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BER AND PAPR REDUCTION OF OFDM USING NEW COMPANDING TECHNIQUES

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Abstract--- *In multipath propagation systems OFDM provides good choice but also suffers with high peak to average power ratio (PAPR) at the transmitter side.For high rate data transmission in wireless communication, OFDM system is one which attracts every researcher towards it. Because, it has several advantages such as high number of orthogonal sub-carriers, no inter-symbol interference, high spectral efficiency, tolerance in multipath delay spread, power efficiency, frequency selective fading immunity etc. Among all above advantage it has one major flaw of peak-to-average-power ratio (PAPR). In fact, PAPR in OFDM system is the most detrimental aspect which degrades power and spectral spreading. In previous techniques they are used clipping and filtering method. In clipping method the PAPR is reduced according to the clipping limit only so PAPR reduction is less. For improvement of the PAPR reduction we propose novel techniques i) PAPR reduction using Pre-coding ii) PAPR reduction using Companding technique. We use both μ- law and A-law companding technique. This method gives lesser complexity, higher efficiency, and greater stability.*

Keywords: Orthogonal frequency division multiplexing(OFDM), companding, de-companding, pre-coder and PAPR.

1. INTRODUCTION

All the traditional single carrier based modulation schemes can achieve the less data rates, because of complexities in the receivers and multipath fading of wireless channels. But, we need higher data rates in applications of present wireless network and multimedia [1]. However, the duration of symbols will gets reduced while increasing the data rates in communication systems. Hence, the modulation systems which uses single carriers will suffer from inter symbol interference (ISI) due to the diffusive impulse response of the channel which needs a channel equalization mechanism to reduce it there by increase in hardware complexity. In order to overcome this problem, an advanced communication system named as "Orthogonal Frequency Division Multiplexing (OFDM)" has introduced. It uses a modulation system that considers multiple carrier to send the input information. The objective of OFDM is to sub divide the total frequency selective fading channels into many flat fading sub channels with orthogonal narrow band. In OFDM system high-bit-rate data stream is transmitted in parallel over a number of lower data rate subcarriers and do not undergo ISI due to the long symbol duration[2]. Because of higher spectral efficiency, it has been used in many wireless network applications such as digital audio video broadcasting (DAVB) [3] and [5], Wireless Personal Area Network (WPAN), Wireless Local Area Network (WLAN) [4], Wireless Metropolitan Area Network (WMAN). It is also plays a vital role in IEEE 802.2, 802.16 [6], [7] and even in long term evaluation (LTE) i.e., 4G networks for very high speed packet access (HSPA+). But however, in real time practical application the communication will depends on limitation of peak power.

In such cases, OFDM has a major issue that is higher amplitude fluctuations i.e., large fluctuations in envelope. These fluctuations will create some serious

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problems or difficulties, which is known as peak to average power ratio (PAPR) or peak to mean power ratio (PMAR). It degrades the system efficiency which in results complexity in the digital to analog converts (DAC), analog to digital converters (ADC) and lowers the efficiency of power amplifiers (PAs). Hence, it is necessary to amplify these peak signals to get the normalized signal thereby reduce the PAPR. To do so, we require the Pas with large linear range, which makes it more expensive. If PA has limited linear range, then its operation in nonlinear mode introduces out of band radiation and in band distortion. It is also necessary to have D/A and A/D converters with large dynamic range to convert discrete time OFDM signal to analog signal and vice versa. To overcome the effects of PAPR a combination of both precoding and companding is proposed in this paper

2. PAPR IN OFDM SYSTEM

In this paper, we consider an OFDM system with M-QAM modulation and take a total of N baseband modulated symbols per OFDM block. Figure (1) illustrates that in an OFDM system first of all , the serial input baseband modulated symbols are converted in to parallel stream The output data vector is assumed as: X=[X1, X2, … , XN]T and Xi is ith data symbol. Than OFDM signal is calculated using the 'N' point IFFT. Oversampling is recommended for the better approximation of the PAPR of the continuous-time OFDM signals, the. It can be implemented by computing an LN-point IFFT of the data block with (L-1) N zero-padding and the oversampled IFFT output can be expressed as:

$$x[n] = \frac{1}{\sqrt{LN}} \sum_{k=0}^{LN-1} X_k \, e^{j\frac{2\pi}{LN}nk}, \; n = 0, 1, \ldots, LN-1 \quad (1)$$

We are considering the oversample factor as 'L' .The PAPR parameter in any OFDM symbols can be calculated by using the following equation:

$$PAPR = \frac{\max\limits_{0 \le n \le LN-1} |x[n]|^2}{E\left[|x[n]|^2\right]} \quad (2)$$

