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PAPR Reduction in OFDM System using QPSK Modulation and Companding Technique

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Abstract

Orthogonal Frequency Division Multiplexing (OFDM) is a spectrally efficient multicarrier modulation technique for high speed data transmission over multipath fading channels. One of the main issues of OFDM is high Peak-to-Average Power Ratio (PAPR) of the transmitted signal which adversely affects the complexity of power amplifiers. A-Law Companding method is also used in digital file formats and telephony systems for better signal-to-noise ratio (SNR) at lower bit rates. In this paper, Companding technique method is proposed to reduce peak-to-average of OFDM signal. Simulation results show that the proposed scheme may obtain significant PAPR reduction while maintaining good performance in the companding method. In this model this problem can be overcome by using the A-Law Companding Technique. By plotting the graph between BER and SNR it can be prove that this model is efficient.

Keyword :-OFDM, PAPR, BER, Companding, Simulink.

1. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) has become a very popular technique for high data rate transmissions in wireless communication applications. One of the advantages of OFDM is that it has proven to be robust against channel hostilities like multipath distortion and fading. The latest wireless communication applications like WiMAX and DVB-H recommended the use of OFDM transmissions as the principle modulation technique. However, one of the major problem of 'OFDM is the occurrence of high peak -to -average power ratio (PAPR). This imposes the constraint on the transmission power amplifiers due to distortion problems in addition to scaling issues for analog-to-digital and digital-to –analog converters. As the consequence these problems can introduce data reception errors as well as interference with other frequency subcarrier transmissions. [1] A number of PAPR reduction techniques includes for example clipping, windowing, selective mapping (SLM), Partial transmit Sequences (PTS). Recently, companding has been proposed as a tool for reducing the PAPR of OFDM signals. Orthogonal frequency-division multiplexing (OFDM) is a method of encoding digital data on multiple carrier frequencies. OFDM has developed into a popular scheme for wideband digital communication, whether wireless or over copper wires, used in applications such as digital television and audio broadcasting, DSL broadband internet access, wireless networks, and 4G mobile communications.[2] In OFDM transmission Systems when the number of subcarriers increases the Gaussian distributed signal approaches to that of a sample function; Peak-to-average power ratio (PAPR) is a good measure of the resulting occasional peaks. One of the main drawbacks of the OFDM system is the high Peak – to – average Power ratio which leads to increase in complexity of Analog to Digital Converters (ADC) and Digital to Analog Converters (DAC) while introducing intermediation distortion, spectral spreading and undesired out-of band radiation. Large PAPR also leads to Adjacent Channel Interference, degradation of Bit Error Rate (BER) performance and variation of OFDM signal constellation. The above mentioned issues can severely harm the OFDM system performance and demands expensive transmitters for normal operation. Since the positive features of OFDM can support the design of highly effective wireless communication systems, extensive research activities were carried out in the late. Besides a lot of advantages, there are some disadvantages which are:

1] Inter Symbol Interference (ISI) is high.
2] Peak to Average Power Ratio (PAPR) is very high.

2. PAPR PROBLEM IN OFDM

OFDM Consist of no. of independently modulated Subcarriers which can give a large (PAP) ratio. Two main problems occur in High Peak-to-Average Power Ratio one is it increased Complexity of the Analog to Digital and Digital to Analog Converters and another is it reduced efficiency of the RF Power amplifier. PAPR puts a stringent requirement on the Power amplifier and reduces the efficiency in the sense that a higher input back off factor is needed before the peaks in the signal experiences significant distortion due to power amplifier non-linearity. When N number of Sinusoidal signals gets added, the Peak magnitude would have value of N, Where at some time instance, the average might be quite low due to the destructive interference between the Sinusoids or it could be high due to the constructive interference between the sinusoids. In OFDM system, some of the input sequences which are needed to be transmitted would result in higher PAPR than others. So, an input sequence that requires all such carriers. To transmit their maximum amplitudes would certainly result in a high output PAPR. Thus by restricting the possible input sequences to a smallest set of values, there might be possibility to obtain output signals guaranteed low output PAPR [5]. The peak to average power ratio can be defined as the ratio of peak amplitude squared (giving the peak power) divided by RMS value squared (giving average power) as in (1).

$$\mathrm{PAPR} = \frac{|x|_{peak}{}^{2}}{x_{rms^2}} = \mathrm{C}^2 \qquad (1)$$

Where C = Creast factor is calculated from peak amplitude of waveform divided by RMS value of waveform as in (2).

$$\mathrm{C} = \frac{|x|_{peak}}{x_{rms}} \qquad (2)$$

It is expressed in decibels (dB). PAPR determine for many signals parameter, such as voltage, current, power, frequency and phase.

