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Reduction Of PAPR Value Using Combined RS Coding And μ-Law Companding In OFDM System

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Abstract

The high Peak-to-Average Power Ratio (PAPR) is one of the serious problems in the application of OFDM technology. The companding transform approach is a very suitable technique to reduce PAPR. In order to improve the performance of OFDM system it is necessary to consider the effect of PAPR reduction on OFDM system. This paper , proposed a hybrid method for the reduction of PAPR value of the OFDM system. Proposed method consist of two stages. In the first stage of the proposed scheme, the data are encode by RS coding. In the second stage, the proposed scheme utilizes the μ-law companding to reduce the PAPR value of the OFDM system. The simulation results indicate that the proposed method provide significant reduction in PAPR value when compared with other existing approaches.

1. Introduction

OFDM(orthogonal-frequency-division multiplexing) is a promising technique that is able to provide high data rates over multipath fading channels. However, OFDM systems have the inherent problem of a high peak-to- average power ratio (PAPR), which causes poor power efficiency or serious performance degradation in the transmitted signal. To reduce the PAPR, many techniques have been proposed, such as clipping, coding, partial transmit sequence (PTS), selected mapping (SLM) [1-3], and nonlinear companding transforms [4,5] These schemes are primarily signal scrambling techniques, such as PTS, and signal distortion techniques such as the clipping and companding techniques. Among those PAPR reduction methods, the simplest scheme to use is the clipping process. However, use of the clipping processing causes both in-band distortion and out-of-band distortion, and causes an increased bit error rate (BER) in the system. As an alternative approach, the companding technique shows better performance than the clipping technique, because the inverse companding transform (expanding) can be applied at the receiver end to reduce the distortion of signal. A DCT may reduce the PAPR of an OFDM signal, but does not increase the BER of system. The idea is to use the different transform to reduce the autocorrelation of the input sequence to reduce the peak to average power problem. In addition, it requires no side information to be transmitted to the receiver. Inspired by the literature [5,9], an efficient PAPR reducing technique based on a joint RS coding and μ-law compnding is proposed.

2. PAPR Problem of OFDM signal

Let the data block of length N be represented by a vector $X= [\ X_1\ ,\ X_2\ ,\ \ldots\ldots\ldots X_{N-1}\ ]^T$ Duration of any symbol X_k in the set X is T and represents one of the subcarrier { f_n , n=0,1,2,3,….N-1} set. As the N sub - carriers chosen to transmit the signal are orthogonal to each other, so we can have $f_n = n\Delta f$ where Δf = 1/NT and NT is the duration of the OFDM data block X. The complex data block for the OFDM signal to be transmitted is given by

$$x(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} x_n e^{j2\pi n\Delta f t} \quad 0 \leq t \leq NT \qquad (1)$$

The PAPR of the transmitted signal is defined as

$$PAPR = \frac{\max_{0 \le t \le NT} |x(t)|^2}{\frac{1}{NT}\int_0^{NT} |x(t)|^2} \qquad (2)$$

Reducing the max|x(t)| is the principle goal of PAPR reduction techniques.

3. Reed-Solomon Code

In 1960, Irving Reed and Gus Solomon published a paper in the Journal of the Society for Industrial and Applied Mathematics [6]. This paper described a new class of error-correcting codes that are now called Reed-Solomon (R-S) codes. These codes have great power and utility, and are today found in many applications from compact disc players to deep-space applications. This article is an attempt to describe the paramount features of R-S codes and the fundamentals of how they work. Reed-Solomon codes are nonbinary cyclic codes with symbols made up of m-bit sequences, where m is any positive integer having a value greater than 2. R-S (n, k) codes on m-bit symbols exist for all n and k for which

$$0 < k < n < 2^m + 2 \qquad (3)$$

where k is the number of data symbols being encoded, and n is the total number of code symbols in the encoded block. For the most conventional R-S (n, k) code,

$$(n, k) = (2^m - 1, 2^m - 1 - 2t) \qquad (4)$$

where t is the symbol-error correcting capability of the code, and $n - k = 2t$ is the number of parity symbols. An extended R-S code can be made up with $n = 2^m$ or $n = 2^m + 1$, but not any further.