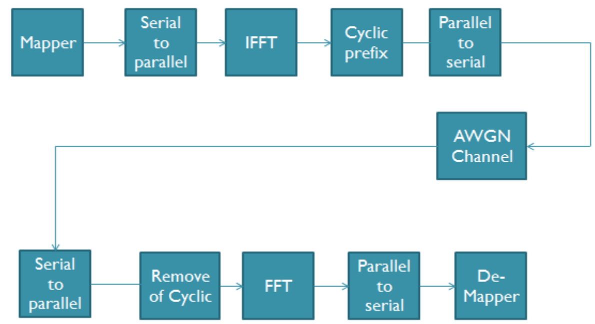

Figure1.A simple block diagram of an OFDM system

When N is large, the distribution of the output time vector converges to Gaussian due to Central Limit Theorem Hence, Complementary Cumulative Distribution Function (CCDF) can be written as:

$$P(PAPR > PAPR_0) = 1 - (1 - e^{-PAPR0})^N \quad (3)$$

In order to obtain sufficient transmission power most of the radio systems employ High Power Amplifiers (HPA) in the transmitters for the achievement of the maximum output power efficiency and for this reason High Power Amplifiers (HPA) are usually operated at or near the saturation region where its input output characteristic is non-linear. But this non linearity makes the HPA very sensitive to the variations of the signal amplitude. Due to the non-linearity of the HPA reduces the spectral efficiency of the OFDM transmitter. Which leads to the variations of the instantaneous power of the OFDM signals and their will be high value of PAPR. Because, the HPA will introduce inter-modulation between the different subcarriers and as a result additional interference and the reduction of the spectral efficiency will occur. If High Power Amplifier (HPA) are operate in its linear region for zero distortion of the OFDM signal, then the HPA with a large dynamic range are require. But these amplifiers are very expensive. Thus, if we reduce the PAPR of the OFDM signal by manipulating the various PAPR reduction techniques on the digital data than we arereducing the cost of OFDM system and reducing the complexity of A/D and D/A converters.

3.PROPOSED TECHNIQUES

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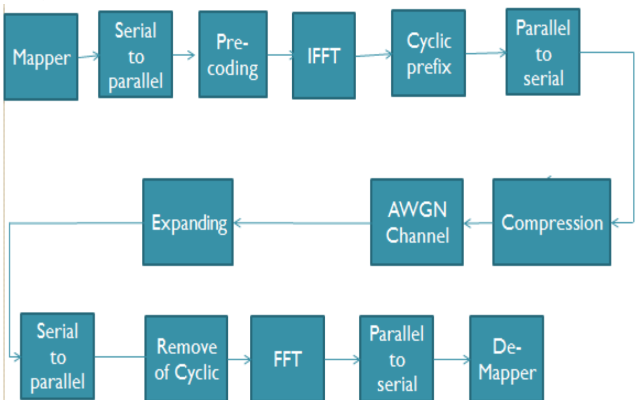
For the PAPR reduction the proposed technique ofPrecoding and Companding will be discussed in the following sections.

3.1.*COMPANDING TECHNIQUES*

In telecommunication and signal processing companding is a method of mitigating the detrimental effects of a channel with limited dynamic range. The name is a combination of the



words compressing and expanding. The use of companding allows signals with a large dynamic range to be transmitted over facilities that have a ompanding is io applications such as professional wireless microphones and analog recording. In practice, companders are designed to operate according to relatively simple dynamic range compressor functions that are designed to be suitable for implementation using simple analog electronic circuits. The two mostpopular compander functions used for elecommunications are the A-law and µ law functions.

Figure2. A simple block diagram of an OFDM system with pre- coding and companding.

Fig.2. shows that the PAPR reduction using companding and de-companding algorithm i.e., companding in the transmitter to reduce the PAPR and the de-companding block in the receiver to calculate the bit error rate (BER).

