AWGN) channel only. In this channel only one path between the transmitter and the receiver exists and only a constant attenuation and noise is considered. Therefore no multipath effect is taken into account. This is a basic investigation and it is intended as a basis of understanding OFDM better in order for future studies of this technique in multipath channels.

II . DATA COLLECTION

As shown in the block diagram of fig.2.1 the OFDM transmitter starts with the channel coding block, if the source coded data is available at the input. The channel coding block adds redundancy to its input signal by performing the operations such as scrambling, convolution coding, code puncturing and interleaving. The data will combat fading problems in a better way due to the added redundancy. After channel coding, the next stage in OFDM transmitter is OFDM modulation. The preferred modulation schemes are BPSK, QPSK and QAM. Some additional subcarrier known as pilot subcarriers are included in order to create the reference at the receiver. Such a reference is required for carrying out the channel estimation procedure. The modulated signal is passed through a D to A converter, Up converter (mixer), RF amplifier before it transmitted.

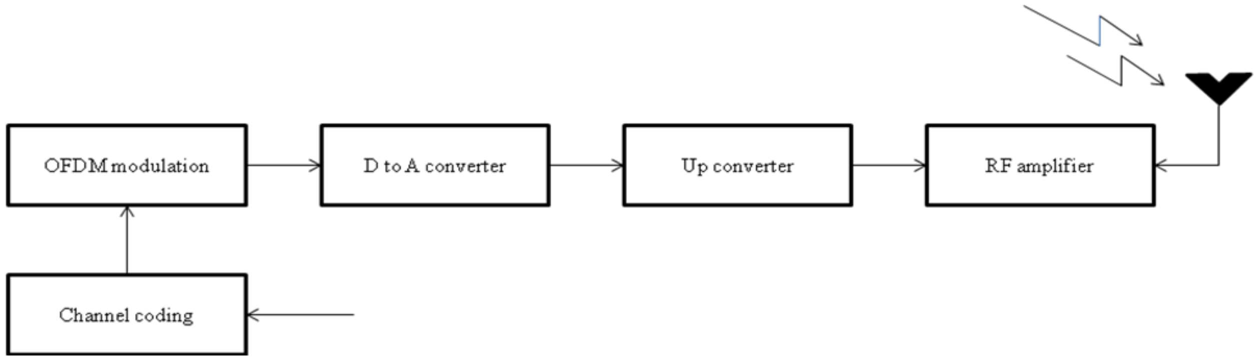

Figure 2.1 OFDM Transmitter

At the receiver the received signal is amplified and down converted using mixer and then passed through an A to D converter. The digital signal at the output of A to D converter is then demodulated using OFDM demodulator and decoded using the channel decoder

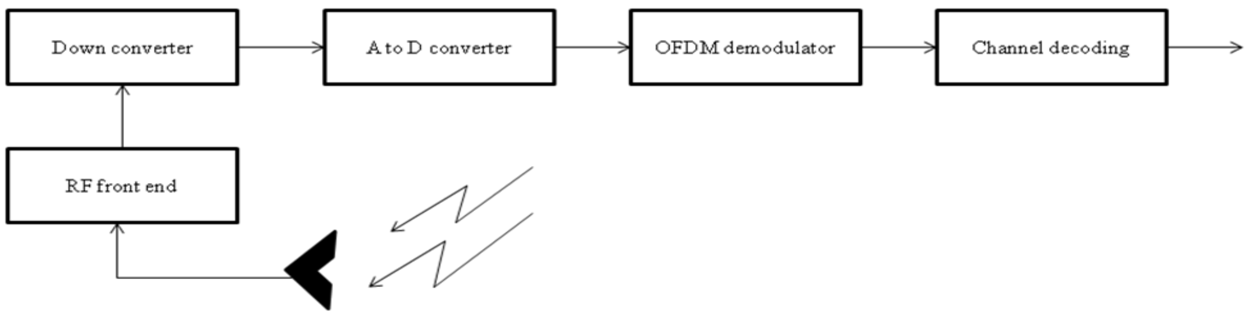

Figure 2.2 OFDM Receiver

III. RESEARCH METHODOLOGY

a) Design of Matlab based simulation module of the OFDM transmitter
b) Design of Matlab based simulation module of the OFDM receiver
c) Design of Matlab based simulation module of the OFDM
d) Analysis of the performance of the OFDM system affected by the inter carrier interference through ratio analysis and BER of the received data

e) Design and simulation of the inter carrier interference self cancellation technique for improved performance.
f) Result analysis

IV. ANALYSIS OF ICI

(A) OFDM Transmission:

On understanding an OFDM transmission, for sending an OFDM modulated symbol, we use multiple sinusoidal signals with frequency separation 1/T are used, where T is the symbol period. The information a_k to be send on each subcarrier k is multiplied by the corresponding carrier $g_k(t) = e^{\frac{j2\pi kt}{T}}$ and the sum of such modulated sinusoidal signals form the transmit signal.

