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Research Article

ANALYSIS OF CLIPPING NOISE IN OFDM BY USING QPSK MODULATION

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ABSTRACT

The aim of the project is to analysis the performance of clipping noise in OFDM by using QPSK modulation with four subcarriers. Now a days in digital communication system in long distance transmission the optical fiber cable will be widely used called optical wireless communication (OWC) systems. orthogonal frequency-division multiplexing (OFDM) systems employing coded modulation Clipping is applied to reduce the peak-to-average-power-ratio (PAPR) of the transmit signal. But clipping noise will be occurred on OWC systems employing OFDM is investigated. There are two existing optical OFDM transmission schemes 1. Asymmetrically clipped optical OFDM (ACO-OFDM) and 2. Direct current biased clipped optical OFDM (DCO-OFDM). The Time domain signal clipping generally results from direct current (DC) biasing and/or from physical limitations of the transmitter front-end. Analytical expressions for the attenuation factor and the clipping noise variance are determined in closed- form and employed in the derivation of the electrical signal-to- noise ratio (SNR). The validity of the model is verified through a bit-error ratio (BER) simulation. Finally the BER performance of ACO-OFDM with DCO-OFDM is compared for different clipping levels and multi level QPSK modulation schemes for ACO and DCO.

Keywords: Clipping noise, Modulation, attenuation, Bit-error ratio.

INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) has become increasingly popular as a communication technique for achieving excellent performance with reasonable computational complexity. Multicarrier modulation techniques have been adopted for transmission over Asymmetric Digital Subscriber Line (ADSL)[1], In the OFC system the QPSK modulation technique will be commonly used like television cable broadcasting , internet broadband service, Digital Television European and Australian standard Wireless Local Area Networks (LANs). Hiperlan[2] ADSL (asymmetric digital subscriber loop) High speed data transmitted along existing telephone lines, etc,. A fundamental goal of modeling fiber communications systems is to understand the physics of the system behavior and to develop computational tools to design systems and predict their performance. Transmission of data through a fiber-optic link unavoidably leads to bit errors due to various effects, the dominant of which are noise from optical amplifiers, fiber nonlinearity, polarization effects, and non-ideal transmitters and receivers. There exist numerous studies that provide techniques to characterize all of these effects and to calculate the bit error ratio (BER) due to them. However, there are still many important unanswered questions and one of them is how to accurately calculate the bit error ratio (BER) in the presence of nonlinear signal distortion. Why is a careful analysis of nonlinear effects in optical fiber communications?

systems important Nearly all modern systems operate in the linear propagation regime, in which the signal evolution is almost linear. However, there always exist small nonlinear interactions and small nonlinear signal distortions accumulated during transmission over hundreds and thousands of kilometers can lead to an increase in the error rate. Reducing the optical power decreases the importance of the nonlinear interactions, but it also decreases the signal-to-noise ratio. There exists an optimal power level at which the BER is minimal. Even if the power level is much lower than optimum, the accumulation of nonlinear distortions during transmission over hundreds or thousands of kilometers of BER can introduce a significant system penalty. Calculating the BER in such a regime or finding the optimal power level requires an accurate model of the nonlinear interactions. A well known modulation technique with an inherent robustness to multipath dispersion is the OFDM transmission scheme. In O-OFDM, the time domain signal envelope is utilized to modulate the intensity of the LED[4]. For this purpose, the signal needs to be real and non-negative. A real-valued time domain signal is obtained when Hermitian symmetry is imposed on the OFDM subcarriers. One approach to obtain a non-negative signal, known as DCO-OFDM, is the addition of a DC bias. A closely related technique, the discrete multi-tone (DMT) modulation, has been employed for digital subscriber line (DSL) data transmission. Another approach, known as ACO-OFDM, is proposed by Armstrong. In comparison to DCO-OFDM, ACO-OFDM achieves an increase in the optical power efficiency at the expense of a 50% reduction in spectral efficiency. By enabling the odd subcarriers for data transmission and setting the even ones to zero, the negative part of the time domain signal can be clipped at the transmitter without any information loss. The information can be still successfully decoded from the odd subcarriers at the receiver. Imperfections of the optical front-ends due to the use of off-the-shelf components result in a non-linear distortion of the transmitted signal such as non-linear transfer effects or signal clipping. An OFDM system employs the inverse fast Fourier transform (IFFT) as a multiplexing technique at the transmitter.