Let a non-linear companding function is (x), and (t) = sin (ωt) be the compander input, then the companded signal (t) can be written as:

$$y(t) = f[x(t)] = f[\sin(\omega t)] \quad (4)$$

The companding algorithm uses a smooth function named as airy function to reduce the peak value. The companding function is as follows:

$$f(x) = \beta . sign(x). [airy(0) - airy(\alpha . |x|)] \quad (5)$$

Where (.) is the airy function, β is the adjusting factor for the average output power of the compander to the same level of input power.

$$\beta = \sqrt{\frac{E[|x|^2]}{E[|airy(0) - airy(\alpha . |x|)|^2]}} \quad (6)$$

Here E [.] denotes the expectation.And the inverse function for the eq. (6) i.e., de- companding at the receiver section, is expressed as follows:

$$f^{-1}(x) = \frac{1}{\alpha} \cdot sgn(x) \cdot airy^{-1}\left[airy(0) - \frac{|x|}{\beta}\right] \quad (7)$$

Next, we analysed the BER performance of new companding algorithm. Assume, (t) is the compander output signal, channel noise to be considered as additive white Gaussian noise (AWGN) is (t). Then the signal that is received can be expressed as follows:

$$\hat{x} = f^{-1}[z(t)] = f^{-1}[y(t) + w(t)] \quad (8)$$

Now, the signal that is decompanded will be simplified as:

$$\hat{x} = f^{-1}[z(t)] = f^{-1}[y(t) + w(t)] \quad (9)$$

A. A-law companding:

It is similar to the µ-law algorithm used in North America and Japan.

For a given input x, the equation for A-law encoding is as follows,

$$F(x) = \mathrm{sgn}(x)\begin{cases} \frac{A|x|}{1+\log(A)}, & |x| < \frac{1}{A} \\ \frac{1+\log A|x|)}{1+\log(A)}, & \frac{1}{A} \le |x| \le 1, \end{cases} \quad (10)$$

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where A is the compression parameter. A-law expansion is given by the inverse function,

$$F^{-1}(y) = \operatorname{sgn}(y)\begin{cases} \frac{|y|(1+\ln(A))}{A}, & |y| < \frac{1}{1+\ln(A)} \\ \frac{\exp(|y|(1+\ln(A))-1)}{A}, & \frac{1}{1+\ln(A)} \le |y| < 1. \end{cases} \quad (11)$$

The reason for this encoding is that the wide dynamic range of speech does not lend itself well to efficient linear digital encoding. A-law encoding effectively reduces the dynamic range of the signal, thereby increasing the coding efficiency and resulting in a signal-to-distortion ratio that is superior to that obtained by linear encoding for a given number of bits.

B. µ -Law Companding:

The µ-law algorithm (sometimes written "µ -law", often approximated as "µ-law") is a companding algorithm, primarily in 8-bit PCM digital telecommunicationsystems inNorth America and Japan. Companding algorithms reduce the dynamic range of an audio signal. In analog systems, this can increase the signal-to-noise ratio (SNR) achieved during transmission; in the digital domain, it can reduce the quantization error (hence increasing signal to quantization noise ratio). These SNR increases can be traded instead for reduced bandwidth for equivalent SNR.

It is similar to the A-law algorithm used in regions where digital telecommunication signals are carried on E-1 circuits, e.g. Europe.hereare two forms of this algorithm an analog version, and a quantized digital version.

Continuous

For a given input x, the equation for µ-law encoding is

$$F(x) = \operatorname{sgn}(x)\frac{\ln(1+\mu|x|)}{\ln(1+\mu)} \quad -1 \le x \le 1 \quad (12)$$

where µ = 255 (8 bits) in the North American and Japanese standards. It is important to note that the range of this function is –1 to 1.

µ-law expansion is then given by the inverse equation:

$$F^{-1}(y) = \operatorname{sgn}(y)(1/\mu)((1+\mu)^{|y|} - 1) \quad -1 \le y \le 1 \quad (13)$$

The equations are culled from Cisco's Waveform Coding Techniques.

C. Pre-coding Scheme

Pre-coder based OFDM system which uses a pre-coding matrix to multiply the modulated signal and then by applying inverse FFT to reduce the PAPR. The complex baseband OFDM signal with N sub carriers can be written as

$$x(t) = \frac{1}{\sqrt{N}}\sum_{k=0}^{N-1} P.X_k\, e^{j2\pi k\Delta f} \quad (14)$$

$$0 \le t \le NT$$

Walsh-Hadamard Transform

The Walsh-Hadamard Transform (WHT) is a non sinusoidal and it is an orthogonal technique which decomposes a signal into set of basic functions. These functions are called Walsh functions, The Hadamard transform scheme reduce the occurrence of the high peaks comparing the conventional OFDM system. We used the Hadamard transform because it reduce the autocorrelation of the input sequence to reduce the peak to average power (PAPR) of OFDM signal. It also not requires to send side information to the receiver. The FWHT for a signal x of length N are defined as:

$$y_n = \frac{1}{N}\sum_{i=0}^{N-1} x_i WAL(n.i) \quad (15)$$

OFDM Algorithm steps

Step1: Generate message bit stream by using rand int command in mat lab

Step 2: Encode the message bit using Pre-encoding technique.

