# A Review on Optimized Transmission of Images with OFDM over AWGN Channel Using Trigonometric Transforms

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Abstract: In this paper a scheme is proposed for optimized transmission of images over AWGN (Additive White Gaussian Noise) channel with OFDM (Orthogonal Frequency Division Multiplexing) a popular technique in high speed wireless communications. The Low Density Parity Check Coding (LDPC) with coded OFDM is used to improve the BER performance. The Set Partitioning in Hierarchical Trees (SPIHT) algorithm is used for source coding of the images to be transmitted. In this scheme the transmit data sequence of the OFDM signal after Inverse Fast Fourier Transform (IFFT) is grouped into in-phase and in-quadrature components, then each component is transformed using either the Discrete Cosine Transform (DCT) or the Discrete Sine Transform (DST). The main obstacle is the high peak-to-average power ratio (PAPR) in the OFDM system causing non-linearity at the receiving end. This paper focuses on the fact that, on comparing with the other means, the proposed method greatly reduces the PAPR of the OFDM signal.

Keywords: OFDM, PAPR, LDPC, SPIHT, Trigonometric Transforms.

### 1. Introduction

New techniques have developed for digital transmission to fulfill the need of higher data rates in communications which can be used in both wired and wireless environments. A promising modulation technique increasingly being adopted in the telecommunication field [1] is Orthogonal Frequency Division Multiplexing (OFDM), a multicarrier Modulation technique in which a single high rate data-stream is divided into multiple low rate data-streams and is modulated using sub-carriers which are orthogonal to each other. The carriers can be made orthogonal by suitably choosing the frequency spacing between them. OFDM offer advantages like high spectral efficiency, robustness to channel fading, immunity to impulse interferences, flexibility and easy equalization. In-spite of these benefits the major obstacle in using OFDM is that, OFDM signal exhibits very high Peak to Average Power Ratio (PAPR) which is the relation between the maximum powers of a Sample in a given OFDM transmit symbol divided by the average power of that OFDM symbol. The PAPR occurs when in a multicarrier system the different sub-carriers are out of phase with each other. When all the points achieve the maximum value simultaneously; this will cause the output envelope suddenly to shoot up which causes a 'peak' in the output envelope. This peak value can be very high as compared to the average of the whole system. This ratio of the peak to average power value is termed as Peak-to-Average Power Ratio.

# 1.1 Various techniques suggested to reduce the PAPR in the OFDM system

There are several developed techniques to reduce the PAPR in OFDM systems [2, 3] such as clipping [4],

companding [5, 6] Partial Transmit Sequence (PTS) [7], Selected Mapping (SLM) [8] and coding [9]. The clipping technique is the simplest one that can be used in OFDM systems, but it causes additional clipping which degrades the system performance. Signal transformation is one of the techniques to deal with high PAPR involving signal transformation prior to amplification, then an inverse transformation at the receiver prior to demodulation. The authors in [10] concluded that OFDM systems with trigonometric transforms provide higher PAPR reduction than the standard FFT based system. However, they modified the OFDM symbols before transmission using the PTS. Their results reveal that without PTS, the distribution of PAPR is the same for that conventional one, such that the reduction depends on PTS, which makes redundancy in the system. To improve the BER performance of the OFDM system, several error correcting codes have been applied to OFDM.

#### **1.2 What is LDPC?**

LDPC is one of the good candidates for high speed broadband wireless applications. These are a class of linear block codes which provide a reliable transmission for coding that is very close to Shannon's limit and also can beat Turbo codes at long block length but with relatively low decoding complexity. A (N, K) LDPC code can be represented by a very scarce parity-check matrix having M rows, N column and code rate R= K/N, where K=N-M. It was originally invented by Gallager in 1963[11] and rediscovered recently by Mackay and Neal [12]. Hence the combination of the coded OFDM with LDPC (LDPC-COFDM) is used to improve the BER by adaptive bit loading and power allocation of each subcarrier.

#### **1.3 Image Compression Technique**

SPIHT is computationally very fast and among the best image compression algorithms known today. Embedded Zero tree Wavelet (EZW) given by Shapiro gives excellent compression performance. SPIHT is the further enhancement of EZW devised by Said and Pearlman which includes faster implementation. It defines parentchildren relationships between the self-similar sub-bands and hence called 'Set Partitioning in Hierarchical Trees'.