Mathematically the transmit signal $a_k = e^{j2\pi kt/T}.k$

Where, Each information signal a_k multiplies the sinusoidal having frequency of $\frac{k}{T}$ and sum of all such modulated sinusoidals are added and the resultant signal is sent out as s(t)

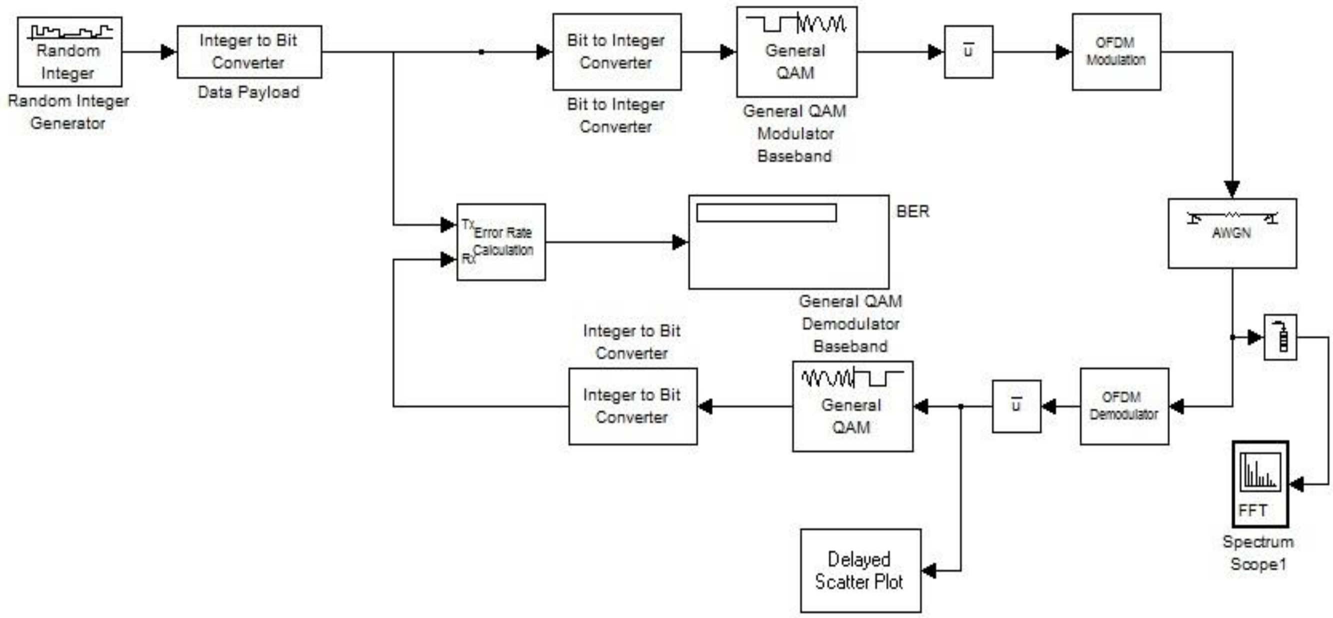

Figure 4.B 64 QAM based OFDM system

(B) OFDM Reception :

In an OFDM receiver, we will multiply the received signal with a bank of correlators and integrate over the period T. The correlator to extract information send on subcarrier k is as follows

$$\frac{1}{\sqrt{T}} \int_T s(t) e^{-\frac{j2\pi mt}{T}} = a_k, \; m = k$$
$$= 0, \quad m \neq k,$$

Where,

m takes values from 0 till $K-1$

(C) Frequency offset:

In typical wireless communication system, the signal to be transmitted is up-converted to a carrier frequency prior to transmission. The receiver is expected to tune to the same carrier frequency for down converting the signal to baseband, prior to demodulation.

However, due to device impairments the carrier frequency of the receiver need not be same as the carrier frequency of the transmitter. When this happens, the received baseband signal, instead of being centered at DC (0 MHz), will be centered at a frequency f_δ.

