Reduce the PAPR in LDPC-COFDM system using Trigonometric Transform

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Abstract— **In this paper we discuss the some peak to average power ratio reduction techniques by using orthogonal frequency division multiplexing . This paper targets on 2 factors reducing the Peak to average power ratio of the orthogonal frequency division multiplexing signal and improving the quality of the reconstructed images by using coded Orthogonal Frequency Division Multiplexing system. In this system the coding technique used for Low Density Parity Check Coding (LDPC) over AWGN Channel . We use the Any given image by using SPIHT algorithm compression technique to apply on that system .This system is greatly reduce the PAPR value**

Keywords— **OFDM, PAPR, SPIHT, LDPC, Trigonometric transforms.**

I. Introduction

The principles of orthogonal frequency division multiplexing (OFDM) modulation have been in existence for several decades. However, in recent years these techniques have quickly moved out of textbooks and research laboratories and into practice in modern communications systems. The techniques are employed in data delivery systems over the phone line, digital radio and television, and wireless networking systems. What is OFDM? And why has it recently become so popular? This article will review the fundamentals behind OFDM techniques, and also discuss common impairments and how, in some cases, OFDM mitigates their effect.

Where applicable, the impairment effects and techniques will be compared to those in a single carrier system. Orthogonal frequency division multiplexing (OFDM) has been shown to be an effective technique to combat multipath fading in wireless communications. It has been successfully used for HF radio applications and has been chosen as the standard for digital audio broadcasting and digital terrestrial TV broadcasting in Europe and high-speed wireless local areas networks. In this tutorial, we present the basic principles of OFDM and discuss the problems, and some of the potential solutions, in implementing an OFDM system. Techniques for peak-to-average power ratio reduction, time and frequency synchronization, and channel estimation In this paper we discuss the some peak to average power ratio reduction techniques by using orthogonal frequency division multiplexing . This paper targets on 2 factors reducing the Peak to average power ratio of the orthogonal frequency division multiplexing signal and improving the quality of the reconstructed images by using coded Orthogonal Frequency Division Multiplexing system. In this system the coding technique used for Low Density Parity Check Coding (LDPC) over AWGN Channel . We use the Any given image by using SPIHT algorithm compression technique to apply on that system .This system is greatly reduce the PAPR value .The combination of the high spectral efficiency OFDM modulation technique and LDPC coding will be a good candidate for high speed broadband wireless applications. The BER performance of the Low Density Parity Check Coding- Coded Orthogonal Frequency Division Multiplexing system (LDPC-COFDM) is influenced by the sub channels which have deep fad due to frequency selective fading. According to this combination, several algorithms were introduced into LDPC-COFDM system to improve the BER by adaptive bit loading and power allocation of each subcarrier . The simulation experiments are carried out to study the transmission of SPIHT coded images on LDPC COFDM modified by Trigonometric transforms over AWGN channel. In image transmission of existing OFDM system, the peak to average power ratio (PAPR) is very high. It effects the system performance and received image quality at received end. Hence, in this proposed project we aim at:

Reducing the Peak-to Average Power Ratio (PAPR) of the OFDM signal in existing OFDM system. Improving the image quality obtained at receiver end. Also to improve the Bit Error Rate (BER) performance in existing OFDM system

The wavelet decomposition depth is an important criteria that really matters. Lower level settings cause the spatial orientation trees to be handicapped by low algorithm depth. This is interesting due to the fact that three-level decomposition is usually enough for image composition methods based on DWT. This simulation revealed a fact that SPIHT is most efficient. The input image is 8 bits per pixel, gray scale test image, 'Building' from MATLAB toolbox is utilized in the simulation has a resolution 256x256 pixels. The parameters used in the simulation are: the number of subcarriers of a LDPC coded OFDM system (N) is considered to be 256, Cyclic Prefix is 64, Rate of the SPIHT (r) = 0 to l. LDPC code of R = 1;2 is employed with sum-product decoding, where R denotes the code rate and a (512, 1024) parity check matrix is used. The maximum number of iterations in sum-product decoding is set to 10. The SPHIT coder is chosen as the source coding technique due to its flexibility of code rate and simplicity of designing optimal 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 are 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 codeword is on different