The proposed method concentrates on two objectives, reducing the PAPR of the OFDM signal and improving the quality of the reconstructed images. It considers the trigonometric transforms as a way for reducing the PAPR by using the characteristics of the DCT/DST energy focused in the low component. The data of OFDM signal is modulated by IFFT then using DCT/DST, which can reduce the PAPR. Compared with the means of Selected Mapping (SLM)-OFDM and Partial Transmit Sequence (PTS)-OFDM, OFDM system modified by DCT/DST maintain the system orthogonal properties, which will not result in additional noise and will not transmit the side information.

# 2. Previous Schemes for PAPR Reduction

There are many techniques developed to reduce the PAPR in OFDM systems categorized into 'signal distortion method' and 'signal scrambling method' some of these are:

- i. Clipping [4]: The clipping technique is the simplest one used in OFDM systems from the type Signal Distortion for reducing PAPR, since this method creates additional clipping noise and degrades the performance, hence not used.
- ii. Companding [5, 6]: Companding also termed as 'nonlinear companding transforms' is the scheme transforming the amplitude or power of the Gaussiandistributed OFDM signals into uniform distribution without changing the average power, this scheme adjust both small and large signals without bias and they are able to offer better system performance in term of PAPR reduction and bit error-rate (BER) for OFDM systems. But, companding technique is a distortion technique [13].
- iii. Partial Transmit sequence (PTS) [7]: This technique is from the type signal scrambling for PAPR reduction. PTS is the scheme in which the input data is divided into smaller disjoint sub-blocks multiplied by rotating phase factors and then added to form OFDM symbol for transmission. Hence, this scheme is used to design an optimal phase factor for sub-block set that minimizes the PAPR. In [10] trigonometric transforms were suggested as an alternative for the FFT to reduce PAPR and modified the OFDM symbols before transmission using the PTS, this brings redundancy in the system.

- iv. Selected Mapping (SLM) [8]: This technique is also from the type signal scrambling for PAPR reduction. The basic idea of this technique is to generate several OFDM symbols as candidates and then select the one with the lowest PAPR for actual transmission. But, using this technique results in additional side noise.
- v. Coding [9]: The block coding technique is to transmit only the code-words with low PAPR. This technique gives good PAPR reduction performance. The difficulty in using the coding technique is that for the OFDM systems with large sub-carriers, either it encounters design difficulties or the consequent coding rate becomes prohibitively low.

Hence, from the above it can be concluded that for OFDM PAPR reduction techniques are based on computational complexity, bandwidth expansion, spectral release and performance characteristics.

For image transmission over the OFDM system SPIHT algorithm is suggested in several research works [14, 15] because the SPIHT has a good rate-distortion performance for motionless images with comparatively low complexity and it is scalable or completely embeddable.

# 3. Set Partitioning in Hierarchical Trees (SPIHT) Algorithm

The SPIHT algorithm has been introduced by Amir Said and William Pearlman in 1996 article named as 'SPIHT'. Image compression is a typical application of wavelets in digital signal processing which minimizes the size in bytes of a graphics file without degrading the quality of the image. Compression offers a means to reduce the cost of storage and increase the speed of transmission. One of the Image compression algorithm based on Discrete Wavelet Transform (DWT) is Embedded Zero tree Wavelet (EZW) given by Shapiro which gives excellent compression performance, both in terms of statistical PSNR and subjective human perception of the reconstructed image. SPIHT is the further development of EZW algorithm. One of the most important characteristics of DWT is multiresolution decomposition. There are various wavelet based image compression algorithms which are JPEG 2000, MPEG, EZW, SPIHT, etc.

In this paper we will deal with EZW since SPIHT is advancement in EZW algorithm for image compression. JPEG and MPEG produce annoying visual degradation when operating at low bit-rates because they introduce errors in visually important parts of the image structure and also introduces the blocking artifacts in the reproduced image.

