INTERNATIONAL JOURNAL OF SCIENTIFIC PROGRESS AND RESEARCH (IJSPR) ISSN: 2349-4689
Issue 160, Volume 60, Number 01, June 2019

Development of Nonlinear Interference Cancellation for MU-OFDM System

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Abstract – Cancellation of interference in multi user OFDM system is crucial task to deal due to fading due to multiple streams of transmission. To mitigate the effect of interference we need to follow the technique which cancels out the effect of interference. During transmission of signals they interfere with each other and create unwanted frequencies as well as peaks and dips, which differ than the reference power levels of original signals, these peaks and dips need to eliminate to maintain the power level and effects of interference. In this work we have implemented interference cancellation strategy with SUI channel. The simulation has been performed with different m-ary QAM scheme with m=4,8 and 16. The effect of technique is nonlinear in nature so that the proposed system is non-linear in nature. From the simulation outcomes it can be seen that the various interference and m-QAM scheme significantly reduces the symbol error rate (SER). Optimal values of SER achieved with 8-QAM and CF=6.

Keywords- Interference cancellation, SER, OFDM, m-QAM.

I. INTRODUCTION

Since its inception, wireless communications technology has continued to evolve. Digital succeeded analog in wireless communications for reasons related to resource (e.g. bandwidth) economy, flexibility, cost, etc. For improved quality of service (QoS), such as throughput, data rate and bit-error ratio (BER), different channel coding and multiple access schemes have been investigated by researchers based on design merits. At first, frequency division multiple access (FDMA) was used, then time domain multiple access (TDMA) and code division multiple access (CDMA).

Recently, an enhanced FDM technology, orthogonal frequency division multiplexing (OFDM) and multiple access (OFDMA), has dominated the market as the air-interface protocol for wideband systems, including those employing multi-antenna technology. The commonest examples include wireless fidelity (WiFi), world-wide interoperability for microwave access (WiMAX), digital audio/video broadcasting (DAB/DVB) and long-term evolution (LTE).

OFDM scheme has been preferred because it is robust over frequency- selective transmissions. Unfortunately, OFDM is not similarly suitable for doubly-selective channels due to Doppler effects. Since future-generation wireless networks anticipate high data rate (driven by users who are always "on the move"), Doppler effects are non-negotiable. Thus, "on the move", mobile nodes/base stations are expected to offer "rich" seamless services irrespective of the mobile speed. Modern broadband technologies must therefore be able to provide excellent QoS at high speed.

OFDM converts a frequency-selective fading channel into a flat (non-frequency selective) fading channel, reduces equalization to a simple tap division, eliminates inter-symbol interference (ISI) because it can operate with a cyclic prefix (CP) and can multiplex large input data such that the overall system data rate is improved.

However, mobile devices as their names imply are always "on the move". Thus, the relative motion of the mobile and base station leads to Doppler effect which degrades the performance of OFDM system. The relative mobility causes the orthogonality of the adjacent sub-channels of an OFDM system to be degraded due to the spreading of each of the sinc-shaped sub-channels. This introduces inter-carrier interference (ICI). This relative motion causes both time and frequency selectivity in the channel; introducing ICI. OFDM can withstand frequency selectivity well.

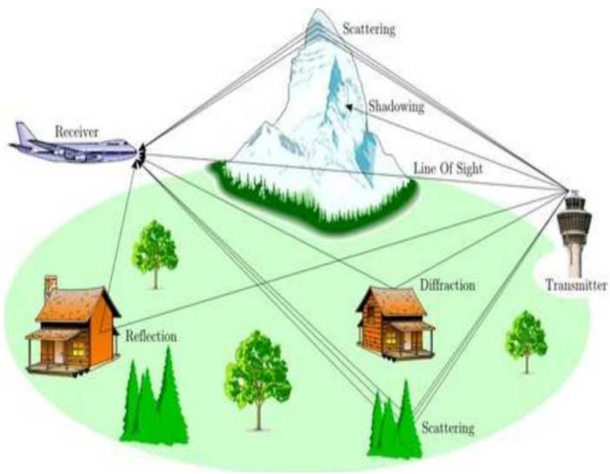

Fig.1.1Multipath Propagation

The transmitted signal faces various obstacles and surfaces of reflection, as a result of which the received signals from the same source reach at different times. This gives rise to the formation of echoes which affect the other incoming signals. Dielectric constants, permeability, conductivity and thickness are the main factors affecting the system.