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Subcarrier. At the same time, the proposed method reduces the PAPR greatly and the system has character of low complexity hardware. To generate OFDM successfully the relationship between all the carriers must be carefully controlled to maintain the orthogonality of the carriers. Coded OFDM, or COFDM, is a term used for a system in which the error control coding and OFDM modulation processes work closely together. An important step in a COFDM system is to interleave and code the bits prior to the IFFT. This step serves the purpose of taking adjacent bits in the source data and spreading them out across multiple subcarriers. One or more subcarriers may be lost or impaired due to a frequency null, and this loss would cause a continuous stream of bit errors. Such a burst of errors would typically be hard to correct. The interleaving at the transmitter spreads out the contiguous bits such that the bit errors become spaced far apart in time. This spacing makes it easier for the decoder to correct the errors. Another important step in a COFDM system is to use channel information from the equalizer to determine the reliability of the received bits. The values of the equalizer response are used to infer the strength of the received subcarriers. For example, if the equalizer response had a large value at a certain frequency, it would correspond to a frequency null at that point in the channel. The equalizer response would have a large value at that point because it is trying to compensate for the weak received signal. This reliability information is passed on to the decoding blocks so that they can properly weight the bits when making decoding decisions. In the case of a frequency null, the bits would be marked as “low confidence” and those bits would not be weighted as heavily as bits from a strong subcarrier. COFDM systems are able to achieve excellent performance on frequency selective channels because of the combined benefits of multicarrier modulation and coding.

For this reason, OFDM is generated by firstly choosing the spectrum required, based on the input data, and modulation scheme used. Each carrier to be produced is assigned some data to transmit. The required amplitude and phase of the carrier is then calculated based on the modulation scheme (typically differential BPSK, QPSK, or QAM). The required spectrum is then converted back to its time domain signal using an Inverse Fourier Transform. In most applications, an Inverse Fast Fourier Transform (IFFT) is used. The IFFT performs the transformation very efficiently, and provides a simple way of ensuring the carrier signals produced are orthogonal. The Fast Fourier Transform (FFT) transforms a cyclic time domain signal into its equivalent frequency spectrum. This is done by finding the equivalent waveform, generated by a sum of orthogonal sinusoidal components. The amplitude and phase of the sinusoidal components represent the frequency spectrum of the time domain signal. The IFFT performs the reverse process, transforming a spectrum (amplitude and phase of each component) into a time domain signal. An IFFT converts a number of complex data points, of length which is a power of 2, into the time domain signal of the same number of points. Each data point in frequency spectrum used for an FFT or IFFT is called a bin. The orthogonal carriers required for the OFDM signal can be easily generated bynsetting the amplitude and phase of each bin, then performing the IFFT. Since each bin of an IFFT corresponds to the amplitude and phase of a set of orthogonal sinusoids, the reverse process guarantees that the carriers generated are orthogonal.

II. Literature review

There are several developed techniques to reduce the PAPR in OFDM systems such as clipping, companding , Partial Transmit Sequence (PTS) , Selected Mapping (SLM) and coding . The clipping technique is the simplest one that can be used in OFDM systems, but it causes additional clipping no which degrades the system performance. An alternative technique to mitigate the PAPR problem is based On signal transformations This technique involves a signal transformation prior to amplification, then an inverse transformation at the receiver prior to demodulation. Y. Sun, X. Wang and Liu proposed the paper[]"A Joint Channel Estimation and Unequal Error Protection Scheme for Image Transmission in Wireless OFDM Systems. Gusmo, R. Dinis and N. Esteves[2] ,proposed the paper " On Frequency Domain Equalization and Diversity Combining for Broadband Wireless Communications" This is concerned with the use of frequency-domain equalization and space diversity within block transmission schemes for broadband wireless communications. C. Yuan Yang and M. Kai Ku[18] proposed the paper, "LDPC Coded OFDM Modulation for High Spectral Efficiency Transmission" This paper investigates efficient low-density parity-check (LDPC) coded orthogonal frequency division multiplexing (OFDM) modulation schemes for fixed wireless application.

