BER and PAPR Reduction in OFDM System By Using Companding Technique

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Abstract

One of the challenging issues for OFDM is its high Peak to Average Power Ratio (PAPR) which limits its applications in wireless communication systems using multicarrier modulation technique as OFDM, which reduces the efficiency of transmit high power amplifier. In this paper, we introduced companding technique with different value of µ. Later in this paper, simulation results show the PAPR and BER performance and then comparison by changing modulation scheme without any technique and with companding technique are evaluated.

Keywords

Peak to average power ratio (PAPR),Bit error rate (BER),Complementary Cumulative Distribution Function (CCDF).Orthogonal frequency division multiplexing (OFDM),

1. Introduction

Companding is a signal processing technique used in the digital systems primary in audio such as microphones (more effectively in wireless) to reduce the noise levels in the sound quality mainly owing to low-level radio frequency interference in the frequency channel. Literally, the term "companding" is composed of the words "compressing" and "expanding"[1]. By using companding technique in a wireless system, the audio signal is compressed in the transmitter and expanded in the receiver. The deviation in the frequency ranges of the audio deviation in compression process reduces before it is transmitted and that is restored to the original frequency ranges by the expansion process at the receiver's end [2, 3].

The objective of the companding process is to preserve the signal-to-noise ratio of the original audio. In the digital systems companding is also used by compressing the signals before input to an analog-to-digital converter, and then expanding after a digital-to-analog converter [4]. A-law and µ-law follows by T-carrier telephone system implements the companding. This technique is also used in the digital file formats for better signal-to-noise ratio (SNR) at very low bit rates. Two international standards for encoding signal data to 8-bit codes are A-law and µ-law. µ-law is the accepted standard in the United States and Japan while A-law is the accepted European standard [5,6]. Here we use µ-law companding. In this paper we first present PAPR evaluation by changing modulation scheme without any technique and with companding technique.

The remainder of the paper is organized as follows:

In section II, PAPR in OFDM system. While Reduction techniques are describes in section III, comparative simulation results are presented in section IV. Finally conclusions are given in section V.

2. PAPR IN OFDM SYSTEM

In this section, we discuss the basic of OFDM system and the definition of PAPR. OFDM signal may be generated by an *N*- point inverse Fast

Fourier Transform (IFFT) in the transmitter, and the Fast Fourier Transform (FFT) is employed at the receiver to restore the signal.

If we consider N modulated data symbols from a particular signaling constellation, $X_k = (X_1, . . ., X_{n-1})$, over a time interval $[0, T]$, the OFDM symbol can be written as,

$$x(t) = \sum_{k=0}^{n-1} X_k e^{j2\pi k f_0 t} \qquad (1)$$

where $f_0 = 1/T$.

Replacing $t = n.T_b$, where $T_b = T/N$, the discrete time version can be given by:

$$x_n = \sum_{k=0}^{n-1} X_k e^{j2\pi kn/N} \qquad (2)$$

The PAPR of the signal, $x(t)$, is then given as the ratio of the peak instantaneous power to the average power, written as [9]:

$$PAPR = \max_{0<t<T} \frac{|x(t)|^2}{E[|X(T)|^2\}} \qquad (3)$$

Where $E[\cdot]$ denotes the expectation operator. In practice, the occurrence of these large PAPR requires inefficient hardware design and implementations and also affects bit error rate during signal transmission. The first problem of inefficient hardware design will be discussed. The PAPR ratio is a measure of the dynamic range in OFDM signals. Thus high PAPR induces a high dynamic range which describes high variability in the signal range. The large PAPR levels increases the implementation complexity (the number of quantization bits) of the A/D and the D/A converters such that large peaks can be represented with good precision [7,8]. To avoid any loss of information, these large dynamic ranges must be compensated by the hardware such as A/D and D/A converters through hardware design. Because high PAPR signals generally exhibit high energy concentrations over small portions of the signal, the designing of hardware to compensate for only a small fraction of the signal leads to inefficiency in design and implementation costs. Another problem which is experienced by OFDM signals that have high PAPR involves the development of non-linear distortions. High power amplifiers used at the transmitters only perform effectively when signals passing through the amplifier are within the dynamic range, catered by the amplifiers. When amplifiers limit the transfer of large induced peak powers in signals, amplifiers are then forced to operate in the non-linear regions creating non-linear distortions. These non-linear distortions are a major problem that causes out of band radiation which influences BER. The ideal condition is that the power amplifier is intuitively recoverable to

their original form. Once distortions are nonlinear, the changing in signals is no longer predictable or recoverable. The CCDF of the PAPR denotes the probability that the PAPR of a data block exceeds a certain threshold $PAPR_0$.

$$CCDF\left(PAPR(x(t))\right) = P_r(PAPR(x(t)) > PAPR_0) \quad (4)$$

The cumulative distribution function (CDF) of the PAPR is one of the most frequently used performance measures for PAPR reduction techniques. Then, according to the central limit theorem, the real and imaginary part of OFDM signal are Gaussian distributed while the amplitude and phase have Rayleigh and uniform distribution, respectively.