Multipath channel propagation is devised in such a manner that there will be a minimized effect of the echoes in the system in an indoor environment. Measures are needed to be taken in order to minimize echo in order to avoid ISI (Inter Symbol Interference). The figure 1.1 shows the scenario for multipath propagation.

II. SYSTEM MODEL

Orthogonal Frequency Division Multiplexing (OFDM) is a multi-carrier communication system. OFDM extends the concept of single sub-carrier modulation by using parallel multiple sub-carriers within a channel. It uses a large number of closely separated orthogonal sub-carriers that are transmitted in parallel. Each of the sub-carrier is modulated with any conventional digital modulation scheme (such as QPSK, 16QAM, etc.) at low symbol rate. The combination of all sub-carriers enables data rates equivalent to conventional single-carrier modulation schemes. Thus OFDM can be considered as similar to the Frequency Division Multiplexing (FDM). In FDM different streams of information are mapped onto separate parallel frequency channels. Each FDM channel is separated from the others by a frequency guard band to reduce the possible interference between adjacent channels.

The OFDM scheme differs from the traditional FDM in following ways:

i. Multiple carriers carry single information stream

ii. Sub-carriers are orthogonal to each other

iii. A guard interval is added between adjacent symbols to minimize the channel delay spread and inter symbol interference (ISI).

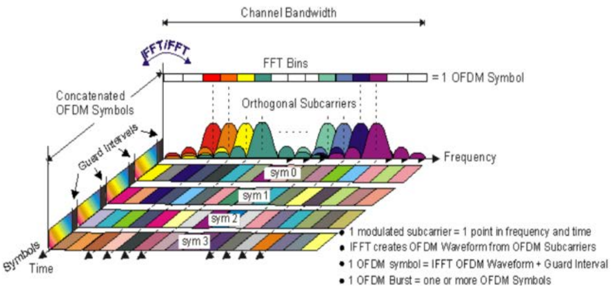

Fig.2.1 Frequency and time representation of OFDM spectrum

Figure 2.1 shows the main concepts of an OFDM signal and the inter relationship between the frequency and time domains. The frequency axis contains N number of information carrying orthogonal sub-carriers. In the frequency domain, sub-carriers are independently modulated with complex data. Inverse FFT operation is performed on the frequency domain sub-carriers to produce the OFDM symbol in the time-domain. After IFFT operation, guard intervals are inserted to each symbols to prevent ISI at the receiver. Without ambiguity, it can be noted that ISI is caused by multi-path delay spread in the radio channel. At the receiver FFT operation is carried out on the OFDM symbols to recover the original transmit data bits.

III. PROPOSED METHODOLOGY

The accuracy of channel state information symbol estimated at receiver substantially influences the performance of overall OFDM system. The main challenges associated with OFDM systems today are channel identification and tracking, channel coding and equalization. Peaks and dips is a crucial design factor in any communication system. It also has a direct impact on the efficiency of Power Amplifiers (PAs), which yield maximum efficiency when they operate at their saturation point. When OFDM signals add up constructively, they may result in a high instantaneous peak power forcing the PA to operate with a large back-off, thus lowering power efficiency. Conversely, allowing the PA to operate in its non-linear region will lead to signal clipping. This distortion increases out-of-band radiation which i) gives rise to unwanted signals interfering with the signal of interest, thereby degrading system performance, and ii) violates the standards set by telecommunications regulators.

OFDMA is an extension of OFDM, by means of which a fraction of the total number of sub-carriers per OFDM symbol is allocated to each user. This is achieved by dividing the total number of sub-carriers into groups, termed sub-channels. Sub-carriers are allocated to sub-channels or chunks in either a localized or a distributed manner. The approach uses a block of contiguous sub-carriers to form a sub-channel. Fig 3.1 shows the block representation of proposed system. There are three fundamental block are there in proposed system which are described as follows.