III.MOTIVATION

If There are still some challenging issues, which remain unresolved in the design of OFDM systems. One of the major problems is high PAPR of transmitted OFDM signals. Therefore, the OFDM receiver detection efficiency is very sensitive to the nonlinear devices used in its signal processing loop, such as Digital to Analog Converter (DAC) and High Power Amplifier (HPA), which may severely impair system performance due to induced spectral regrowth and detection efficiency degradation. All fading and Inter-Symbol Interference (ISI) result in severe losses of transmitted image quality. The aim of this project is reduce the PAPR of transmitted OFDM signals, improve the transmitted image quality & The SPIHT coder is chosen as the source coding technique due to its flexibility of code rate and simplicity of designing optimal system.

IV.THE SPIHT ALGORITHM

Use The SPHIT algorithm defines and partitions sets in the wavelet decomposed image using a special data structure called a spatial orientation tree. A spatial orientation tree is a group of wavelet coefficients organized in to a tree rooted in the lowest frequency (coarsest scale) sub band with offspring in several generations along the same spatial orientation in the higher frequency sub band. Fig.1, shows a spatial orientation tree and the parent children dependency defied by the SPHIT algorithm across sub band in the wavelet image. The tree is defied in such a way that each node has either no offspring (the leaves) or four offspring at the same spatial location in the next from sub band level. The pixels in the lowest frequency sub band-tree roots are grouped into blocks of 2x2 adjacent pixels, and in each block one of them; marked by star

as shown in Fig. 1; has no descendants. SPIRT describes this collocation with one to four parent-children relationships,
parent = (i,j)
children = [(2i,2j),(2i + 1,2j),(2i,2j + 1),(2i + 1,2j + 1)]

The SPHIT algorithm consists of three stages: initialization, sorting and refinement. It sorts the wavelet coefficients into three ordered lists: the list of insignificant sets (LIS), the List of Insignificant Pixels (LIP), and the List of Significant Pixels (LSP). At the initialization stage the SPIRT algorithm first defines a start threshold based on the maximum value in the wavelet pyramid, then sets the LSP as an empty list and puts the coordinates of all coefficients in the coarsest level of the wavelet pyramid (Le. the lowest frequency band; LL band) into the LIP and those which have descendants also into the LIS. In the sorting pass, the algorithm first sorts the elements of the LIP and then the sets with roots in the LIS. For each pixel in the LIP it performs a significance test against the current threshold and outputs the test result to the output bit stream. All test results are encoded as either 0 or 1, depending on the test outcome, so that the SPHIT algorithm directly produces a binary bit stream. If a coefficient is significant, its sign is coded and its coordinate is moved to the LSP. During the sorting pass of LIS, the SPHIT encoder carries out the significance test for each set in the LIS and outputs the significance information. If a set is significant, it is partitioned into its offspring and leaves. Sorting and partitioning are carried out until all significant coefficients have been found and stored in the LSP. After the sorting pass for all elements in the LIP and LIS, SPHIT does a refmement pass with the current threshold for all entries in the LSP, except those which have been moved to the LSP during the last sorting pass. Then the current threshold is divided by two and the sorting and refmement stages are continued until a predefined bit-budget is exhausted. Details of SPHIT algorithms are presented in [12].In this scheme, each node with message searches for possible path nodes to copy its message. Hence, possible path nodes of a node are considered. Using NSS, each node having message selects its path nodes to provide a sufficient level of end-to-end latency while examining its transmission effort. Here, it derives the CSS measure to permit CR-Networks nodes to decide which licensed channels should be used. The aim of CSS is to maximize spectrum utilization with minimum interference to primary system. Assume that there are M licensed channels with different bandwidth values and y denotes the bandwidth of channel c. Each CR-Networks node is also assumed to periodically sense a set of M licensed channels. Mi denotes the set including Ids of licensed channels that are periodically sensed by node i. suppose that channel c is periodically sensed by node i in each slot and channel c is idle during the time interval x called channel idle duration. Here, it use the product of channel bandwidth y and the channel idle duration x, tc = xy, as a metric to examine the channel idleness. Furthermore, failures in the sensing of primary users are assumed to cause the collisions among the transmissions of primary users and CR-Networks nodes.