Where, $f_\delta = f_{Tx} - f_{Rx}$

The baseband representation is (ignoring noise):- $y(t) = s(t)e^{j2\pi f_\delta t}$

Where, $y(t)$ Is the received signal ; $s(t)$ is the transmitted signal and f_δ is the frequency offset.

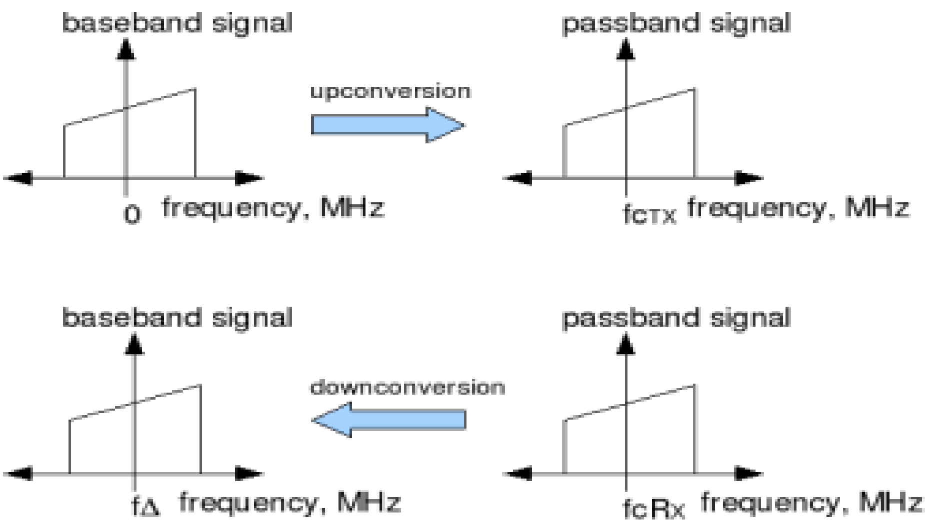

Figure 4.C Up/Down Conversion

VI. EFFECT OF FREQUENCY OFFSET IN OFDM RECEIVER

Let us assume that the frequency offset f_δ is a fraction of subcarrier spacing 1/T i.e $f_\delta = \frac{\delta}{T}$. Also, for simplifying the equations, let's assume that the transmitted symbols on all subcarriers, $a_k = 1$. The received signal is, $y(t) = s(t)e^{\frac{j2\pi\delta}{T}t}$

For $\delta = 0$, The integral reduces to the OFDM receiver with no impairments case,however, for non zero values of δ, we can see that the amplitude of the correlation with subcarrier m include.

(1) Distortion due to frequency offset between actual frequency $\frac{m+\delta}{T}$ and the desired frequency $\frac{m}{T}$.
(2) Distortion due to interference with other sub-carrier with desired frequency. This term isalso known as Inter-Carrier Interference (ICI).