Reed-Solomon codes achieve the *largest possible* code minimum distance for any linear code with the same encoder input and output block lengths. For nonbinary codes, the distance between two codewords is defined (analogous to Hamming distance) as the number of symbols in which the sequences differ. For Reed-Solomon codes, the code minimum distance is given by [6]

$$d\text{min} = n - k + 1 \qquad (5)$$

The code is capable of correcting any combination of t or fewer errors, where t can be expressed as [6]

$$t = \left\lfloor \frac{d_{min}-1}{2} \right\rfloor = \left\lfloor \frac{n-k}{2} \right\rfloor \qquad (6)$$

where $\lfloor x \rfloor$ means the largest integer not to exceed x. Equation (6) illustrates that for the case of R-S codes, correcting t symbol errors requires no more than $2t$ parity symbols. Equation (6) lends itself to the following intuitive reasoning. One can say that the decoder has $n - k$ redundant symbols to "spend," which is twice the amount of correctable errors. For each error, one redundant symbol is used to locate the error, and another redundant symbol is used to find its correct value.

4. Discrete Cosine Transform

Like other transforms, such as the Hadamard transform, the DCT decorrelates the data sequence. To reduce the PAPR in an OFDM signal, a DCT is applied to reduce the autocorrelation of the input sequence before the IFFT operation is applied [5]. In this section, review of DCT is done. The formal definition of a one-dimensional DCT of length N is given by the following formula:

$$X_c(k) = \alpha(k) \sum_{n=0}^{N-1} x(n) \cos\left[\frac{\pi(2n+1)k}{2N}\right] \qquad (7)$$

For k= 0,1, ………………N-1

Similarly, the inverse transformation is defined as

$$x(n) = \sum_{n=0}^{N-1} \alpha(k)\ X_c(k) \cos\left[\frac{\pi(2n+1)k}{2N}\right] \qquad (8)$$

For n=0,1,2 …….N-1

For both equations (7) and (8) $\alpha(k)$ is defined as

$$\alpha(k) = \begin{cases} \frac{1}{\sqrt{N}} & for\ k = 0 \\ \frac{2}{\sqrt{N}} & for\ k \neq 0 \end{cases} \qquad (9)$$

Equation (7) can be expressed in matrix form as:

$$X_c = C_N x \qquad (10)$$

Where X_c and x are both vectors of dimension N*1 and C_N is a DCT matrix of dimension of N*N. the rows(or column) of the DCT matrix, C_N , are orthogonal matrix vectors. This property of the DCT matrix can be used to reduce the peak power of OFDM signal. [5]

5. Companding

Companding is simply a system in which information is first compressed, transmitted through a bandwith limited channel, and expanded at the receiving end. In this propose work μ-law companding is used. In which compression is used at the transmit end after the IFFT process and expansion is used at the reciver end prior to the FFT process. For the discrete OFDM signal given by x the companded signal s can be given by

$$s = Cx = sgn(x)\frac{\ln(1+\mu|x|)}{\ln(1+\mu)} \qquad (11)$$

Where μ is the companding parameter.

This transform reduces the PAPR of OFDM signal by amplifying the small signal and attenuating the period of high signal.On the receiver end, the receiver signal must be expanded by the inverse companding transform before it can be sent to the FFT processing unit.

6. Proposed Hybrid Technique

To reduce the PAPR of an OFDM signal, a scheme involving the combination of a encoding and companding technique is proposed. Companding is used to reduce PAPR. In this proposed work, RS Coding is used for generation of multicarrier for OFDM system and µ-law companding is used for the reduction of PAPR value of OFDM signal. The block diagram of proposed hybrid approach system is shown in fig1.

