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# IMPROVED PERFORMANCE IN IMAGE TRANSMISSION WITH OFDM

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***Abstract— Orthogonal Frequency Division Multiplexing is the high speed communication system in wireless communication. The new scheme proposed is to improve image transmission by using orthogonal frequency division multiplexing system over AWGN channel. One of the major issues of OFDM systems is that the composite transmit signal can exhibit a very high PAPR. The performance of the PAPR is improved by the reduction techniques of Selective Mapping and Partial Transmit Sequence. Simulation is performed using MATLAB.***

***Keywords— AWGN-Additive White Gaussian Noise, OFDM-Orthogonal Frequency Division Multiplexing, PAPR-Peak to Average Power Ratio, PTS-Partial Transmit Sequence, SLM-Selective Mapping.***

## I. INTRODUCTION

Modern wireless communication system demands higher data environment and reliable transmission. OFDM is a Multi Carrier Modulation (MCM) technique for high speed data transmission in wireless communication systems. OFDM uses the principles of Frequency Division Multiplexing (FDM) in more controlled manner, allowing an improved spectral efficiency. The basic principle of OFDM is to split a high data rate stream into a number of lower data rate streams that are transmitted simultaneously over a number of orthogonal subcarriers, hence the name OFDM [4].

These subcarriers are overlapped with each other to provide efficient bandwidth utilization without Inter-Carrier-Interference (ICI). OFDM faces several challenges. The key challenges are Inter-Symbol-Interference (ISI) due to multipath-use guard interval, large Peak-to-Average Power Ratio (PAPR) due to nonlinearity of amplifier and phase noise problems of oscillator [3]. OFDM used several applications including Digital Audio Broadcasting (DAB), Digital Video Broadcasting (DVB), Asymmetric Digital Subscriber Lines (ADSL) and Wireless LANs (WLAN).

OFDM system suffers from serious problem of high PAPR. The OFDM signal is superposition of multiple sub-carriers. In this case the instantaneous power output might increase greatly and become higher than the mean power of system. To transmit signals with high PAPR, it requires power amplifiers with very high power [5]. This gives rise to non-linear distortion which changes the superposition of the signal spectrum resulting in performance degradation.

## II. SYSTEM MODEL

OFDM system is used for image transmission through AWGN channel. The PAPR performance of the system is improved by reduction techniques as Selective Mapping (SLM) and Partial Transmit Sequence (PTS). The system model is shown in Fig.1.

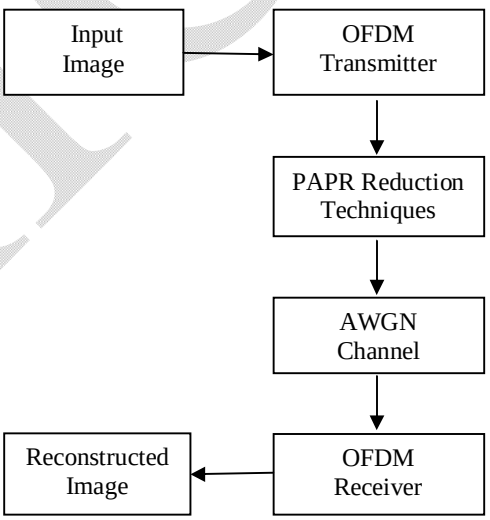


***Fig.1: System Model***

The input image is coded to binary format and transmitted through OFDM system. High PAPR value is exist in OFDM before transmitting through AWGN channel. SLM and PTS are the reduction techniques used to improve the PAPR performance of existing OFDM system. Additive White Gaussian Noise (AWGN) channel is the efficient communication channel for image transmission in OFDM. The OFDM receiver receives the data and reconstructed the image.

## III. OFDM SYSTEM

Orthogonal Frequency Division Multiplexing (OFDM) is an attractive multi carrier modulation technique. It is implemented to achieve high speed data transmission. The orthogonal subcarriers are used to achieve spectrally efficient multi carrier modulation. The basic OFDM trans-receiver system is illustrated in the following Fig.2.

