PAPR Reduction in OFDM Using Partial Transmit Sequence (PTS)

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Absract -- **In recent years, OFDM has gained a lot of interest in diverse-digital communication applications. This has been due to its favorable properties like high spectral efficiency and robustness to channel fading. Some of the major drawbacks in OFDM are its high peak-to-average-power ratio(PAPR) of the transmitted signals and the synchronization of signals. OFDM consist of large number of independent subcarriers, as a result of which the amplitude of such a signal can have high peak values. Coding, phase rotation and clipping are among many PAPR reduction schemes that have been proposed to overcome this problem. Significant reduction in PAPR has been achieved using Partial Transmit Sequence(PTS) which comes under Signal scrambling techniques.**

Index Terms -- OFDM - Orthogonal Frequency Division Multiplexing, PTS - Partial Transmit Sequence, QAM – Quadrature Amplitude Modulation, PAPR- Peak-to-Average Power Ratio, Companding, CCDF-Complementary Cumulative Distribution Function, ICI- Inter Carrier Interference, ISI-Inter Symbol Interference, BER- Bit Error Rate

I. INTRODUCTION

Today OFDM is widely used in many applications like Digital Audio Broadcasting (DAB), Digital Video Broadcasting (DVB), High Definition Television (HDTV), etc because of its high program broadcasting capacity and end-to-end transmission system.

In serial transmission system, the data symbols were transmitted serially in which each data occupies whole available bandwidth. But Orthogonal frequency division multiplexing is an individual form of the multicarrier modulation technique where parallel transmission of data takesplace over single carrier with more lower rate subcarriers using FDM. This technique is widely used in present generation because of its major distinct features like follows:

OFDM provides strength not in favor of intersymbol interference and multipath fading because for the lower rate subcarriers, the symbol period increases. And its also robust against narrowband interference. With the utilization of adaptive modulation technique, OFDM allows resourceful use of on hand radio frequency (RF). It enables the bandwidth-on-demand technology and privileged spectral efficiency. So OFDM does not necessitate adjacent bandwidth for operation. OFDM makes on its own frequency networks possible, which is for the most part attractive for broadcasting applications.

However, there are many problems that need to be conquer before OFDM finds extensive use in recent wireless communication systems.

- OFDM has a comparatively large peak-to-average power ratio (PAPR), which tends to condense the power efficiency of RF amplifiers. Framing up of OFDM signals with lower crest-factor is predominantly significant if the number of subcarriers is more because the peak power of a sum of N sinusoidal signals can be as large as N times the mean power. Furthermore, output peak extracting produces out of band transmission due to inter-modulation distortion.
- Multicarrier systems are naturally more vulnerable to phase noise and frequency offset. Doppler shift and Frequency jitter between the transmitter and receiver causes inter-carrier-interference (ICI) which humiliates performance of the system unless suitable compensation techniques are employed.

OFDM remains a chosen modulation scheme for upcoming broadband radio area systems because of its inherent flexibility in power loading across the subcarriers and concerning adaptive modulation.

Several techniques are there to reduce the PAPR in OFDM system such as signal scrambling techniques and signal distortion techniques under which several sub-techniques are present which will be explained later in this paper.

The remaining paper is organized as follows. The next section deals with the introduction to OFDM and its block diagram, followed by details about BER, PAPR in OFDM system several techniques to reduce PAPR in OFDM, the implemented techniques and its simulations results and finally with conclusions.

II. FFT BASED OFDM

The OFDM block diagram is shown in fig.1.. Signal generator will produce sequence of binary data, which consists of 0s and 1s. Depending on the system transmission rate, the output from the generator will determine the bit rate for the transmission[1]. The binary number is in multiple of 2 since it has a random probability of a 0 or 1.

An OFDM symbol is mapped from a binary to a complex signal with an amplitude and phase represented by a real and imaginary number. This is then encoded and interleaved so as to produce a matrix to be mapped onto the modulated values in the form of amplitude and phase.