3. PAPR REDUCTION IN OFDM.

It can be either decrease in the peak amplitude of the subcarriers or increase in the average power of the transmitted OFDM Signal. If the OFDM Signal passed through an A-Law Compander which is designed to cover the range of all amplitudes encountered, the subcarrier with highest peak amplitude will remain relatively unaltered if the near higher levels of the transfer Character, while other sum carriers with lower Peak amplitudes will amplify with varying but larger gains. Thus Peak power remains relatively unaltered while average of the signal is increased due to the companding Process. As a result there is potential reduction in PAPR. The higher PAPR in an OFDM system essentially arises because of the IFFT operation. Data symbols across subcarriers can add up to produce a high peak value signal. PAPR of an OFDM system is characterized using the CCDF (Complementary Cumulative Distribution Function).

$$\bar{F}_x(x) = P(X > x) \qquad (3)$$

Symbols are random, instantaneous power or peak power for group of symbols is random depending on ombination of symbols. Hence, Random variable is best characterized by distribution function. Here we are using CCDF [6]. CCDF = 1-CDF, Ideally we want the PAPR to be 0 dB

4. SIMULINK MODEL

The various blocks are used for designing the models which are listed below:

A. Random Integer Generator

The Random Integer Generator block generates uniformly distributed random integers in the range [0, M-1], where M is the M-ary number defined in the dialog box. The M-ary number can be either a scalar or a vector.

B. QPSK Modulator Baseband:

The QPSK Modulator Baseband block modulates using the quaternary phase shift keying method. The output is a baseband representation of the modulated signal.

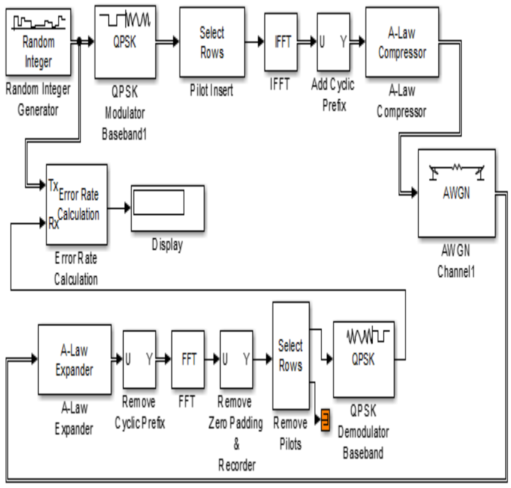

Figure 1 Simulink model of OFDM system for reduction of PAPR using A-Law Companding technique

C. Pilot Insertion

The Multiport Selector block extracts multiple subsets of Rows or columns from M-by-N input matrix u, and propagates each new sub matrix to a distinct output port. The block treats an unoriented length-M vector input as an M- by-1 matrix.

D. IFFT

The IFFT block computes the inverse fast Fourier transform (IFFT) of each row of a sample-based 1 –by-P input vector or across the first dimension (P) of an N-D input array.

E. Adding Cyclic Prefix

The Selector block generates as output selected or reordered elements of an input vector, matrix, or multidimensional signal. A Selector block accepts vector, matrix or multidimensional signals as input.

F. A-law Compressor

The A-Law Compressor block implements an A-law compressor for the input signal.

G. AWGN Channel

The AWGN Channel block adds white Gaussian noise to a real or complex input signal. When the input signal is real this block adds real Gaussian noise and produces a real output signal. When the input signal is complex, this block adds complex Gaussian noise and produces a complex output signal.

H. A-law Expander

The A-Law Expander block recovers data that the A-Law Compressor block compressed.

I. Pilot Removal

The Multiport Selector block extracts multiple subsets of rows or columns from M-by-N input matrix u, and propagates each new sub matrix to a distinct output port, The block treats an un oriented length-M vector input as an M- by-1 matrix.

J. Removing Cyclic Prefix

The Selector block generates as output selected or Recorded elements of an input vector, matrix, multidimensional signal. A Selector block accepts vector, matrix or mutidimenational signals as a input.

K. FFT

When you specify an FFT length not equal to the Length of the input vector, (or first dimension of the input array), block implements zero padding or modulo-M, (FFT Length) data wrapping. This occurs before the IFFT operation [7].

L. QPSK Demodulator Baseband

QPSK Demodulator Baseband block the modulated a signal that was modulated using the quaternary phase shift keying method. The input is a baseband representation of the modulated signal. The input must be a complex signal. Block accepts a scalar or column vector input signal.

M. Error Rate Calculation

The Error Rate Calculation block compares input data from a transmitter with input data from a receiver. It calculates the error rate as a running statistic, by dividing the total number of unequal pairs of data elements by the total number of input data elements from one source.