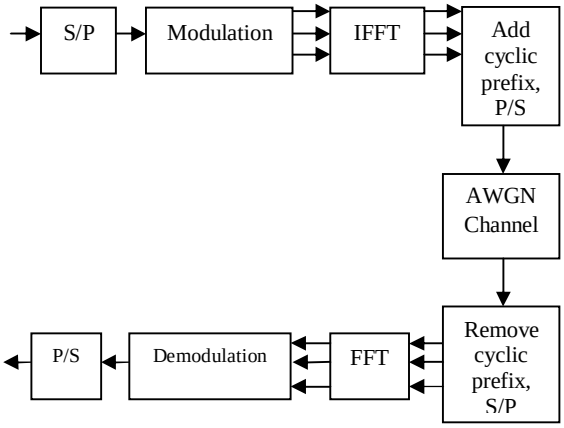


***Fig.2: Basic OFDM System***

The input data stream is passed through serial to parallel (S/P) converter, whose output is a set of parallel symbols. These symbols modulated over each of the orthogonal subcarriers. The data of each parallel channel is modulated by any modulation techniques as Binary Phase Shift Keying (BPSK), Quadrature Phase Shift Keying (QPSK), and Quadrature Amplitude Modulation (QAM). The most efficiently used OFDM modulation is QAM.

The OFDM modulator output contains the frequency components are converted to time samples by performing an Inverse Fast Fourier Transform (IFFT). The cyclic prefix is added to the OFDM symbol, and the resulting time samples are ordered by parallel to serial (P/S) convertor. The OFDM signal is transmitted through AWGN channel to improve the transmission efficiency of the system. The OFDM signal is received and removes the cyclic prefix. The resulting time samples are serial to parallel (S/P) converted and passed through Fast Fourier Transform (FFT) for forming frequency components. The FFT output is demodulated and parallel to serial (P/S) converted to recover the data.

## IV. PEAK-TO-AVERAGE POWER RATIO

The Peak-to-Average Power Ratio (PAPR) is an important attribute of the OFDM communication system. Peak-to-Average Power Ratio can be defined as the ratio of peak power to average power value of the signal. The PAPR of the transmitted signal s (t) is given by the relationship:

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

*Where*

- $\max [s(t)]^2$ is the peak signal power and
- $E\{[s(t)]^2\}$ is the average signal power

PAPR gets increased due to the occurrence of large amount of subcarriers that are modulated independently in OFDM system and the signals which undergoes coherent addition resulting in same phase. A low PAPR allows the transmit power amplifier to operate efficiently, whereas a high PAPR forces the transmit power amplifier to have a large back off in order to ensure linear amplification of signal.

The Cumulative Distribution Function (CDF) is the most regularly used parameter to measure the efficiency of the PAPR technique. The CDF of the amplitude of a signal is given by,

$$F(z) = 1 - e^{-z} \quad \text{(1)}$$

This expression is assumes that, the N time domain signals are mutually independent and uncorrelated.

$$P(PAPR \le z) = F(z)^N = (1-e^{-z})^N \quad \text{(2)}$$

The Complementary Cumulative Distribution Function (CCDF) is used to instead of CDF which helps to measure the probability that the signal is at or higher than a given amplitude of PAPR.

$$P(PAPR > z) = 1 - P(PAPR \le z) = 1 - F(z)^N = 1 - (1-\exp(z))^N \quad \text{(3)}$$

## V. PAPR REDUCTION TECHNIQUES

Several techniques are adopted to reduce the PAPR of OFDM signals. These techniques are divided into two groups; Signal Distortion and Signal Scrambling techniques. Signal distortion techniques introduce interference and system complexity. Signal distortion techniques minimize high peak by distorting signal before amplification. Signal scrambling techniques is to scramble each OFDM signal with different scrambling sequences and works with side information.