V. SYSTEM MODEL AND ASSUMPTIONS

The block diagram of the proposed LDPC-COFDM system is illustrated in Fig. 2. As will be shown in the next sections, the proposed modifications will be in the transform and replacement block. The SPIRT coder is chosen the source coding technique due to its flexibility of code rate and simplicity of designing optimal system. The SPHIT divides the image stream into several layers according to the importance of progressive image stream.

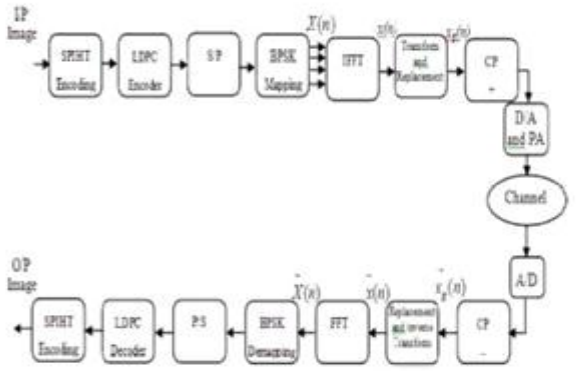


Fig. 1: The LDPC COFDM system model with trigonometric transforms

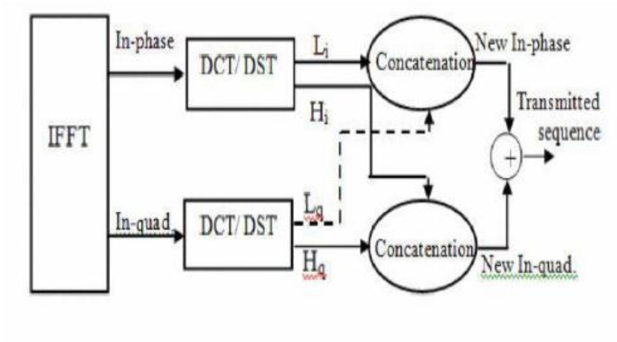


Fig. 2: The trigonometric transform and replacement process.

Then the image stream is converted to a binary format. Afterwards the information bits are 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 an IFFT circuit, such that the OFDM signal is generated. The resulting OFDM signal can be expressed as follows:

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

where Xn is a discrete time sample. The output of IFFT is split into two components; in-phase and in-quadrature. Then, either the DCT or the DST is applied to both components, separately. The first half of samples of the in-phase 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 in-phase 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 in-quadrature 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 can be called (xin) 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 (IBI). The continuous COFDM signal x/.J) is generated at the output of the digital to Analog (D/A) converter. According to [I], the PAPR of transmitted Analog signal can be expressed as follows:

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

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 (Nf +Ng), where Ng is the guard interval length. At the receiver, the guard interval is removed and the time interval [O,T] is evaluated. The replacement 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 are decoded with each LDPC encoded block and data bits are restored. These data are converted into image format, such that SPIHT decoder can be obtained.