# 3.1 EZW Algorithm

Embedded Zero Tree Wavelet (EZW) is used as an EZW [16] encoder which is specially designed to use with wavelet transforms. This encoder encodes the decomposed image by recognizing the priority of decomposed image pixel. The encoding process is performed using two passes namely: dominant pass and subordinate pass. The

dominant pass generates any one of four possible combinations they are, significant positive (SP), significant negative (SN), isolated zero (IZ), and zero-tree root (ZR). Depending on the current threshold, the coefficients are encoded as 0 or 1 in the subordinate pass. The decoding unit reconstructs the values by identifying the symbols as positive, negative, zero tree and isolated zero tree. Inverse transformation is the process of recovering back the image data from the obtained image values. The image data transformed and decomposed under encoding side is re-arranged from higher level decomposition to lower level with the highest decomposed level been arranged at the top.

#### 3.2 Set Partitioning In Hierarchical Trees

Said and Pearlman [17] further enhanced the performance of EZW by presenting a more efficient and faster implementation called set partitioning in hierarchical trees. SPIHT is one of the best algorithms in terms of the peak signal-to-noise ratio (PSNR) and execution time. Set partitioning in hierarchical trees provide excellent rate distortion performance with low encoding complexity.

SPIHT introduces three lists:

a) List of Significant Pixels (LSP), b) List of Insignificant Pixels (LIP) and c) List of Insignificant Sets (LIS).

First initialization is done, and then algorithm takes two stages for each level of threshold: 1. the sorting pass (in which lists are organized) and 2. The refinement pass.

LIS is further divided into two types of sets of insignificant pixels:

Type A (all descendants are zero) Type B (all grandchildren and further descendants are zero).

SPIHT algorithm defines four types of sets, which are sets of coordinates of coefficients:

O(i,j): set of coordinates of all offspring of node (i,j); children only

D (i,j): set of coordinates of all descendants of node (i,j); children, grandchildren, great-grand, etc.

H (i,j): set of all tree roots (nodes in the highest pyramid level); parents

L (i,j): D (i,j) – O(i,j) (all descendants except the offspring); grandchildren, great-grand, etc.

To find the number of passes we use the formula  $n = [log_2 c max]$ 

We find initial threshold as  $T_0=2^n$ .

The SPIHT algorithm forms a hierarchical quad tree data structure for the wavelet transformed coefficients. The set of root node and corresponding descendants are together called as spatial orientation tree (SOT).



Figure 1: Parent-children dependency and spatial orientation trees across wavelet sub-bands in SPIHT

Algorithm consists of both encoding and decoding process.

#### **Encoding:**

Step 1: initialization Choose threshold  $T_0=2[log_2c max]$ Step 2: load the LIP with {(0,0),(0,1),(1,0),(1,1)} Step 3: load LIS with descendants i.e. {D (0,1),D (1,0),D(1,1)}. Step 4: LSP=Empty. Step 5: Process LIP If (0,0)>T<sub>0</sub>,we transmit 1 and load LSP with(0,0); if (0,0)>0 we transmit 0. Step 6: Process LIS if D(0,1),D(1,0),D(1,1)<T0 transmit 0. We get a bit stream.

#### **Decoding:**

Step 1: Initialization n=  $[log_{2}c max]$ Step 2: Find threshold  $T_{0}=2^{n}$ . Step 3: consider LIP, LSP and LIS. Step 4: consider the encoded bit steam Step 5: Process LIP Receive the bit stream, if 1st bit is 1 combine next bit to 1 i.e. 1 0 this indicates ist element of LIP is significant positive. If next bit is 0 we take it as insignificant Step 6: reconstruct the 1st element of LIP value by  $(3/2)*2^{n}$ . Step 7: if D(0,1),D(1,0),D(1,1)<T0 we get 0 Step 8: Finally again load LIP, LSP, LIS.

# 4. OFDM System Descriptions with Proposed Modification

The block diagram of the proposed LDPC-COFDM system is illustrated in Fig-2.

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As will be shown in the following sections, the proposed modifications will be in the transform and replacement block. The SPIHT coder is chosen as the source coding technique due to its flexibility of code rate and simplicity of designing best system. The SPHIT divides the image stream into several layers according to the importance of progressive image stream. Then the image stream is converted to a binary format. Afterwards the information bits will be LDPC encoded at the LDPC encoder. The OFDM considered in this paper utilizes N frequency tones (number of subcarriers) hence the baseband data is first converted into parallel data of N sub-channels so that each bit of a code-word is on different subcarrier. The N subcarriers are chosen to be orthogonal, then, the transmitted data of each parallel sub-channel is modulated by Binary phase Shift Keying (BPSK) modulation because it provides high throughput and best performance when combined with the OFDM.