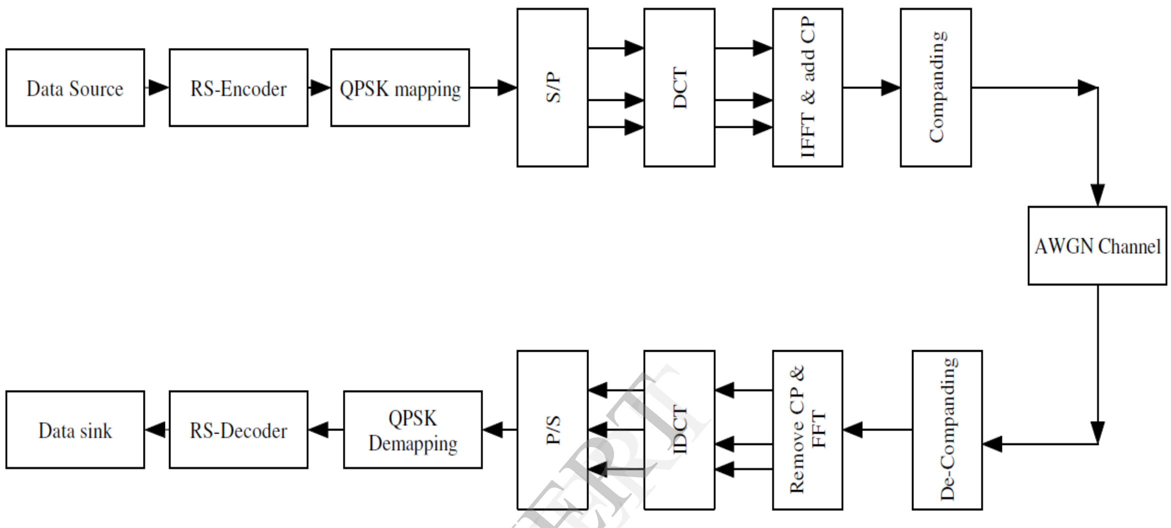

Fig.1 Block Digaram of Proposed Hybrid Technique

7.Simulation Results

In this section, we present the results of computer simulations used to evaluate PAPR reduction capability of the proposed scheme. The channel was modeled as additive white Gaussian noise (AWGN). In the simulation, an OFDM system with QPSK modulation was considered. We can evaluate the performance of the PAPR reduction scheme using the complementary cumulative distribution (CCDF) of the PAPR of the OFDM signal.

7.1 PAPR Calculation of Proposed Hybrid Technique

Fig. 2 shows the PAPR Performance of the proposed technique and other existing technique. The PAPR value of proposed hybrid technique is reduced by 7.5 dB at CCDF = 10^{-3} for companding parameter factor, µ=10 when compared with the case of original system.The proposed technique reduce the PAPR by 7.5 dB over original system, but the DCT based scheme reduced the PAPR by 7dB, at CCDF = 10^{-3}.

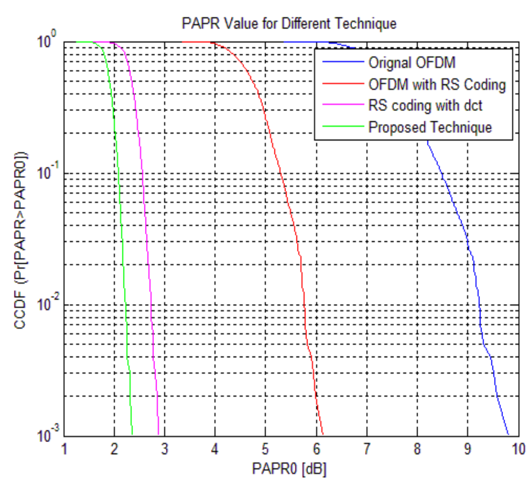

Fig.2 Comparison of the PAPR of Proposed Technique

7.2PAPR Calculation For Different Companding Parameter

Fig.3 shows the PAPR performance of proposed hybrid technique under the effect of different companding parameter values. The different companding parameter used in this work are μ=10,100 and 255 by increasing the companding parameter the PAPR performance of proposed hybrid technique is improved.The PAPR of OFDM system at CCDF=10^{-3} is reduced by 7.5 dB, 7.8dB, and 8.1dB corresponding to the value of comapnding parameter μ=10,100,255 when compared with the case of original system.