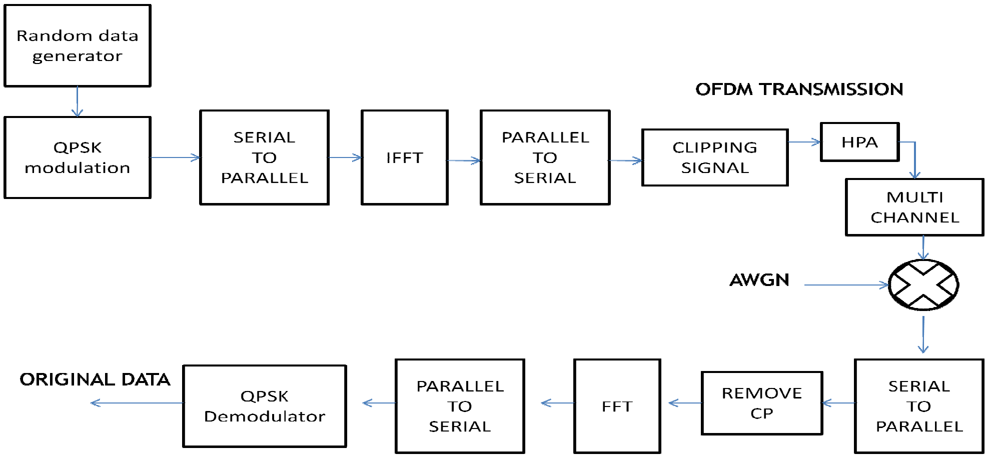


Figure 2: Block diagram of the OFDM system.

RANDOM DATA GENERATOR

It generates the random data of first 100000 bits in the form of 0,s and 1,s and applied as an input to the transmitter.

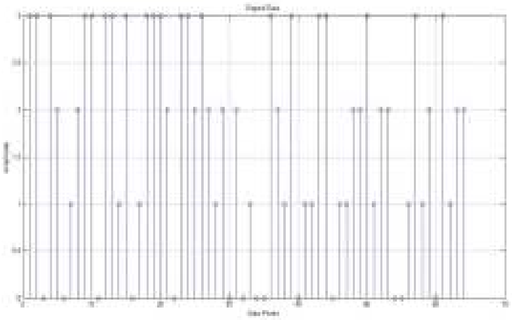


Figure 3: Original signal to transmit

DIGITAL MODULATION

Digital Modulation is the principle of dividing the data streams into several bit streams, each has a much lower bit rate, and by using these bit streams to modulate several carriers. In digital communication system the selection of the modulation technique is highly important. The objective of a digital communication system is to transmit digital data between two or more nodes . This is performed in real systems with a modulator at the transmitting end and a demodulator at the receiving end.

QUADRATURE PHASE SHIFT KEYING (QPSK)

In QPSK, the data bits to be modulated are grouped into symbols, each containing two bits, and each symbol can take on one of four possible values: 00, 01, 10, or 11. During each symbol interval, the modulator shifts the carrier to one of four possible phases corresponding to the four possible values of the input symbol. In the ideal case, the phases are each 90 degrees apart, and these phases are usually selected such that the signal constellation matches the configuration.

$$I \cos \omega ct + Q \sin \omega ct = R \cos (\omega ct + \theta) \qquad (4.1)$$

Where

$$R = \sqrt{I^2 + Q^2}$$

$$\theta = \tan^{-1}(Q/I)$$

QPSK use four constellation points, 0, 90, -90 and 180. Each constellation points representing two bits of data. QPSK uses more symbols as compared to BPSK. Figure 3.2 shows the QPSK constellations.

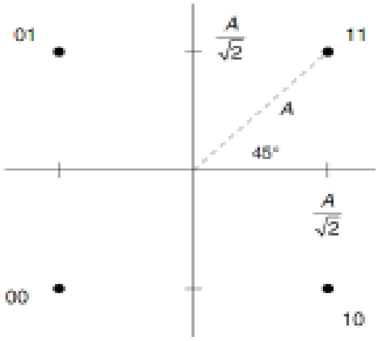


Figure 4: QPSK constellations model

When I and Q take on values of ±A/ 2 in all possible combinations, the phase of the resulting output signal takes on values of 45, 135, 225, and 315 degrees. If the output of this modulator is to be represented in complex-envelope form referenced to the carrier frequency, the modulated signal is given simply as x(t) = I(t) + jQ(t)