This involves taking N parallel streams of symbols (N being the number of sub-carriers used in the transmission of the data) and performing an IFFT operation. The output of the IFFT operation in discrete time is as follows:

$$X_k(n) = \frac{1}{\sqrt{N}} \sum_{i=0}^{N-1} X_m(i) \exp(j2\pi \frac{n}{N} i) \qquad (1)$$

Where X$m(i)$ | $0 \leq i \leq$ N-1 are complex numbers in the discrete frequency domain and $X_k(n)$ | $0 \leq n \leq$ N-1 is a sequence in the discrete time domain.

The cyclic prefix (CP) is lastly added before transmission to minimize the inter-symbol interference (ISI). At the receiver, the process is reversed to obtain the decoded data. The CP is removed to obtain the data in the discrete time domain and then processed using the FFT for data recovery. The output of the FFT in the frequency domain is as follows:

$$U_m(i) = \sum_{i=0}^{N-1} U_k(n) \exp(-j2\pi \frac{n}{N} i) \qquad (2)$$

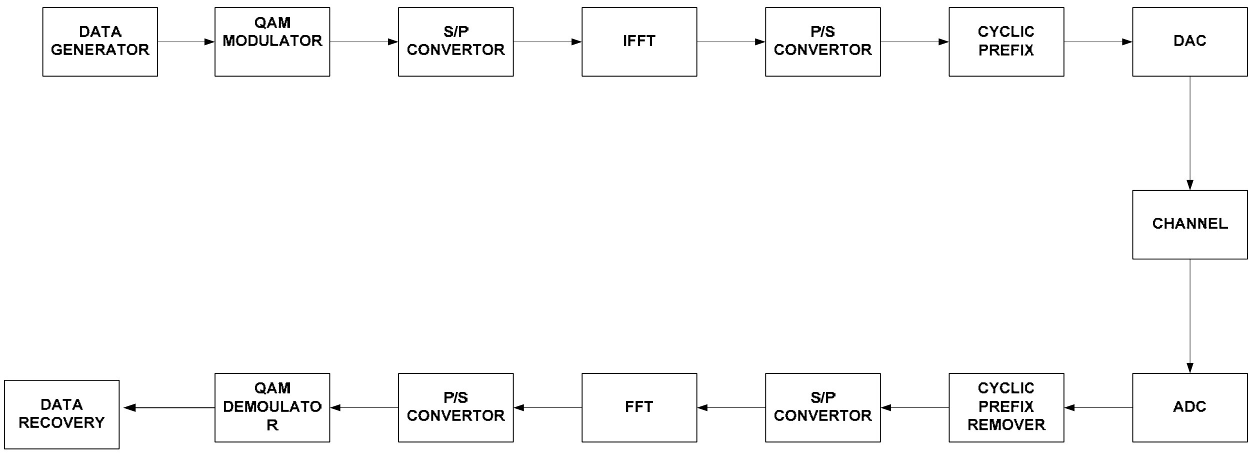

Fig:1. Block Illustration of FFT-Based OFDM

III. PAPR IN OFDM

The peak-to-average power ratio (PAPR) is a related measure that is defined as the peak amplitude squared (giving the peak power) divided by the RMS value squared (giving the average power. PAPR is therefore dimensionless quantities. The PAPR is most used in signal processing applications. As it is a power ratio, it is normally expressed in decibels (dB).

We can consider OFDM transmission with N sub-carriers and sub-carrier spacing f = 1/NT, where T is the modulation interval and NT is the duration of the OFDM symbol not including the guard interval. Therefore we can model the complex envelope of an OFDM is given by

$$x(t) = \frac{1}{N} \sum_{k=0}^{N-1} X_k \, e^{j2} \ , \quad 0 \leq t \ \leq NT \qquad (3)$$

The PAPR of an OFDM signal is defined as the ratio of the maximum instantaneous power to its average power (P_{av}):

$$PAPR[x(t)] = \frac{\underset{0\le t\le NT}{MAX}(|x(t)|^2)}{P_{av}} \qquad (4)$$

where (P_{av}) = average power of x(t) .

In PTS, PAPR reduction is based on the sampled, discrete-time signal which can be written as

$$x[n] = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k \, e^{\frac{j2\pi nk}{LN}}, \quad 0 \le n \le LN-1 \qquad (5)$$

where L is the over sampling factor.