3. Proposed Technique

The principles of the used techniques which are companding will be studied in the following.

Companding Technique

The compander consists of compressor and expander. The compressor is a simple logarithm computation. The reverse computation of a compressor is called an expander. In this paper, the compression at the transmit end after the IFFT process and expansion at the receiver end prior to FFT process are used. There are two types of companders that are used here which are described in details in [9,10]. These two types are μ-law and A-law companders.

μ-law Companding:

The μ-law compander employs the logarithmic function at the transmitting side. In general a μ law compression characteristic:

$$y = \frac{\log_e(1+\frac{\mu|x|}{V}}{\log_e(1+\mu)} \text{sgn}(x) \dots\dots\dots\dots(5)$$

where μ is the μ-law parameter of the compander, where x: input signal, V : is the maximum value of the signal x. μ: parameter controls the amount of compression. The maximum value of output y is the same maximum of input x is equal V.

For normalized input signal with $|x| \leq 1$, the characteristic becomes:

$$y = \frac{\log(1+\mu|x|)}{\log(1+\mu))} \quad \dots\dots\dots\dots\dots(6)$$

The μ-law expander is the inverse of the compressor:

$$X = \frac{V}{\mu} (e^{|y| \log\frac{(1+\mu)}{v}} - 1) \text{sgn}(y) \dots\dots (7)$$
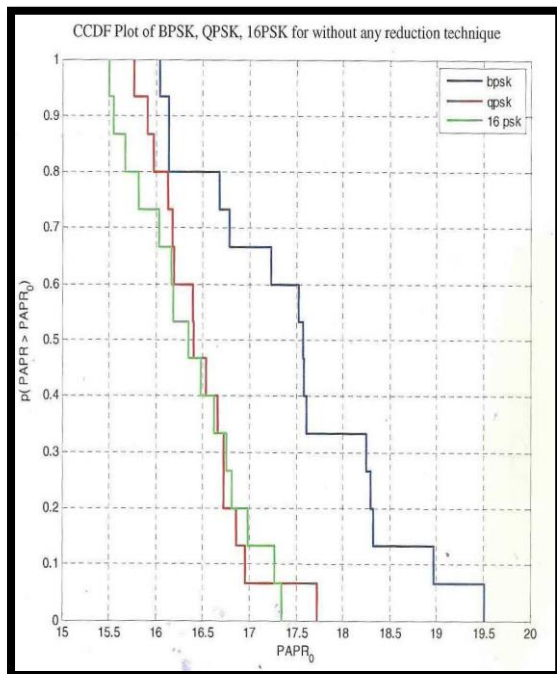
A-law Companding

The characteristic of this compander is given by:

$$y = \begin{cases} \dfrac{1+\ln A|x|}{1+\ln A}, & \dfrac{1}{A} \le |x| \le 1 \\ \dfrac{A|x|}{1+\ln A}, & 0 \le |x| \le \dfrac{1}{A} \end{cases} \quad \text{......(8)}$$

A: parameter controls the amount of compression.