Finally, the modulated data are fed into IFFT circuit, such that the OFDM signal is generated. The resulting OFDM signal can be expressed as follows:

Where  $X_n$  is a discrete time sample,

$$x(t) \cong x[n] = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X_n e^{j2\pi f_n t} , 0 \le t \le T$$

The output of IFFT will be split into two components; inphase and in-quadrature as shown below:



Figure 3: The trigonometric transform and replacement Process

Then, either the DCT or the DST is applied to both components, separately. The first half of samples of the inphase component after the transform (Li) is concatenated with the first half of samples of the in-quadrature component after the transform (Lq) to form the new inphase component. Similarly, the second half of samples of the in-phase component after the transform (Hi) is concatenated with the second half of samples of the inquadrature component after the transform (Hq) to form the new In-quadrature component. Finally, the new components are added to produce the OFDM signal as shown in Fig-3. This sequence after this process will be called x<sub>g</sub> (n) with the subscript d referring to the trigonometric transformation process. Each data block is padded with a cyclic prefix (CP) of a length longer than channel impulse response to mitigate the inter-Block Interference (lBI). The continuous COFDM signal  $x_g(t)$  is generated at the output of the digital to analog (D/A) converter. According to [18], the PAPR of transmitted analog signal can be expressed as follows:

$$PAPR = \frac{max \left| x_g(t) \right|^2}{E\left[ \left| x_g(t) \right|^2 \right]}$$

Where E [.] is the average power. Generally, the PAPR is considered for a single OFDM symbol, which has a time duration T. This duration comprises a number of samples equal to  $(N_f + N_g)$ , where  $N_g$  is the guard interval length. At the receiver, the guard interval is removed and the time interval [0, T] is evaluated. There placement and inverse transform are then applied to the received samples. Afterwards, the OFDM sub-channel demodulation is implemented by using a (FFT) then the Parallel-to-Serial (P/S) conversion is implemented. This received OFDM symbols are demodulated at the demodulator. The demodulated bits will be decoded with each LDPC encoded block and data bits are restored. These data will be converted into image format, such that SPIHT decoder can be obtained.

To verify the efficiency of the proposed method; trigonometric transforms will be added to the OFDM system to reduce the PAPR, the analysis will be distributed into two methods: one with DCT and other with DST and these will be compared with COFDM and SPIHT coder will be set as source coding. The three transmission schemes will be designed as:

- 1 The system which consists of coded OFDM.
- 2 The system 1 with the DCT transforms for the transmitted signal.
- 3 The system 1 with the DST transforms for the transmitted signal.

Simulation will be carried out based on the above three schemes. The complementary cumulative distribution (CCDF) curves will be presented for the proposed SPIHT LDPC COFDM with Trigonometric transforms. This CCDF is a statistical sign about the signal power distribution. Also, there will be comparison between DCT and DST that which of the schemes give better reduction of the PAPR from the simulation results. At last, the effect of the SPIHT compression ratios on the Peak Signal-To-Noise Ratio (PSNR) of the received image will also be studied. This PSNR is mathematically defined as follows:

$$PSNR = 10 \log_{10} \left( \frac{Peak^2}{MSE} \right)$$

Where, MSE is the mean squared error between the original and the reconstructed image, and Peak is the maximum possible magnitude for a pixel inside the image.

# 5. Conclusion

In this paper, a review is presented on various methods to reduce the PAPR of the OFDM system and the efficient use of trigonometric transforms in the coded OFDM with LDPC and SPIHT as a compression technique for image transmission. The PSNR for the received images at different rates will also be studied. The practicality of the proposed system will be studied and proved using simulations over the AWGN channel.