Step3: Apply interleaving technique for the encoded data.

Step4: Perform modulation algorithm for interleaved data here we are using two modulation technique they are QAM and PSK use different modulation index value like M=16,256

Step5: Convert that modulation output serial to parallel

Step6: Apply IFFT for modulation data. The IFFT channel length is 64.

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Step7: Generate OFDM channel by using Additive White Gaussian noise.

Step8: Apply FFT for OFDM channel.

Step8: Convert that channel is parallel to serial

Step9: Apply Demodulation technique.

Step 10 : For this channel we apply Decoding that is pre-decoding technique.

Step 11: De interleave the data.

Step12: Apply Companding technique for Received data.

4.SIMULATION RESULT

Below figure shows the simulation of PAPR reduction by using pre-coding and companding technique

This technique is efficient in its own way because it give more reduction in PAPR by changing value of M.

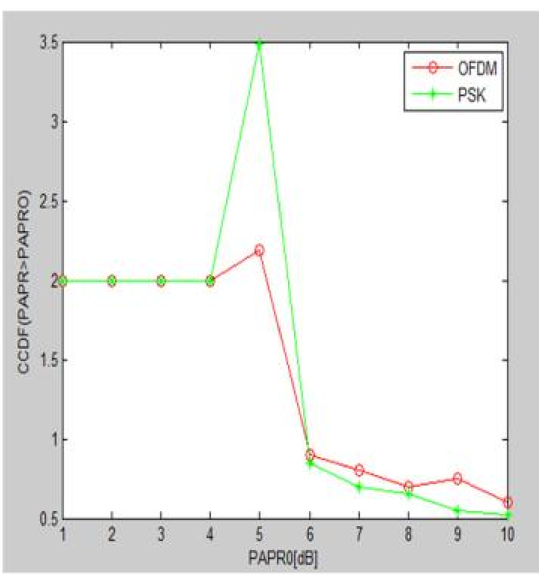

Fig.3.Comparison between OFDM and PSK modulation with M=32 and N=128 using pre-coding techniques

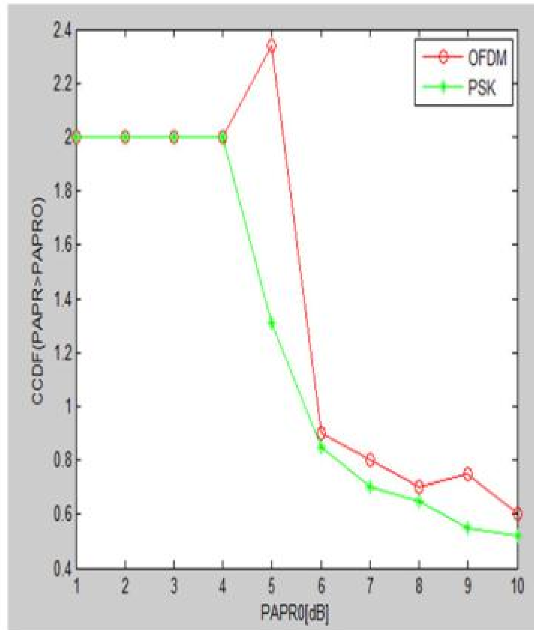

Fig.4.Comparison between OFDM and PSK modulation with M=64 and N=128 using pre-coding techniques

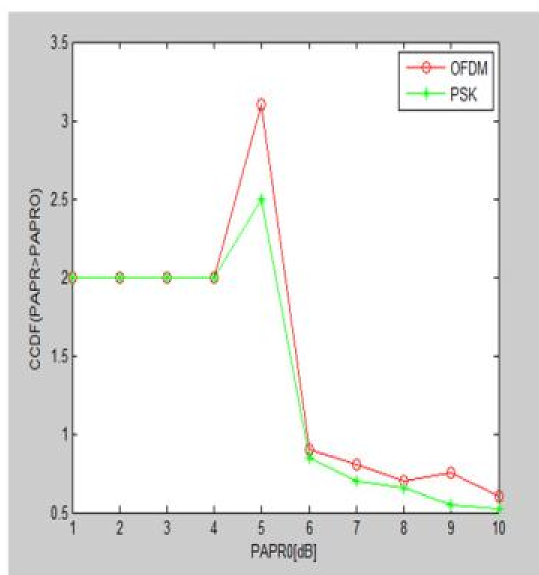

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Fig.5.Comparison between OFDM and PSK modulation with M=128 and N=128 using pre-coding techniques