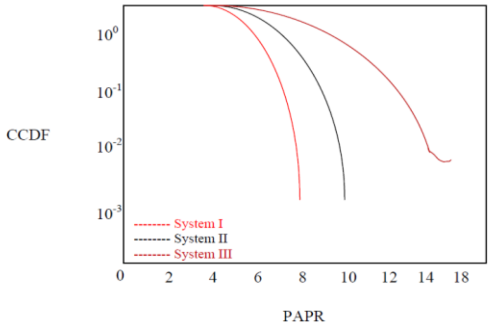
VI. RESULT AND DISCUSSION

In this section, simulation experiments are carried out to study the transmission of SPIHT coded images on LDPC COFDM modified by Trigonometric transforms over AWGN channel. The parameters used in the simulation are: the number of subcarriers of a LDPC coded OFDM system (N) is considered to be 256, Cyclic Prefix is 64, Rate of the SPIHT (r) = 0 to l. LDPC code of R = 1;2 is employed with sum-product decoding, where R denotes the code rate and a (512, 1024) parity check matrix is used. The maximum number of iterations in sum-product decoding is set to 10. The input image is 8 bits per pixel, gray scale test image, 'Building' from MATLAB toolbox is utilized in the simulation has a resolution 256x256 pixels. The fidelity of it was measured by the Peak Signal-to-Noise Ratio, PSNR, which usually expressed in terms of the logarithmic scale. 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. The peak value is 255 for an 8 bits/pixel of original image. To verify the effectiveness of the proposed method; adding Trigonometric transforms to the OFDM system to reduce the P APR, the analysis is divided into two methods one with DCT and another with DST and compare them with COFDM and set SPIHT coder as source coding. The three transmission schemes were designed as follows:

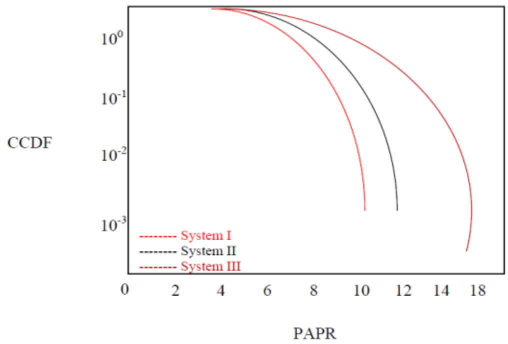
Scheme I : The system which consists of coded OFDM

Scheme II : The system I with the DCT transforms for the transmitted signal.

Scheme III: The system I with the DST transform for the transmitted signal.



a) r = 0.5

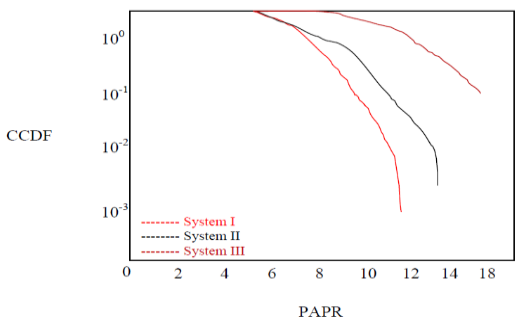


b) r = 1.0

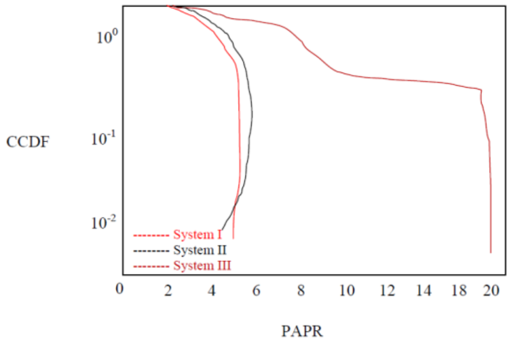
Fig.3(a ,b). CCDF of the PAPR for the LDPC COFDM (system I) that with DCT (system II) and finally that with DCT

Simulation were carried out respectively according to the above three schemes. Firstly, we present the simulation of the complementary cumulative distribution function (CCDF) curves for the proposed SPIHT LDPC COFDM with Trigonometric transforms. The CCDF is a useful statistical indication about the signal power distribution. It is defined as the probability that the signal is at or higher than a given amplitude PAPR• Fig. 3 (a, b) shows the CCDFs of the PAPR for the three proposed schemes at different SPIHT rates: 0.5 and 1 respectively.