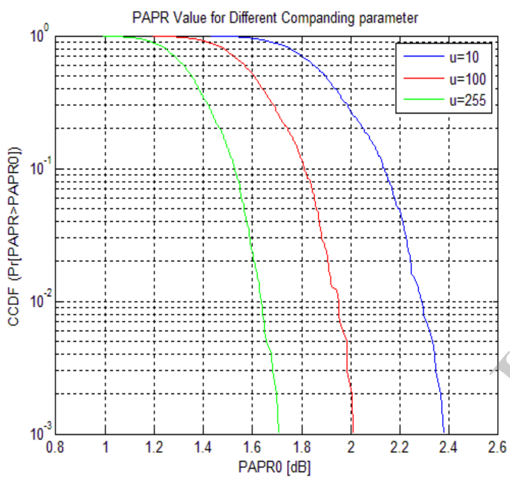

Fig. 3 PAPR of proposed technique for different value of μ with RS code

8. Conclusion

This paper proposed hybrid method for the reduction of PAPR value of OFDM system ,the simulation results has been carried out in terms of reduction of PAPR value of the system for different technique, and companding parameter. It has been observed from simulation results that when companding is added with RS code, there is 7.6 dB reduction in PAPR value of system while when companding parameter is increase the performance of proposed system keeps on improving in terms of PAPR value.

Simulation results indicate that the proposed hybrid method provided better results when compared with existing work.

REFERENCES

[1] T. Jiang and Y. Imai, “An Overview: Peak-To-Average Power Ratio Reduction Techniques for OFDM Signals,” *IEEE Transactions on Broadcasting*, Vol. 54, No. 2, 2008, pp. 257- 268

[2] S. H. Han and J. H. Lee, “An Overview of Peak-to-Av- erage Power Ratio Reduction Techniques for Multicarrier Transmission,” *IEEE Transaction on Wireless Commu-nication*, April 2005, pp. 56-65.

[3] X. B. Wang, “Reduction of Peak-to-Average Power Ratio of OFDM System Using a Companding Technique,” *IEEE Transaction on Broadcasting*, Vol. 45, No. 3, 1999, pp. 303-307.

[4] X. Huang, J. H. Lu, J. L. Zhen, *et al*., “Companding Transform for Reduction in Peak-to-Average Power of OFDM Signals,” *IEEE Transactions on Wireless Communications*, Vol. 3, No. 6, 2004, pp. 2030-2039.

[5] Zhongpeng Wang in “Combined DCT and Companding for PAPR Reduction in OFDM Signals” Scientific Research Journal of Signal and Information Processing,Vol:2, pp. 100-104, 2011.

[6] Reed, I. S. and Solomon, G., “Polynomial Codes Over Certain Finite Fields,” *SIAM Journal of Applied Math.*, vol. 8, 1960, pp. 300-304.

[7] Pepin Magnangana Zoko Goyoro, Ibrahim James Moumouni, Sroy Abouty “SLM Using Riemann Sequence Combined with DCT Transform for PAPR Reduction in OFDM Communication Systems” International Journal of World Academy of Science in Computer and information Engineering Issue No. 64, pp. 347-352, 2012.

[8] Chau-Yun Hsu, Hsin-Chieh Chao, Wen-Yu Tsai “PAPR Reduction of OFDM Signals Using Coefficient Array of Orthogonal Transform Kernels” IEEE Transactions on Wireless Communications, Vol. 8,Issue No. 7, pp. 3320-3325 ,2006.

[9] Abhishek Katariya, Neha Jain, Amita Yadav “Performance Elevation Criteria Of RS Coded OFDM Transmission Over Noisy Channel” International Journal of Soft Computing and Engineering Vol.1, Issue No.-3, July 2011