1. Transmitter

At transmitter side input data or information which is to be transmitted processed for transmission through system. In transmitter there are two fundamental blocks are used are briefed as follows

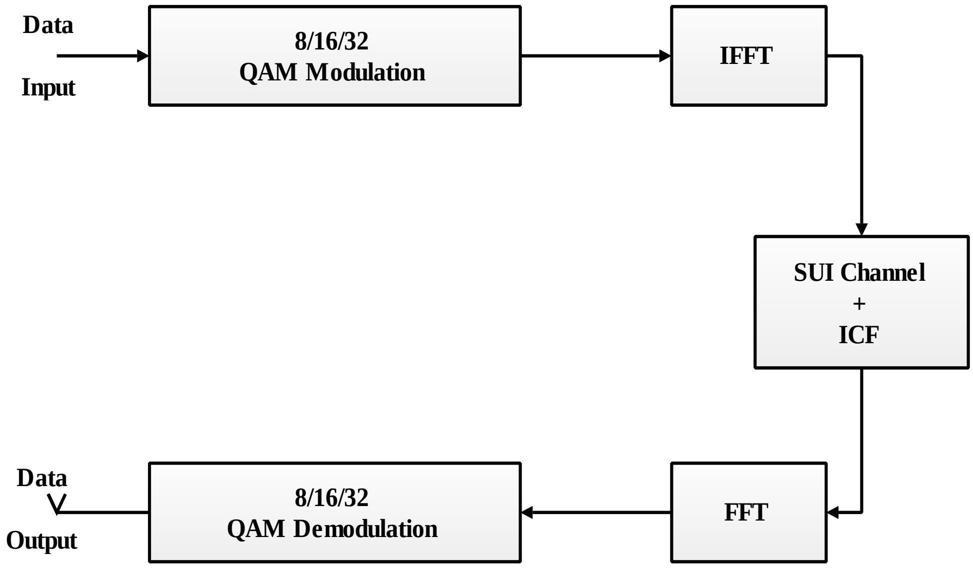

Fig.3.1 Block Diagram of Proposed System

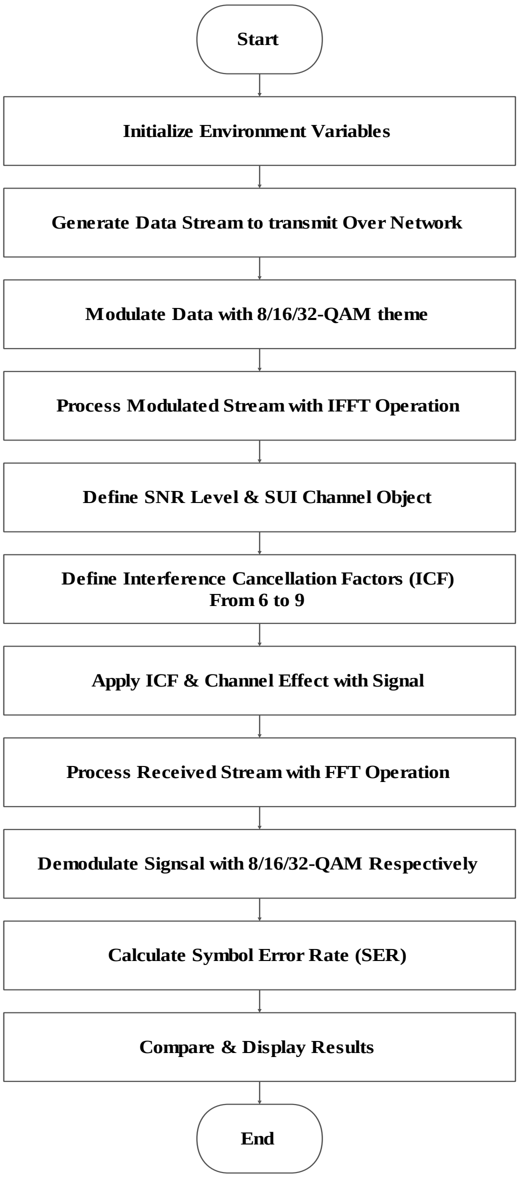

Fig.3.2 Flow Chart of Proposed Methodology

- QAM Modulation

Quadrature Amplitude Modulation, QAM uses both parts of amplitude and phase to provide a type of modulation capable of providing high levels of effectiveness in spectrum use. The data for each carrier to be transmitted is modulated in a QAM format. Quadrature Amplitude Modulation, QAM uses components of both amplitude and phase to provide a form of modulation that can deliver high levels of efficiency in spectrum use. The data to be transmitted on each carrier will be modulated in a QAM format.