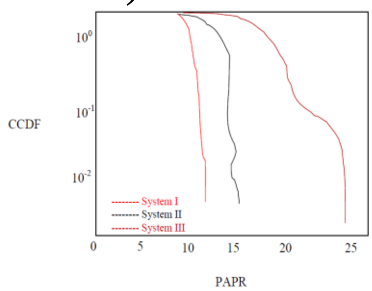
Clearly, the PAPR performance of the proposed systems II and III outperforms the system I without each other. The figure reveals that system with the DST has a better reduction in the PAPR than that with the DCT nearly up to 0.25dB (Fig. 3(b)). It is also noted that the PAPR can be achieved by increasing the value of SPIHT rate as the data increased and the statistical distribution is clearer. On the other side, the effect of the SPIHT compression ratios on the PSNR of the received image results in the three schemes and compare with the OFDM system without LDPC.



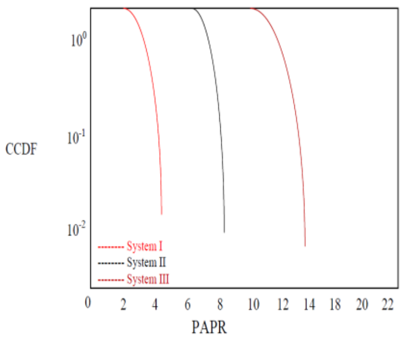
a) N=128



b) N=256



c)N=512



d) N=1024

Fig. 4(a, b, c, d): CCDF of PAPR for the proposed schemes for different numbers of subcarriers when SPIHT compression rate is set to 0.2.

For the lower SNR values (5dB), the PSNR performance deteriorates for all schemes except that with the DST however at higher SNR values (l0dB or greater) all the schemes have the ideal performance which is equal to the output of SPHIT Compression. It can be noticed form this figure, for system III at low SNR and all systems at higher SNR, as the SPHIT rate increases the PSNR also increases. This is due to the fact of injecting more information about the image to the receiver and thus it will have more capability to reproduce a better reconstructed image. Finally, the impact of the number of subcarriers on the performance of the three schemes is studied and shown in Fig.4 at lower SPIRT rate r = 0.2 to save the bandwidth on the channel.

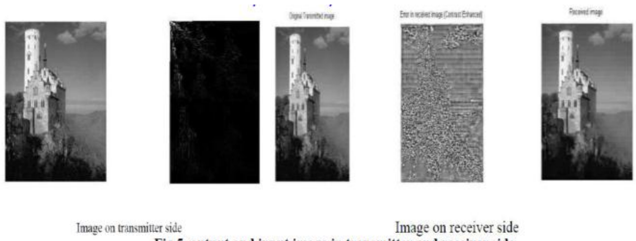


Fig.5 output and input image in transmitter and receiver side

It is clear that, the Scheme III provides a significant PAPR reduction, especially for a large number of subcarriers. and Fig.5 shows the output and input image in transmitter and receiver side , and also Table 1. shows Describing the Different PAPR values Using 256*256 gray scale image .

Rate	Image Name-Building			
	PAPR values	Max signal level	RMS signal values	PEAK to RMS power ratio(DB)
r=0.5	18.7300	0.95	0.21365	12.8513db
	15.1200	0.95	0.18356	11.3256db
	14.1628	0.95	0.25039	11.5821db
	12.9391	0.95	0.26174	11.1971db
r=1.0	18.7300	0.95	0.21365	12.8513db
	16.1900	0.95	0.18356	11.3256db
	14.1928	0.95	0.25039	11.5821db
	12.9291	0.95	0.26174	11.1971db

Table 1.Different PAPR values Using 256*256 grayscale image

VII. CONCLUSION

In this paper, an efficient LDPC coded OFDM system with trigonometric transforms supporting image transmission using SPIHT compression technique is presented and studied. The effectiveness of the proposed system is investigated through simulations over AWGN channel. It is found that the proposed system must be designed carefully in order to achieve a reduction in the PAPR without degrading the PSNR performance. For LDPC COFDM with rate (r=O.5) and rate of SPHIT rate (r = 1) the OFDM signal can be reduced by nearly 7dB or 7.25dB by adding the DCT or DST respectively. We also showed the PSNR for the received image at different rates. This work shows the performance of the system model using 256x256 gray scale images.

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