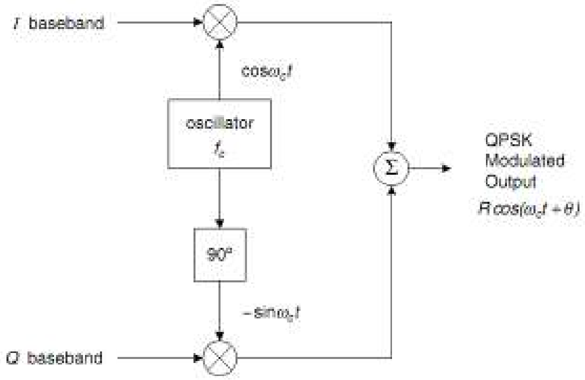


Figure 5: Block diagram of QPSK modulator.

Simulation of this idealized signal requires only a trivial model of the modulator.

$$S_{QPSK} = \sqrt{\frac{2E_S}{T_s}}\cos\left(2\pi f_c t + (i-1)\frac{\pi}{2}\right) \quad \text{for } i = 1,2,3,4$$

- i. **Four** different phase states in **one** symbol period
- ii. **Two** bits of information in each symbol
- iii. Phase: 0 π/2 π 3π/2 → possible phase values
- iv. Symbol: 00 01 11 10

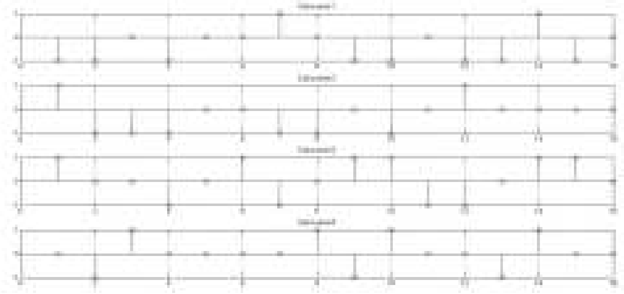


Figure 6: Subcarrier for QPSK.

The block diagram for a quadrature demodulator is shown in Figure 7. Prior to lowpass filtering, the output of each multiplier will contain both baseband components and “double-frequency” components. A segment of the I -channel multiplier output for the case of QPSK is shown in Figure 9.6. The lowpass filters remove the double-frequency components, leaving just the baseband components. In the ideal case, the filtered I and Q outputs duplicate the I and Q waveforms that were originally input to the quadrature modulator at the transmitter. For the case of QPSK, the I and Q outputs from the quadrature demodulator can be processed separately as independent binary waveforms. Figure 9.7 shows how a quadrature demodulator can be augmented for demodulation of QPSK. The processing needed to recover bit clocks from the I and Q baseband waveforms

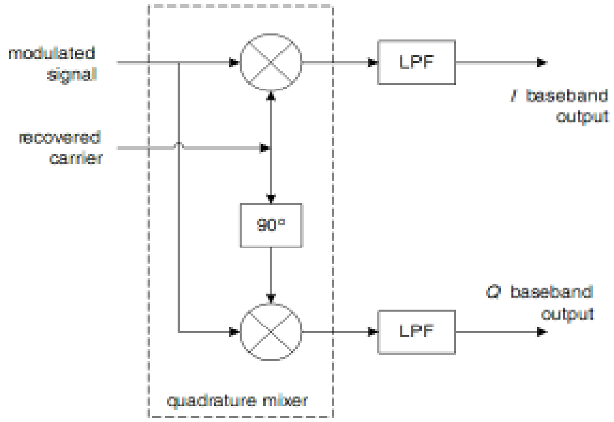


Figure 7: Quadrature demodulator.

ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING (OFDM)

OFDM is a multi-carrier digital modulation technique that has been recognized as an excellent method for high speed bi-directional wireless data communication. OFDM effectively squeezes multiple modulated carriers tightly together, reducing the required bandwidth but keeping the modulated signals orthogonal so they do not interfere with each other.