- IFFT

A reverse fourier transform is used to discover the respective time waveform after the necessary spectrum is worked out. Then the guard period is added to each symbol beginning.

2. Channel Model Used

A Channel model is then applied to the transmitted signal. Standard channel models used in mobile radio environment have been referred. The model makes it possible to control the signal-to-noise ratio and multipath. The signal-to-noise ratio is set by adding a known quantity of noise to the transmitted signal. SUI Channel model with interference cancellation factor (ICF) model is referred to simulate proposed system. For an OFDM wireless communication scheme, in frequency and time domains, the channel transfer characteristic at separate subcarriers seems unequal. Therefore, a dynamic channel estimate is needed.

3. Receiver

The transmitted signal from transmitter is received at the receiver and original information is recovered from it after denoising demodulation and amplification process. The process which we have used in our system at receiver end is described as follows.

- FFT

The inverse operation of the receiver on the received transmitted signal is basically done. Eliminate the guar interval from received signal. The FFT of each symbol is then utilized to locate the initial transmitted spectrum. Each transmission carrier is then assessed and transformed back to the information phrase by demodulating the received symbol. The data words are then combined back to the same word size as the original data.

- QAM demodulation

To retrieve original information from the acquired sign QAM demodulation is used at receiver end after making use of FFT. In essence, the QAM modulator follows the notion that can be considered from the fundamental QAM concept where there are two carrier signals between them with a 90^0 phase shift. These are then modulated with the two statistics streams recognized as the I or In-phase and the facts streams Q or quadrature data streams.

Process flow of proposed work in MATLAB has sown in Fig.3.2 flow chart of proposed approach.

IV. SIMULATION RESULTS

An OFDM system is modeled the use of Matlab to enable parameters of the system to be tested and verified based on simulation and experimental analysis. The aim of doing the simulations is to measure the overall performance of OFDM system under extraordinary channel conditions, and to enable for exclusive OFDM configurations to be tested. In proposed model to simulate a SUI channel has been reported in this work.

It is important to note that the symbol error rate due to a signal set is completely independent of the shapes of the chosen orthonormal basis functions, as only the signal coefficients and the noise power spectral density can impact the minimum attainable symbol error rate. Also, the probability of symbol error is not affected by the signal space translation, for the signal and noise are independent, nor is it impacted by the signal space rotation, as noise is spherically symmetric.

The N-dimensional space is partitioned into M disjoint regions I_1, …, I_M, and an error occurs whenever the received signal point does not fall in the region Ik associated with the message point m_k. The average probability of symbol error, also known as the average symbol error rate (SER), when symbols are equally-likely, is as follows:

$$P_{SER} = \sum_{i=1}^{M} P(m_i) P\left(\frac{e}{m_i}\right)$$

$$= \sum_{i=1}^{M} P(m_i) P\left(\frac{r \notin I_i}{m_i}\right) = 1 - \sum_{i=1}^{M} P(n)$$

$$= \quad 1 - \frac{1}{M}\sum_{i=1}^{M} P\left(\frac{r \notin I_i}{m_i}\right) = 1 - \frac{1}{M}\sum_{i=1}^{M} \int f_{\frac{r}{si}}(r/si)dr$$

where the integral is N-dimensional, and in general, the N-dimensional integration cannot be analytically done, and instead it should be numerically calculated.

Fig.4.1 shows the waveform of comparison of SER Performance of the OFDM System with different cancellation factors (CF) such as CF=4,6,7,8,9 and 4-QAM Scheme. Fig.4.2 SER Performance of the OFDM System with different cancellation factors (CF) and 8-QAM Scheme has shown. Fig.4.3 SER Performance of the OFDM System with different cancellation factors (CF) and 16-QAM Scheme has been shown.