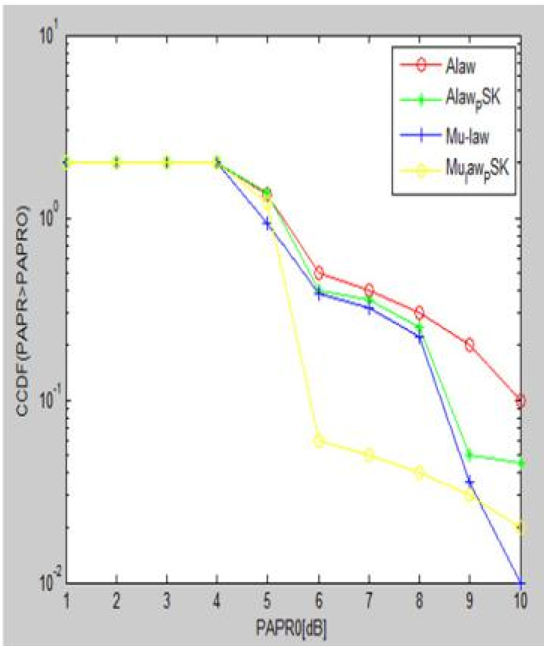

Fig.6.Comparison between A-law and μ-law with M=32 and N=128 or QAM and PSK

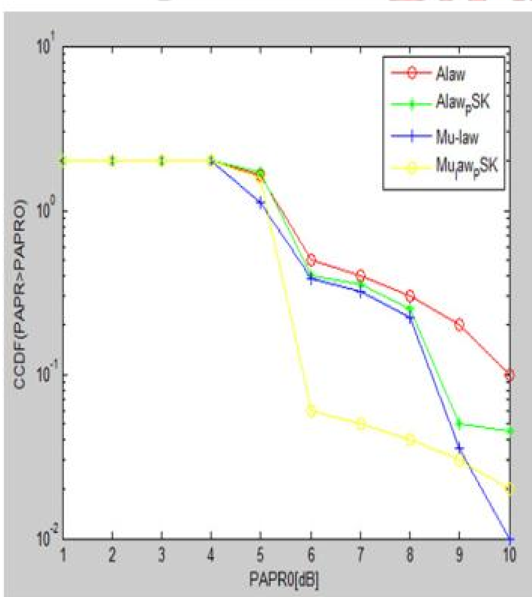

Fig.7.Comparison between A-law and μ-law with M=64 and N=128 or QAM and PSK

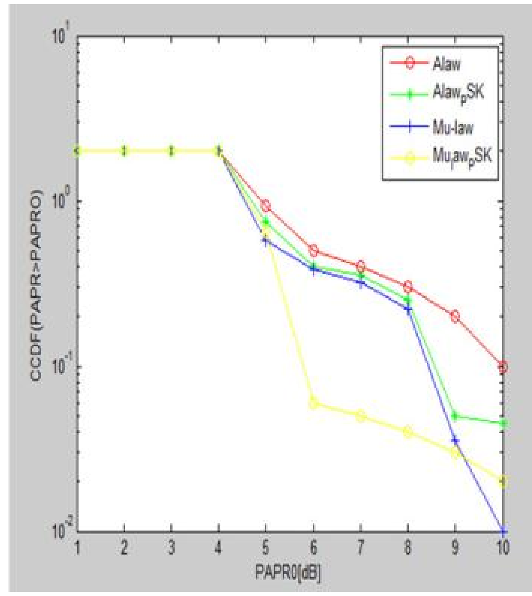

Fig..8.Comparison between A-law and μ-law with M=128 and N=128 or QAM and PSK

x

COMPANDING	M=32	M=64	M=128
PAPR A - LAW-QAM	1.7375Db	1.4013dB	1.1241Db
PAPR A - LAW-PSK	1.6230Db	1.3017dB	0.9851dB
PAPR μ-LAW - QAM	1.5997dB	1.2254dB	0.9704dB
PAPR μ-LAW-PSK	1.0569dB	0.8496dB	0.5690dB

Table.1.Comparisons table of simulation results

5.*CONCULSION AND FUTURE WORK*

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This paper projected and compared techniques for PAPR reduction in OFDM transmission. Projected pre-coding technique is data-independent avoiding block based mostly optimization and companding theme compresses signal to scaleback amplitude distortion. The obtained results show that each the techniques cut back PAPR significantly. Compared to standard OFDM, PAPR is reduced to regarding 4dB.companding technique has been expressed well than pre-coding. Conjointly µ-law companding is healthier than A-law companding. These techniques area unit simply implementable while not optimizing one OFDM block to next.

As a further research work, it involves to include the selected mapping(SLM)and Discrete wavelet transform between the pre-coding techniques

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