4. SIMULATION RESULTS

In this section the comparison for PAPR values of BPSK, QPSK and 16PSK modulation schemes are used without reduction technique and with companding reduction technique are evaluated. Here, simulation was carried out for companding technique. Simulation was carried out for both type of channels (multipath and AWGN) [11]. In companding technique μ law companding is used. In figure 1, the maximum value of PAPR is 19.5dB for BPSK modulation scheme, the value of PAPR is 17.75 dB and 17.25 dB respectively for QPSK and 16PSK modulation scheme in case of without reduction technique. The graph concludes that QPSK & 16PSK modulation scheme are better than the BPSK modulation scheme by an amount of 2 dB in concern with the peak to average power ratio (without any reduction technique)
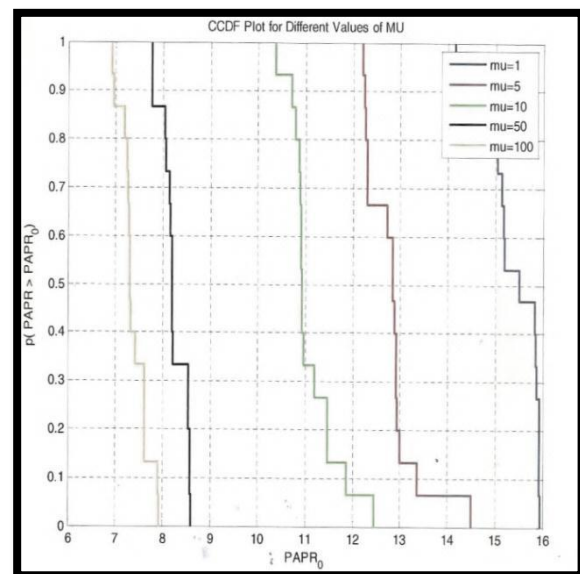

Figure 1: CCDF plot for BPSK, QPSK & 16PSK without any reduction technique

In figure 2 value of PAPR is 8.7 dB while using companding technique along with of BPSK

modulation scheme, the value of PAPR is 8.5 dB in case of QPSK and 16PSK modulation scheme.
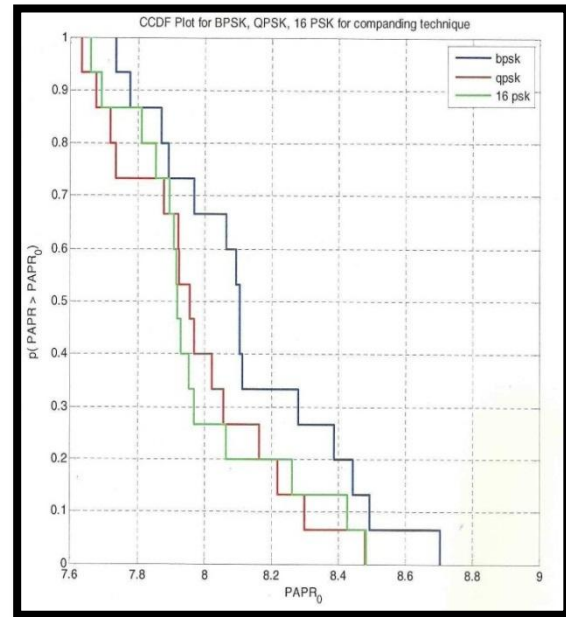
Figure2: CCDF plot for BPSK, QPSK & 16PSK with companding technique

Figure 3: CCDF Plot for different values of μ

So there is no significant change in the value of PAPR while changing the modulation scheme. The graph concludes that any modulation scheme BPSK, QPSK &16PSK is used in case of companding technique. By using this method the PAPR get reduced to 8.5 dB from 19.5 dB (without any reduction technique) In companding technique μ law companding is used. The range of μ is from 1 to 255, In this work the value of μ is taken between 1 to 100.

In figure3 for different values of μ is shown, with μ is varying from 1 to 100. The value of PAPR is 16 dB when the value of μ is 1.Simulation was carried out for both type of channels (multipath and AWGN). The values of PAPR are 14.5 dB, 12.5dB,7.9dB for μ is 5, 10, 50, 100 respectively. So, the large is the value μ of, effective is the reduction in PAPR. For reduction of large amount of PAPR, large value of μ is to be taken.

Figure4: BER Plot for different value of μ

Figure4 shows the BER and E_b/N_o graph for different value ofμ, the value of μ varies from 1 to 100. When the value of μ is increased from 1 to 10, then BER gets reduced. After that when the value of μ is increased to 100, BER is also increased. So, from the BER graph for the different values of μ, it is observed that, when the value of μ has been increased to 10, then BER gets reduced, after that when the value of μ is increased, then BER starts increasing. Therefore, a trade-off is required between PAPR performance and BER evaluation while selecting the value of μ.

5. Conclusion

In this paper, proposed technique for PAPR reduction of OFDM signals had been introduced. The companding technique uses the μ-law with suitable value of μ. Also, it is observed that when the value of μ has been increased 1to 10, then BER gets reduced, after that when the value of μ is increased, then BER starts increasing.

Therefore, a trade-off is required between PAPR performance and BER evaluation while selecting the value ofμ.

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