Hybrid Clipping-Companding Schemes for Peak-to-Average Power Reduction of OFDM Signal

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Abstract: Day by day increasingly, new types of wireless devices are being introduced. These devices have access to the internet. Thus the spectral efficiency of the current network needed to be improved. For this OFDM signals are introduced. In this paper, we propose to discuss the technique to reduce the peak to average power ratio for an OFDM signal, so that it can be used further. Also different techniques have been proposed in the literature to reduce PAPR of OFDM signal which is the main drawback for not using OFDM systems. Since high PAPR demands the amplifier of large dynamic range which might cause amplifier to go into non-saturation region; also complexity in Analog to Digital and Digital to Analog convertor increases which overall reduce the efficiency of the system in every aspects.

Keywords- OFDM, Companding, PAPR.

I. INTRODUCTION

Wireless is an emerging field, which has seen enormous growth in last several years. The high data rate of future mobile networks will be achieved by increasing the amount of spectrum allocated to the service and by improvement in spectral efficiency [1]. The spectral efficiency of 3G network is too low to support high data rate services at low cost. As a consequence one of the main focuses of 4G systems will to significantly improve the spectral efficiency. This requirement of improvement in spectral efficiency makes OFDM a potential candidate for the physical layer of 4G mobile systems. The rest of the paper is organized as follows: section 2 gives the introduction to OFDM system; in section 3 we discuss different PAPR reduction techniques; section 4 results are analyzed after using companding techniques to reduce PAPR. Finally, a conclusion is drawn in section 5.

II. OFDM SYSTEM

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 internet access, wireless networks, power line networks, and 4G mobile communications. It divides the allocated spectrum into parallel orthogonal sub channels. It splits a high rate stream into many lower rate streams, which are transmitted at the same time over these sub-channels. OFDM is a spectral efficient scheme. OFDM systems are implemented using a combination of Fast Fourier Transform (FFT) and Inverse of Fast Fourier Transform (IFFT). They are mathematically equivalent version of DFT and IDFT.

![Fig 2.1. OFDM System](image)

III. PAPR REDUCTION TECHNIQUES

Peak to average power ratio (PAPR) is a measurement of a waveform calculated from the peak amplitude of the waveform divided by the Average value of the waveform as shown in Figure 3.1. The peak to average power ratio for a signal x (t) is defined as [4]

\[
PAPR = \max_x \left[ \frac{|x(t)x^*(t)|}{E[x(t)x^*(t)]} \right]
\]

Where (*) corresponds to the conjugate operator

Expressing in decibels: \( PAPR_{dB} = 10\log_{10}(PAPR) \)

High peak to average power ratio is the main drawback in the implementation of OFDM system. It is must to reduce PAPR. The reason for high PAPR in OFDM system is that in time domain, a multicarrier signal is the sum of many narrowband signals [6]. At some time instances, this sum is large and other time is small, which means that the peak value of signal is substantially larger than the average value. Various Techniques proposed to reduce
PAPR are given as [5]: 1. Clipping and filtering. 2. Coding schemes. 3. Partial transmission sequence. 4. Selective Mapping. 5. Interleaving technique. 6. Tone reservation. 7. Tone injection. 8. Active constellation extension technique. 9. Non-Linear Companding transform. One of the most attractive schemes is nonlinear companding transform which has a good system performance including PAPR reduction and low BER, low implementation complexity and no bandwidth expansion. It is known that the CCDF of PAPR can be used to eliminate the bounds for the minimum number of redundancy bits required to identify the PAPR sequences and evaluate the performance of any PAPR reduction schemes.

IV. NON LINEAR COMPANDING

One of the most attractive scheme found to be Non-linear companding transform due to its good system performance, low BER, no bandwidth expansion and low implementation complexity. Low PAPR OFDM system can be designed using approach of Clipping-Companding function which will give improved BER and Quality of service of the system. The first nonlinear companding transform is the Mu-law companding which is based on speech processing algorithm law and it has shown better performance than that of clipping method.

The companded signal \( t_n (0 \leq n \leq N) \) is given by:

\[
t_n = h(s_n)
\]

where \( h(.) \) is the companding function that changes only the amplitude of input signal. Finally, the PAPR of OFDM signals in one symbol period is then defined as

\[
PAPR \ (in \ dB) = 10 \log \left[ \max \left( \frac{x(n) \ast x(n)}{E[s(n) \ast s(n)]} \right) \right]
\]

V. RESULTS

Figure 5.1 shows the spectrum of OFDM signal before applying proposed hybrid clipping-companding technique. Original OFDM signal have a sharp power spectrum as shown.

![Fig. 5.1. Original OFDM Signal](image1)

![Fig. 5.2. Clipped OFDM Signal](image2)

Figure 5.2 shows the spectrum of OFDM signal after clipping before applying µ-law companding technique.

![Fig. 5.3. CCDF Vs PAPR Plot for Original OFDM Signal](image3)

Figure 5.3 shows the CCDF Vs PAPR Plot before applying any PAPR reduction technique i.e. Original OFDM signal.

![Fig. 5.4. CCDF Vs PAPR Plot for OFDM Signal using Hybrid Clipping- µ Companding technique](image4)
VI. CONCLUSION

In this paper, the different properties of an OFDM system are analyzed and the advantage and disadvantages of this system are understood. OFDM signals have general problem of high PAPR and also cause high BER if PAPR reduces very significantly. This dissertation work analyzed existing techniques like clipping, tanh companding, logarithmic companding, exponential companding, Mu-law companding, A-law companding and at last Hybrid approach. The result shows that the non-linear companding transform using hybrid techniques exhibits significant improvement in PAPR reduction than the earlier techniques.

VII. REFERENCES