# References

- R. W Chang, "Orthogonal Frequency Division Multiplexing", U.S Patent 3388455, Jan 6, 1970, Filed Nov.4. 1966.
- [2] T. Jiang and Y. Wu, "An Overview: Peak-to-Average Power Ratio Reduction Techniques for OFDM Signals", IEEE Transactions on Broadcasting, Vol. 54, No. 2, pp. 257-268, Jun. 2008.
- [3] F.S. AI-Kamali, M. I. Dessouky, B.M. Sallam, F. Shawki and F. E. Abd EI-Samie, "Transceiver Scheme For Single-Carrier Frequency Division Multiple Access Implementing the Wavelet Transform and Peak-To-Average-Power Ratio Reduction Methods" IET Communications, Vol. 4, No. 1, pp. 69-79, 2010.
- [4] J. Kim and Y. Shin, "An Effective Clipped Companding Scheme for PAPR Reduction of OFDM Signals", Proceedings of the IEEE ICC'08, pp.668-672, 2008.
- [5] T. Jiang, W. Yao, P. Guo, Y. Song and D. Qu, "Two Novel Nonlinear Companding Schemes With Iterative Receiver to Reduce PAPR in Multi-Carrier

Modulation Systems", IEEE Transactions on Broadcasting, Vol. 51, No. 2, pp. 268 - 273, Jun. 2006.

- [6] F. S. AI-Kamali, M. I. Dessouky, B. M. Sallam, F. Shawki and F. E. Abd EI-Samie, "Performance Enhancement of SC-FDMA Systems Using a Companding Technique", Ann. Telecommun. , Vol. 65, No. 5-6, pp. 293-300, 2010.
- [7] L. Guan, T. Jiang, D. Qu and Y. Zhou, "Joint Channel Estimation and PTS to Reduce Peak-to-Average-Power Ratio in OFDM Systems without Side Information", IEEE Signal Processing Letters, Vol. 17, No. 10, pp. 883-886, October 2010.
- [8] E. S. Hassan, S. E. EI-Khamy, M. I. Dessouky, S. A. EI-Dolil and F. E. Abd EI-Samie, "A Simple Selective Mapping Algorithm For The Peak-To-Average Power Ratio In Space Time Block Coded MIMO-OFDM Systems" Proceedings of the International Conference on High Performance Computing, Networking and Communication Systems (HPCNCS-08), 2008.
- [9] T. Jiang and G. Zhu, "Complement Block Coding for Reduction in Peak-to-Average Power Ratio of OFDM Signals," IEEE Communications Magazine, vol. 43, no.9, pp. S17 - S22, Sept. 2005.
- [10] A. Rushdi and J. Tuqan, "Peak reduction in Trigonometric Based OFDM System", Proceedings in ACSSC.2007, pp. 1747 - 1751, 2007.
- [11] R G. Gallagher, "Low Density Parity Check Codes", IRE Trans. Inform. Theory, Vol. IT-8, pp. 21-28, Jan. 1962
- [12] D. J. C. MacKay, "Good Error-Correcting Codes Based on Very Sparse Matrices", IEEE Trans. Inform. Theory, Vol.45, pp. 399-43 1, Mar. 1999.
- [13] K. D. Rao and T.S.N. Murthy, "Analysis of Effects of Clipping and Filtering on the Performance of MB-OFDM UWB Signals," Proc. of the 2007 15th International Conference on Digital Signal Processing (DSP 2007), IEEE, pp.559-562.
- [14] Y. Sun, X. Wang and Liu, K.J.R, "A Joint Channel Estimation and Unequal Error Protection Scheme for Image Transmission in Wireless OFDM Systems", Multimedia Signal Processing, IEEE, pp. 380 - 383, 2002.
- [15]S. Wang, J. Dai, C. Hou and X. Liu "Progressive Image Transmission over Wavelet Packet Based OFDM", Proceedings in Electrical and Computer Engineering 2006 Canadian Conference, pp. 950 -953, 2006.
- [16] J.M. Shapiro, "Embedded image coding using the zero trees of wavelet coefficients", IEEE Transactions on Image Processing, Vol. 41, No. 12, pp. 3445-3462, December 1993.
- [17] Said Amir and Pearlman William A., "A New Fast and Efficient Image Codec Based on Set Partitioning in Hierarchical Trees", IEEE Transactions On Circuits and Systems For Video Technology, Vol.6, Pg. No. 243-250, June 1996.
- [18] H. Schulze and C. Luders, Theory and Application of OFDM and CDMA Wideband Wireless Communication John Wiley, 2005