### *5.1 Signal Distortion Techniques*

Signal distortion techniques are Peak Windowing, Envelope scaling, Peak Reduction Carrier, Clipping and Filtering. In peak windowing method, large signal peak multiply with a window function for reducing PAPR of the signal. The

Envelope Scaling technique reduces the PAPR by scaling the input envelope for some subcarriers before sent to the IFFT.

The envelopes of all subcarriers are equal. In Peak Reduction Carrier technique, the data bearing peak reduction carriers are used to reduce the effective PAPR. One of the simple and effective PAPR reduction techniques is clipping, which clip the signal at a desired power level. It introduces distortions as out-of-band noise, which decreases the spectral efficiency. These distortions are removed by clipping and filtering technique.

Although filtering can decrease the spectrum growth, filtering after clipping can reduce the out-of-band radiation, but may also cause some peak re-growth, which the peak signal exceeds in the clip level. The technique of iterative clipping and filtering reduces the PAPR without spectrum expansion.

### *5.2 Signal Scrambling Techniques*

Signal Scrambling Techniques are Block Coding Techniques, Selective mapping (SLM), Partial Transmit Sequence (PTS), Interleaving Technique, Tone Reservation (TR) and Tone Injection (TI). Block Coding Techniques have the idea is that, message symbol with low peak power will be chosen by coding as valid codeword for transmission.

The selective mapping technique is to select data block with smallest PAPR and transmitted because all independent data blocks contain same information. The crucial idea of partial transmit sequence technique is to divide the OFDM sequence into several subsequences and each subsequence is multiplied by different weights until an optimum value is chosen. Highly correlated data structures are used in interleaving method to reduce PAPR. The idea of tone reservation method is based on adding a data block and time domain signal. A data block is dependent on time domain signal to the original multicarrier signal to minimize the peak. Tone Injection technique is an additive method to achieve PAPR reduction without any data loss. SLM and PTS are the best methods to improve the PAPR of OFDM system.

### *5.3 Selective Mapping (SLM)*

Selective Mapping is an effective method to reduce the PAPR of OFDM system with image transmission. The image is coded to binary format and transmitted through the OFDM system. High PAPR value is exist in the system before transmission through the channel. The PAPR is reduced by changing the transmitter section of OFDM system. The OFDM data is serial to parallel (S/P) converted and produce statistically independent sequences which represent the same information. The statistically independent symbol vectors are multiplied with the random phase sequences. The resulting data blocks are forwarded into IFFT operation simultaneously. Eventually, the sequence with the smallest PAPR is selected for final transmission. Fig.3 shows the block diagram of SLM technique for suppressing the high PAPR. This technique effectively reduces PAPR without any distortion.

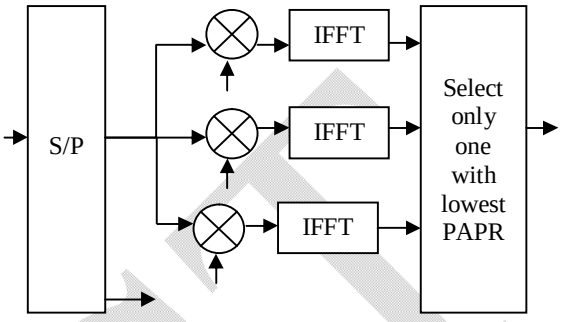


***Fig.3: Block Diagram of SLM***

### *5.4 Partial Transmit Sequence (PTS)*

Partial Transmit Sequence is the best signal scrambling technique for reducing PAPR. The basic idea of this technique is to partitioning the OFDM data into several subblocks. After the IFFT operation, each subblock is multiplied by different phase factors until an optimum value is chosen. The subblocks have the same size. The phase factor used to enable the receiver to identify the different phases. The block diagram of PTS technique is shown in Fig.4. This PAPR reduction technique is better than selective mapping.

