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Comparison of Companding based PAPR Techniques for OFDM Systems

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ABSTRACT

3GPP LTE has utilized the OFDMA for the downlink which provides spectrum flexibility, inherent resistance to Inter symbol Interference (ISI) and many more. However 3GPP LTE systems suffer from a very common problem known as Peak to Average Power ratio. The present paper tried to discuss the companding based techniques for single user OFDMA systems. We have tried our simulations for L=1-4 oversampling rate and 256 FFT matrix and 128 random data bits to decrease the PAPR by overlooking on the complementary cumulative distribution function. It is observed in the simulation that Peak to Average Power ratio reduces to the tune of 6-7db from the original unmodified system.

Keywords:

CCDF, Clipping, PAPR, OFDMA, OFDM.

1. INTRODUCTION

The Quest for high data rates has led to an ever increasing demand of bandwidth. The LTE systems offer a wide varying range of high bandwidth systems that are now utilized in many wireless applications. However LTE systems has accepted Orthogonal Frequency division Multiplexing Access (OFDMA) [1] for downlink and Single Carrier Frequency division Multiple Access SCFDMA [2] in uplink Both OFDM and OFDMA have a common and a very serious problem known as Peak to Average Power Ratio.

A number of Peak to Average Power ratio reduction techniques have been developed and reported in the literature [3].The techniques like Clipping, Active Constellation Extension and tone reservation provides significant improvement in Peak to Average Power ratio. Companding technique when used in the system can be used either in the A mode or in the µ mode as discussed in several papers [4, 5].

To quantify [6] the Peak to Average Power ratio reduction using simple companding the Complementary Cumulative distribution function (CCDF) is widely used.

In the present paper we have tried to analyze the CCDF of companding technique. With these semi analytical results we have tried to derive relationship between the envelope and power distribution function.

2. SYSTEM MODEL

Let us take a block of N symbols X={ X_k, K=0,1,N-1} is formed with each symbol modulating one of a set of subcarriers{f_k ,k=0,1,N-1} where N is the number of subcarriers .The N subcarriers are chosen to be orthogonal , that is $f_k = K\Delta f$, where $\Delta f=1/(N *T)$ and T is the original symbol period .Therefore the complex envelope of the transmitted OFDM signals can be written as [7]: -

$$x(t) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k e^{j2\pi f_k t}, 0 \le t \le NT \tag{1}$$

PAPR is a comparison of the Peak Power detected to Average Power over a period of sample under consideration. The PAPR of the transmit signal is defined as [8]:

$$PAPR = \frac{\max\ |x_k|^2}{E\ [|x_k|^2]} \tag{2}$$

where X(k) is the transmitted signal.

This is followed by inverse fast Fourier transform (ifft) block and then finally by a cyclic prefix insertion that completes the digital stage of the signal flow.

Figure 1 shows the distribution of OFDM signal samples oversampled by different over sampling factor L.

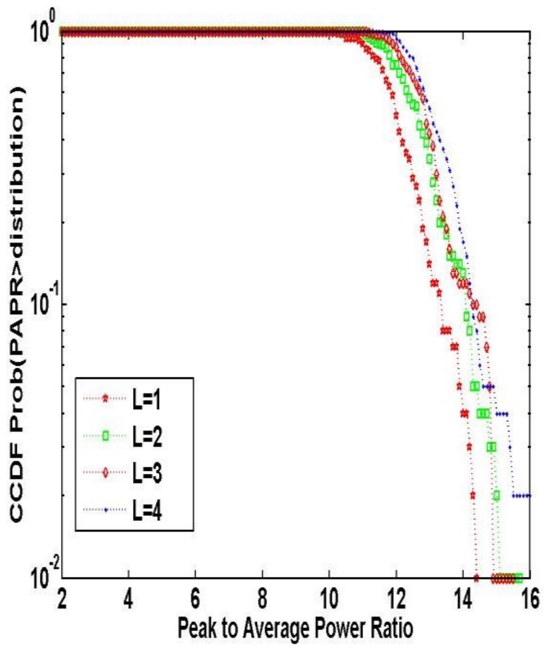

Fig1. PAPR of OFDM samples for different L.