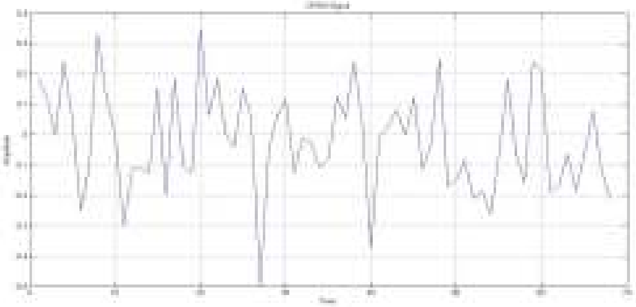


Figure 5.1 OFDM Signal

OFDM is similar to FDM but much more spectrally efficient by spacing the sub-channels much closer together (until they are actually overlapping). This is done by finding frequencies that are orthogonal, which means that they are perpendicular in a mathematical sense, allowing the spectrum of each sub-channel to overlap another without interfering with it. In Figure 8 the effect of this is seen, as the required bandwidth is greatly reduced by removing guard bands (which are present in FDM) and allowing signals to overlap.

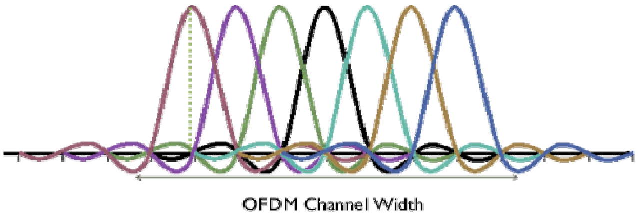


Figure 8: Spectrum overlap in OFDM.

It shows a detailed OFDM communications system. The orthogonality can be completely maintained, even though the signal passes through a time dispersive channel by the cyclic prefix (CP). The CP is the copy of the last part of the OFDM

symbol which is prepended to the transmitted symbol, this makes the transmitted signal periodic which plays a decisive roll in avoiding intersymbol and intercarrier interference .
Although the cyclic prefix is introduces a signal to noise ratio (SRN). It is usually a small price to pay to mitigate interference. The CP denotes the insertion and deletion of the cyclic prefix. The details of OFDM transmitter and receiver structure are succinctly presented in the block diagram below. We note that the OFDM systems basically involve transmission of a cyclic prefixed signal over a fading multipath channel. The prime goal of this tutorial is to explain the significance of Cyclic Prefix.

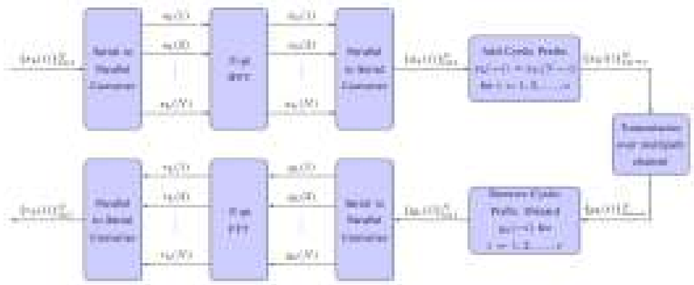


Figure 9: OFDM Transmit Receive Structure

The input symbols {sk(i)}Ni=1 denotes the transmit symbols for the k−th OFDM block. These symbols may come for instance from a M-QAM constellation. N denotes the number of OFDM sub-carriers (the number of constellation symbols to be transmitted in one OFDM block). After serial to parallel conversion of the input symbol stream, a N-pt IFFT is taken to get1{xk(i)}Ni=1. After back parallel to serial conversion, a cyclic redundancy of length ν (the number of CP samples) is added as a prefix in such a way that $x_k(-i) = x$ $(N-i)$ for $i = 1, 2, \dots, \nu$.

Cyclic prefix in multipath channel

Cyclic prefix acts as a buffer region where delayed information from the previous symbols can get stored. The receiver has to exclude samples from the cyclic prefix which got corrupted by the previous symbol when choosing the samples for an OFDM symbol. Further, from the previous section, we learned that a sinusoidal added with a delayed version of the same sinusoidal does not affect the frequency of the sinusoidal (it only affects the amplitude and phase).