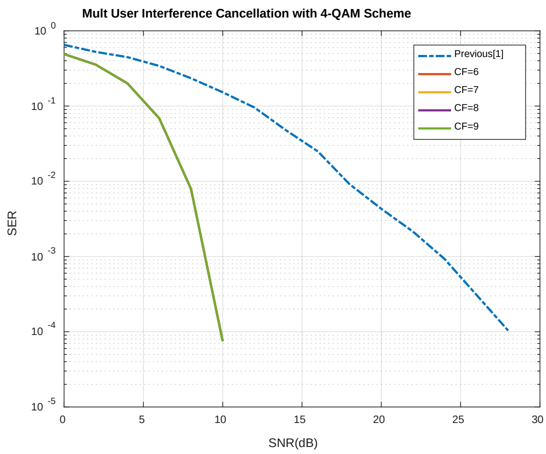

Fig.4.1 SER Performance of the OFDM System with different cancellation factors(CF) and 4-QAM Scheme

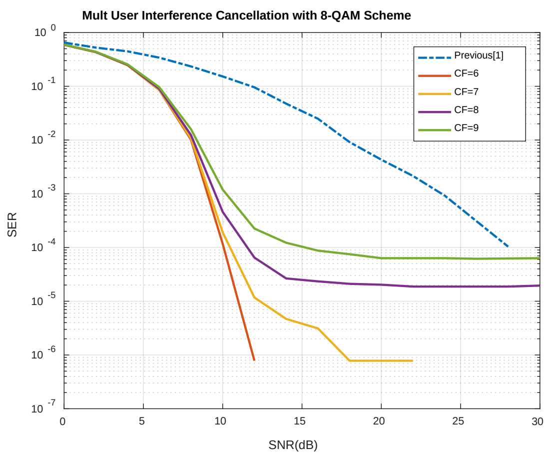

Fig.4.2 SER Performance of the OFDM System with different cancellation factors (CF) and 8-QAM Scheme

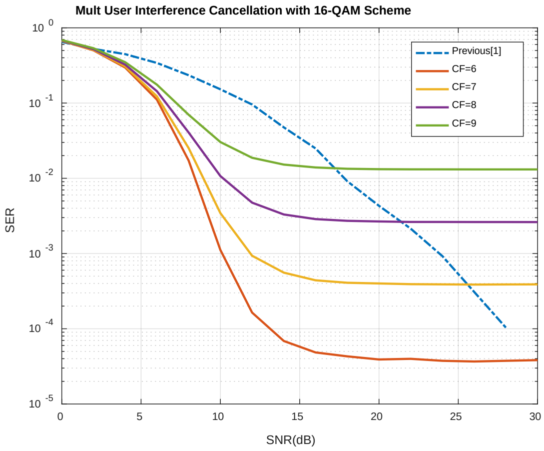

Fig.4.3 SER Performance of the OFDM System with different cancellation factors (CF) and 16-QAM Scheme

V. CONCLUSION AND FUTURE SCOPES

While wireless systems are continually upgrading to the newer generation and higher capacity, their supporting wired networks urgently require advancements in both architecture and enabling technologies. The objective of the research was to design and experimentally verify high-capacity communication systems using Nonlinear Interference Cancellation in MU-OFDM System technologies.

The most important technology that is trending in wireless communication is OFDM. There are many standards using OFDM or its variant. Consequently all the frameworks need to face the essential disadvantage of high peak and interference brought about in ordinary OFDM system. Efficient techniques have been implemented and simulated in MATLAB to reduce the interference and peak of the signal to an acceptable limit. The performance of proposed system has been examined based on comparison of symbol error rate (SER). The comparison outcome shows that proposed system have better SER performance against previous system.

In future work the number of candidates of the signal should be reduced to further reduce the complexity of the system. This can also reduce the time to process the signal. The analysis of avoiding side information that is required to decode the information from the signal at the receiver need to be done.

The spectrum of the signal with and without interference and peak power reduction techniques need to observed. The effect of frequency offset on the spectrum of the signal and also the Bit Error Rate performance due to this frequency offset need to be observed.

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