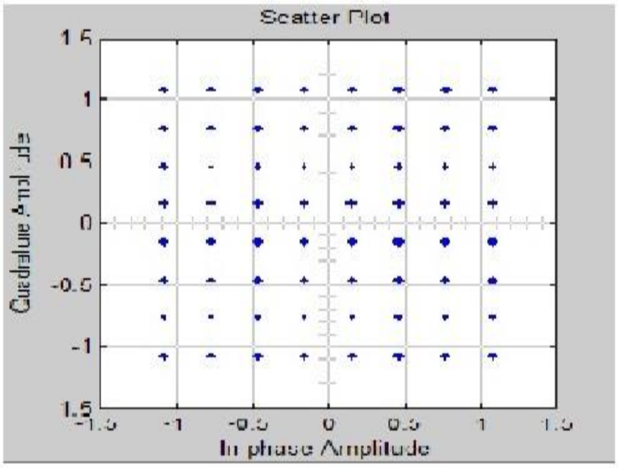

Figure 5.2 Delayed scatter plot between In-phase and Quadrature amplitude

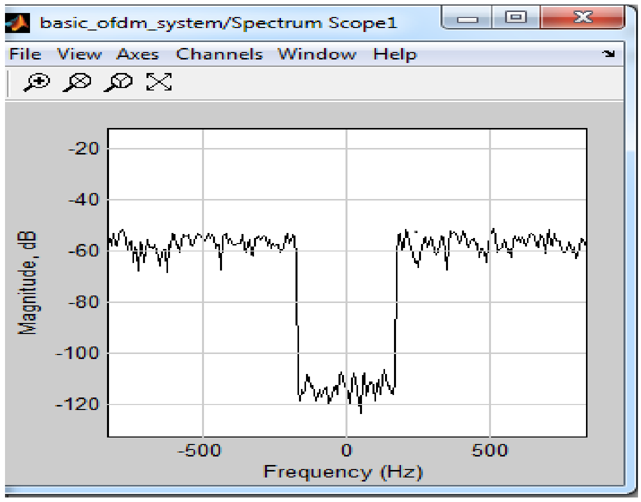

Figure 5.3 Spectrum scope

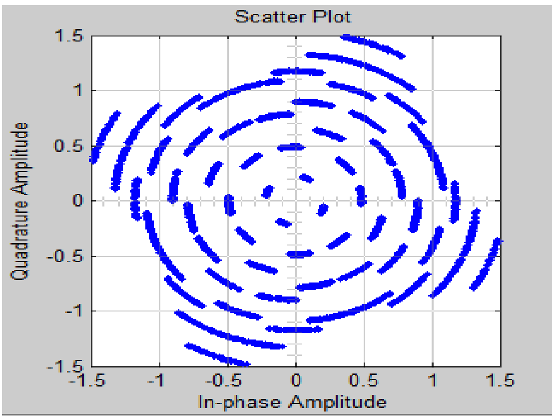

Figure 5.1 Scatter plot-1 between In-phase amplitude and Quadrature amplitude

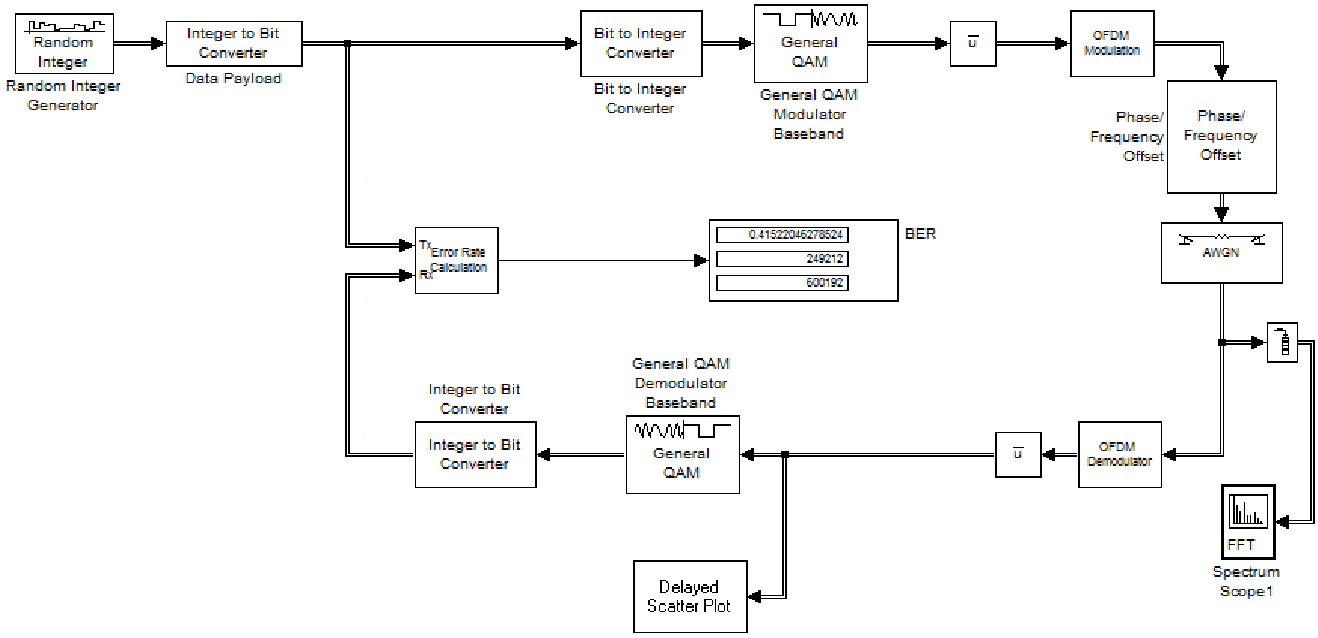

Figure 5.4 QAM based OFDM system with corrupted ICI

VI . CONCLUSION

In this paper, we studied the performance of OFDM system in presence of frequency offset between transmitter and receiver. Inter-carrier interference (ICI) results from the frequency offset affects the performance of OFDM system, the undesirable ICI affects the signal heavily and hence the system performance also.

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