5. A-LAW COMPANDING FOR PAPR REDUCTION

The companding technique, the compression of OFDM signals at the transmitter and expansion at the receiver [8]. In this companding method, the compressor characteristic is piecewise, made up of a linear segment for low level inputs and a logarithmic segment for high level inputs. A-law has mid riser at the origin. Hence it contains non-zero value. The practically used value of "A" is 87.6. The A-law companding is used for PCM telephone systems. The A-law companding is used for PCM telephone systems. This A-law companding technique is used in Europe, Asia, Russia, Africa, China, etc. An A-law algorithm is a standard companding algorithm, used in European digital communications systems to optimize, *i.e.,* modify, the dynamic range of an analog signal for digitizing. For a given input *x*, the equation for A-law encoding is as follows in (4-5),

$$F(x) = \operatorname{sgn}(x) \left\{\frac{A|x|}{1+\ln(A)}\right\} |x|, < 1/A \quad (4)$$

$$F(x) = \operatorname{sgn}(x) \left\{\frac{1+\ln(A|x|)}{1+\ln(A)}\right\}, \frac{1}{A} \quad (5)$$

Where *A* is the compression parameter.
Where, x=input signal, y=output signal Sgn (*x*) =sign of the input (+ or -). |*x*|=absolute value (magnitude of x). A=87.6 (defined by CCITT).

Table 1: Parameters of Simulation

Sr.No.	Description	Specification
1	Modulation Scheme	QPSK/ M=4
2	No. of FFT Size	512
3	Value of A	87.6
4	Channel	AWGN
5	No. of bits per Symbol	1
6	Input Signal Power referenced to 1 Ohm	1

6. SIMULATION RESULTS

The performance of A-law companding using QPSK modulation the results of simulation shows that the Bit Error Rate reduces increasingly at QPSK modulation as shown in Figure 2-3

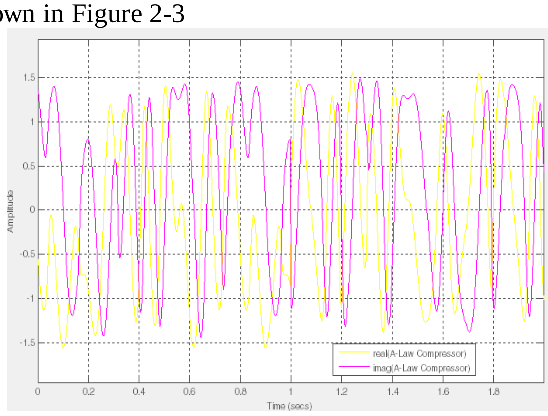

Figure 2 Simulation output of A-law Compressor

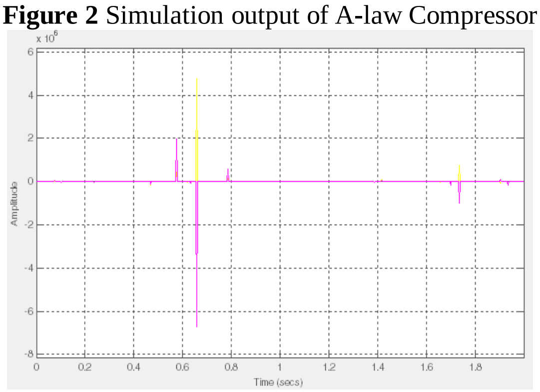

Figure 3 Simulation output of A-law Expander

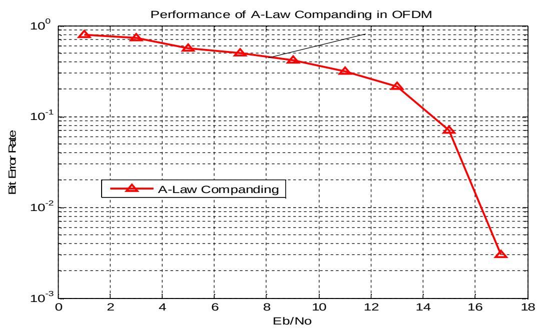

Figure 4 Performance of A-law Companding

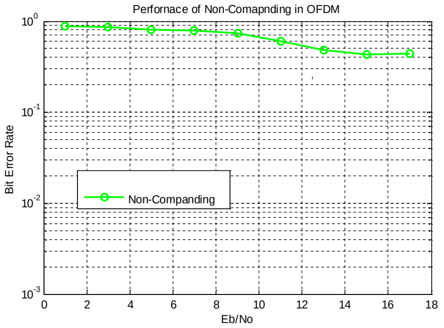

Figure 5 Performance of non Companding

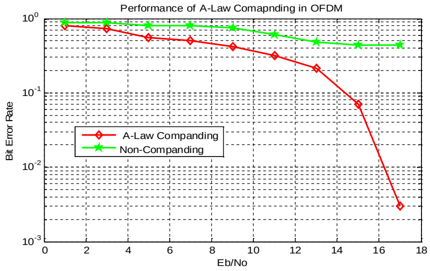

Figure 6 Performance of A-Law Companding and non Companding

7. CONCLUSION

In this paper we considered the PAPR reduction problem in the OFDM system. The proposed PAPR reduction technique was based upon the companding method. Then performance of the OFDM system is simulated by using A-law Companding, it is observed that as the value of "A" increases shown in Fig. there is a significant reduction in the PRPR value and it is clear that by choosing the appropriate value of A, we can get the desired PAPR value. Also we found that to achieve the Bit Error Rate (BER) of 10^{-0} as shown in Fig. A-law technique requires approximately 18 dB reduced SNR value as compared to the OFDM system without companding method.

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