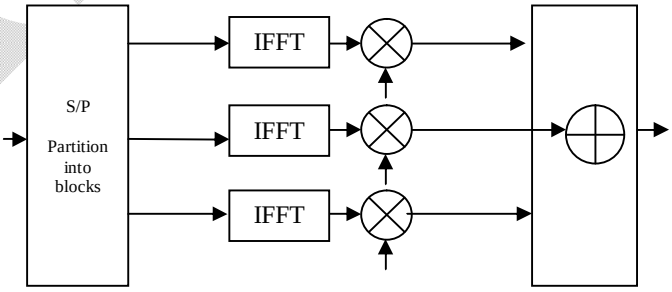


***Fig.4: Block Diagram of PTS***

## VI. SIMULATION RESULTS

OFDM communication system was designed and simulated using MATLAB for image transmission. This MATLAB simulation is carried out to study the PAPR performance of OFDM system with transmission of images over AWGN channel. The input image is 'lena' from MATLAB toolbox. The input image is shown in Fig.5. This image is transmitted through OFDM system and reconstructed the image as shown in Fig.6.

*Fig.5: Input Image*

*Fig.6: Reconstructed Image*

The CCDF of the PAPR for OFDM signal is shown in the Fig.7. It can observed that, the value of PAPR is 9.4 dB before applying the PAPR reduction techniques.

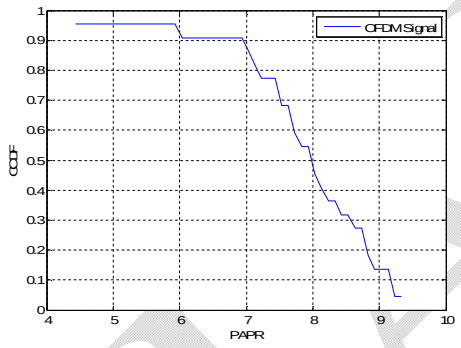


*Fig.7 : CCDF of the PAPR for OFDM Signal*

The simulation of PAPR with CCDF function of the reduction techniques SLM and PTS are analyzed as shown in the Fig.8 and Fig.9. After applying SLM technique, PAPR value is reduced to 7.2 dB and using PTS technique, PAPR value is reduced to 5.4 dB.

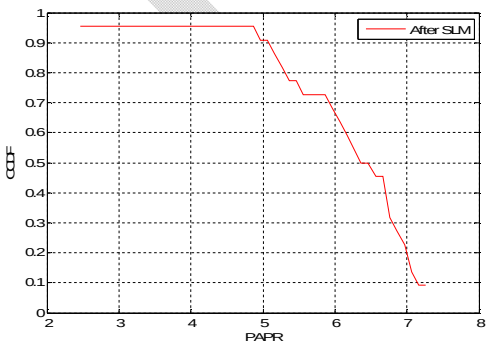


*Fig.8 : CCDF of the PAPR after SLM*

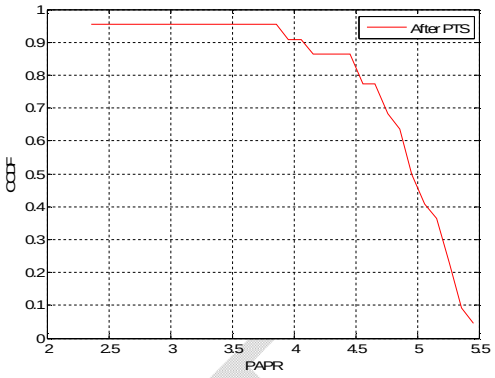


*Fig.9 : CCDF of the PAPR after PTS*

It can be observed that OFDM signal has higher PAPR and after appling the reduction techniques, the PAPR value reduced significantly. Better PAPR can be achieved by PTS technique compared to SLM.

## VII.CONCLUSION

OFDM is very attractive technique for wireless communications due to its spectral efficiency. PAPR is the important problem to be addressed in developing multicarrier transmission in OFDM. In order to minimize the effects of high PAPR in OFDM systems, two typical signal scrambling techniques SLM and PTS are investigated. The PTS method performs better than SLM method in reducing PAPR. In future, this PAPR reduction concept will be expanded for distortion less transmission. The PAPR reduction technique will be developing for low data rate loss and efficient use of channel.

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