The PAPR computed from the L-times over sampled OFDM signal can be defined as

$$\text{PAPR}(\text{X[n]}) = \frac{\underset{0\le n\le LN-1}{MAX}(|x[n]|^2)}{E(x|[n]|^2)} \qquad (6)$$

where E{.} denotes the expectation operator.

IV. CCDF

Cumulative distributive function is to describe the probability of the random variable with the given probability distribution function. Complementary cumulative distributive function is also called as tail distribution which is used to illustrate the PAPR of OFDM signal. The output curve is used to conclude the design parameters of the modulation system. The CCDF of an OFDM system to measure the PAPR can be given as

$$\text{CCDF} = \text{P}_\text{r}\,(\text{PAPR} > \text{PAPR}_0) \qquad (7)$$

Where P_r is the probability distribution function and $PAPR_0$ is the threshold value.

V. PAPR REDUCTION USING PTS

Main idea of PTS is data blocks are divided into non overlapping sub-block with independent rotation factor. This rotation factor generates time domain data with lowest amplitude. This is the modified technique of SLM which gives the better performance than SLM.

Partial Transmit Sequence (PTS)[2] is one of the techniques used to reduce PAPR in OFDM system which is implemented in this paper. The fundamental idea of this technique is sub-dividing the original OFDM symbol data into sub-data which is transmitted through the sub-blocks which are then multiplied by the weighing value which were differed by the phase rotation factor until choosing the optimum value which has low PAPR.

The block diagram for PTS technique implementation is shown in figure 2. The data sequence X in frequency domain is sub-divided into ***v*** sub-sequence which were transmitted in sub-blocks without overlapping and having equal size of N which contains N/V non-zero values in each sub-blocks.

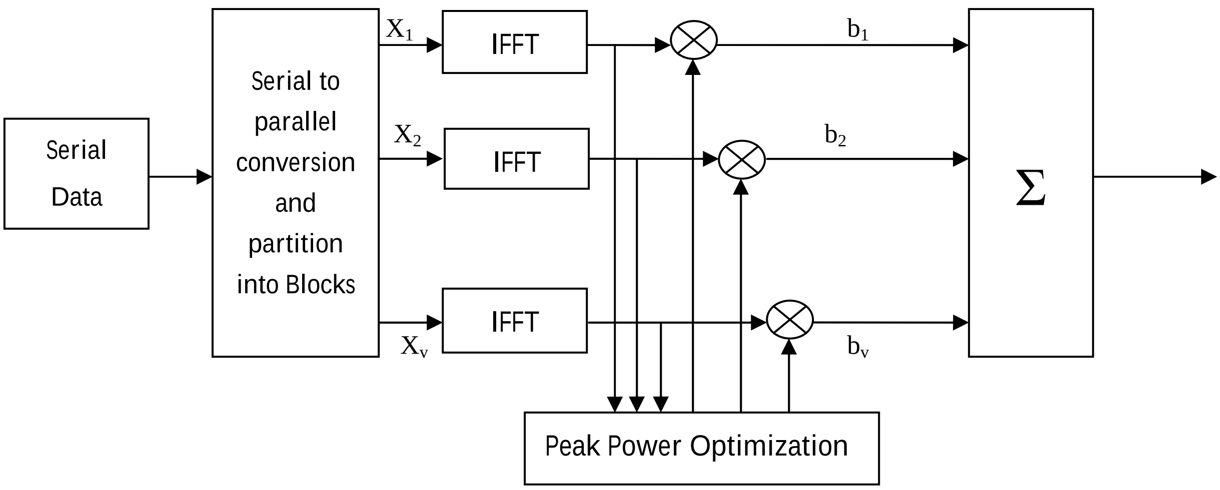

Fig.2.Conventional OFDM diagram employing PTS

With the assumption that the sub-blocks have equal size without having any gap between them. Thus the sub-block vector in frequency domain can be written as follows.

$$X = \sum_{v=1}^{V} b_v X_v \qquad (8)$$

Where $b_v = e^{j\varphi_v}$ (φ_v [0,2π]) { v = 1, 2, 3, …….,X_v} is the weighing factor which is used for phase rotation.