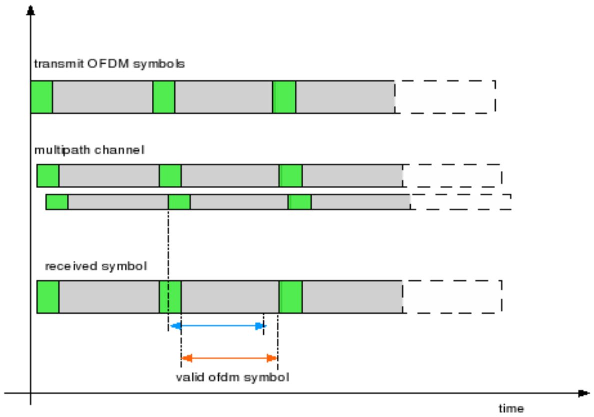


Figure 10: OFDM symbol with multipath

$$\phi_k(t) = \begin{cases} \frac{1}{\sqrt{T-T_{cp}}} e^{j2\pi \frac{k}{T}\Delta(t-T_{cp})} & \text{if } t \in [0,T] \\ 0 & \text{otherwise} \end{cases} \qquad (1.1)$$

Each block is briefly defined below:

a. Multipath

More than one transmission path between transmitter and receiver Received signal is the sum of any versions of the transmitted signal with varying delay and attenuation

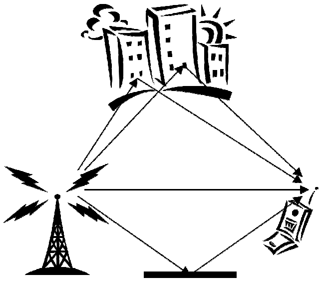
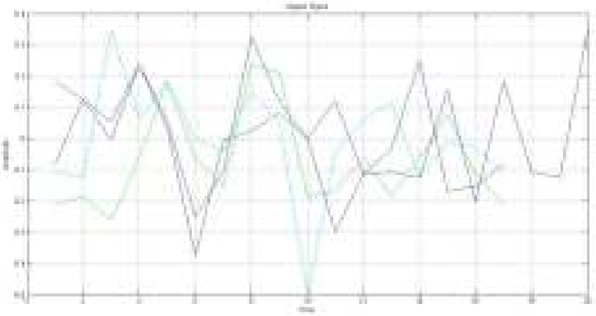


Figure 11: multipath model

CLIPPING NOISE

The non-linear transfer effects due to the short dynamic range of high-power amplifiers (HPA) in OFDM-based RF systems are studied. In OWC, the nonlinear transfer characteristic of the LED can be compensated by pre-distortion. Symmetric signal clipping due to the large peak-to-average-power ratio (PAPR) in RF OFDM is studied. Equivalently, symmetric signal clipping in optical OFDM



IFFT & FFT

A fast Fourier transform (FFT) is an algorithm to compute the discrete Fourier transform (DFT) and its inverse. A Fourier transform converts time (or space) to frequency and vice versa; an FFT rapidly computes such transformations.

Figure 7.1

$$X_k = \sum_{n=0}^{N-1} x_n e^{-i2\pi k \frac{n}{N}} \qquad k = 0, \dots, N-1.$$

The use of the IFFT in OFDM By the use of the Inverse Fast Fourier Transform (IFFT) algorithm. It can be better because it allows precise control. Exploits frequency diversity and helps reduce the transmitter complexity/power consumption.

VI. Error Performance

The probability of bit error for QPSK is obtained as

$$P_b = Q\sqrt{\frac{2E_b}{N_o}} = \frac{1}{2}erfc(\sqrt{\frac{E_b}{N_o}})$$

where Q(x) is the Q-function defined in Appendix B, Section B.2. The probability of making a correct bit decision is (1 − Pb) and the probability of making a correct symbol decision equals the probability of making correct decisions for both bits in the symbol or

$$P_c = (1 - P_b)^2 = 1 - 2P_b + P^2$$

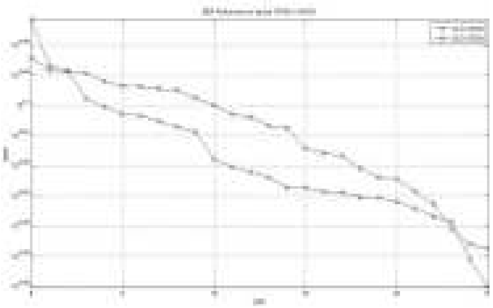


Figure 12: BER performance of ACO & DCO OFDM

CONCLUSION

In this paper to test Conditional hard detection introduces significant SNR gain (equivalent to coding gain), with insignificant increase of system complexity, for the clipping mitigation systems that estimate the clipping distortion from the estimate of the transmit data.

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