The signal with proper modulation is then passed through companding technique.

Companding techniques are signal processing techniques [9] that compress the signal on the transmitter side and expand it on the receiver side. They are commonly used in the systems where higher resolution for lower amplitude signals & lower resolution for higher amplitude signals must be provided.

The µ law companding is used in digital telephone systems of USA, Japan. µ law compression according to standard is defined as

$$f(x) = sgn(x)\, \frac{\ln(1+\mu|x|)}{\ln(1+\mu)} \qquad (3)$$

where µ is parameter of compression µ=255 for USA & Japan & x is the normalized value of the input signal.

The A law companding is recommended standard by comite consultatif international telephonique et telegraphiques(CCITT) which is used in digital telephone system across europe. Compression in this standard is defined as

$$f(x) = sgn(x)\, \frac{A|x|}{1+\ln(A)} \quad 0<|x|<1/A \qquad (4)$$

where A is the compression parameter A=87.6 in Europe & x is the normalized value of the input signal.

3. SIMULATION RESULTS

The simulations have been carried out in MATLAB for 128 data bits, modulation technique 4-QAM and the IFFT is used to generate N=256 orthogonal subcarriers .the table assumes that the oversampling level is kept constant and then accordingly the companding are varied to observe the Peak to Average Power ratio.

Table 1.Simulation Parameters

Parameters	**Values**
FFT Size	256
Sampling frequency	1MHz
M	16
Modulation	QAM
Companding Factor	87.6,255
Companding Type	A law ,µ law
Iteration	4
Oversampling	1-4
Bandwidth	1 MHz

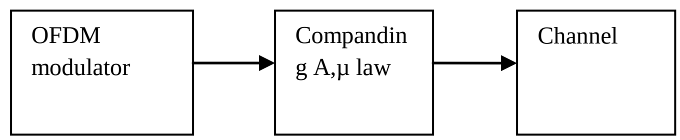

Fig 2.Block diagram for OFDM companding used in the simulation results

With the values of the parameters, indicated in the above table, simulations were implemented. The simulation results are shown in the following CCDF graphs.

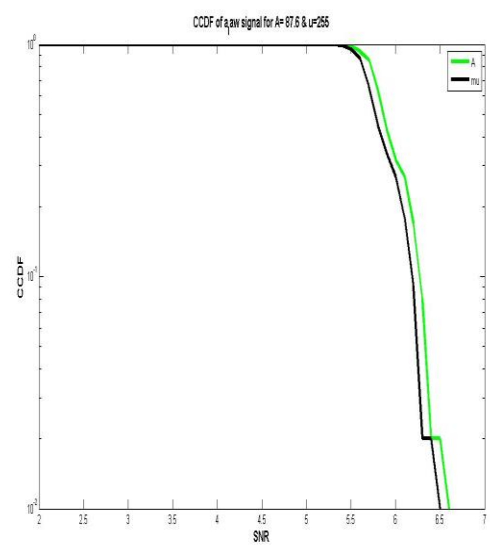

Figure 3: CCDF using A and µ law Companding technique.

The implementation of simulations show that as the companding law changes the Peak to Average Power ratio starts reducing slightly. Hence we found that for a constant oversampling factor of L=2 there is an overall reduction in Power to the tune 6-7dbs.Thus it can be established that for a constant number of subcarriers the Peak to Average Power reduces with changing companding methods.

4. CONCLUSION AND FUTURE WORK

In the paper we have studied about the PAPR problem in OFDM system for single user environment. The Paper tried to discuss a very simple techniques like companding A law and μ laws for a subcarrier N=256, oversampling factor L=2. From the discussions we can easily interpret that PAPR reduction to the tune of 6-7db can be obtained in comparison with original unmodified data block.

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