The time domain for the above sub-block vector can be yield by by applying IFFT function, that is

$$x = \text{IFFT}(X) = \sum_{v=1}^{V} b_v X_v \quad (9)$$

for an optimum result, one of the factor is selected such that it gives minimum output value.Simulation result were sown in fig .3.

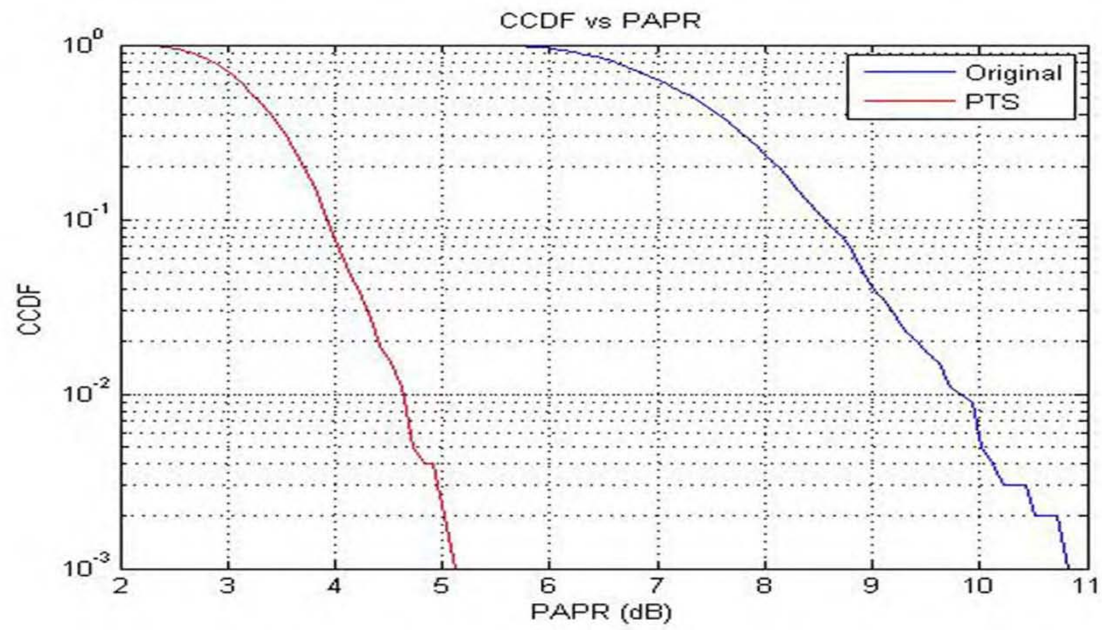

Fig.3.Simulation Result using PTS

VI. CONCLUSION

Thus Peak to average power ratio has been reduced in OFDM using partial transmit sequence.From the results it is observed that the performance of the system has been improved by more than 5 dB using PTS technique.

REFERENCES

[1] Wu, Y. and Zou, W. Y., Orthogonal Frequency Division Multiplexing: A multicarrierModulation Scheme,I EEE Transactionson ConsumeEr lectronicsVol.4l, No.3, August, pp 392-399, 1995

[2] Malhar Chauhan, Saurabh patel, Hardik patel " Different Techniques to Reduce the PAPR in OFDM System", International Journal of Engineering Research and Applications (IJERA) ,Vol. 2, Issue 3, pp.1292-1294, May-Jun 2012,

[3] Md. Ibrahim Abdullah, Md. Zulfiker Mahmud, Md. Shamim Hossain, Md. Nurul Islam " Comparative Study of PAPR Reduction Techniques in OFDM", ARPN Journal of Systems and Software , VOL. 1, NO. 8, November 2011

[4] Zhongpeng Wang "Combined DCT and Companding for PAPR Reduction in OFDM Signals", Journal of Signal and Information Processing, 2, pp.100-104 ,2011,

[5] A. D. S. Jayalath, C. Tellainbura "Side information in PAR reduced PTS-OFDM signals", The 14th IEEE 2003 International Symposium on Persona1,lndoor and Mobile Radio Communication Proceedings .