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A Novel Modified Filtered PTS Scheme to Reduce PAPR in OFDM System

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Abstract - OFDM is a most efficient convenient multi-carrier modulation (MCM) technique. The main idea of OFDM is to divide a high speed data stream into several low speed data streams and modulate on subcarriers that are orthogonal with each other. In this way, OFDM makes the symbol period longer than the delay spread, which avoids the small scale fading and intersymbol interference ISI. Most multicarrier modulation schemes (such as OFDM) have high PAPR compared with single carrier systems. Maintaining the sufficient power of a signal is the least requirement of an system. To maintain the power of signal throughout transmission over communication system and it can be achieved by keeping the average power of the signal and it is in terms of peak to average power ratio (PAPR) i.e. if PAPR is reduced the performance of the system will improve. In this work a advanced and efficient methodology is used which utilizes modified -PTS algorithm with difference carrier sizes to reduce the PAPR. From the simulated results performed for variable data lengths to analyze the performance of the proposed approach. The performance analysis of proposed system in terms of PAPR has done simultaneously.

Keywords - PAPR, Filtered-PTS and CCDF etc.

I. INTRODUCTION

OFDM divides high-speed data streams into low-speed data streams in order to in- crease the duration of the symbol period on each subcarrier, which dramatically decrease the ISI caused by time dispersive channels. In the conventional FDM, the data is transmitted on several uncorrelated sub-channels. The sub-channels or sub-carriers do not overlap in the frequency domain and there are guard bands between adjacent subcarriers. However, in OFDM, because of the orthogonality among sub- carriers, spectral overlapping is possible. This way, for a given bandwidth, OFDM uses the spectrum very efficiently.

At the transmitter, the coding process (convolution coding in general cases) is firstly implemented to decrease the BER. Then, after interleaving, constellation map- ping, and pilot insertion, the high-speed symbols streams are divided into low-speed streams by a serial to parallel converter. After IFFT operations, the parallel symbols streams are transformed into serial symbols, and CP are inserted into the original symbols. Finally, the symbols streams are upconverted and transmitted.

At the receiver, after receiving the RF signal and downcoverting, the analog signals are converted to digital signals by an analog to digital convertor (ADC). After timing and synchronization, the CPs are removed from the OFDM signals. Then, the parallel symbols are fed to the FFT block to transform the received samples in from the time domain to the frequency domain. The constellation demapping is implemented to obtain the coded data stream. Lastly, after

Currently, fourth generation wireless communication systems have been employed in most of the countries in the world. However, there are still some challenges like an explosion of wireless mobile devices and services, which cannot be accommodated even by 4G, such as the spectrum scarcity and high energy consumption [1]. Wireless system designers are continuously facing the increasing demand for mobility required and high data rates by new applications and that's why they have started research on fifth generation wireless systems that are expected to be employed beyond 2020. 5G technology stands for fifth generation mobile technology which is the standard beyond 4G and LTE-advanced.

There are different challenges in 5G, to overcome these we need new breakthroughs and new technologies. Some of the promising technologies for 5G communication are massive MIMO, cognitive radio, visible light communications, spatial modulation, mobile femtocell, green communication. Also we need new cellular architecture for 5G.

The Cumulative Distribution Function (CDF) is one of the most regularly used parameters, which is used to measure the efficiency of any PAPR technique. Normally, the Complementary CDF (CCDF) is used instead of CDF, which helps us to measure the probability that the PAPR of a certain data block exceeds the given threshold.

PAPR reduction techniques vary according to the needs of the system and are dependent on various factors. PAPR reduction capacity, increase in power in transmit signal, loss in data rate, complexity of computation and increase in the bit-error rate at the receiver end are various factors which are taken into account before adopting a PAPR reduction technique of the system.

A very high PAPR in OFDM systems requires high power amplifiers (HPA) to have a large linear region, which decreases the power efficiency. Moreover, the receivers also need to have amplifiers and A/D converters that have a large linear region. Therefore, a high PAPR decreases an OFDM system's performance and efficiency. To solve this problem, many researchers have proposed different PAPR reduction schemes, such as companding and clipping.

The PAPR reduction techniques on which we would work upon and compare in our later stages are as follows:

a. Amplitude Clipping and Filtering

A threshold value of the amplitude is set in this process and any sub-carrier having amplitude more than that value is clipped or that sub-carrier is filtered to bring out a lower PAPR value.

b. Selected Mapping

In this a set of sufficiently different data blocks representing the information same as the original data blocks are selected. Selection of data blocks with low PAPR value makes it suitable for transmission.

c. Partial Transmit Sequence

Transmitting only part of data of varying sub-carrier which covers all the information to be sent in the signal as a whole is called Partial Transmit Sequence Technique.

II. PEAK TO AVERAGE POWER RATIO

When in time domain all the *N* subcarriers are added up constructively, they produce a peak power that is *N* times greater than the average power of the signal. The *PAPR* is calculated by the following equation

$$PAPR = \frac{\max(x^2(t))}{\text{mean}(x^2(t))}$$

Where $x(t)$ is the amplitude of the signal.

The peak power of the OFDM signal, regarding the worst case when all the subcarriers are added-up constructively, is the sum of all the *N* subcarriers: $1 \cdot N = N$. The mean power of the OFDM signal is the sum of all the values of the signal, which is actually *N*, divided by the total number of subcarriers, which is also *N*. Therefore the maximum *PAPR* is:

$$PAPR_m = \frac{N}{\frac{N}{N}} = N$$

This maximum *PAPR* increases whenever the number of subcarriers increases. Thus, if $N \rightarrow ¥ \Rightarrow xk$ becomes Gaussian distributed, for $k = 1, .., N$, which means that

$$P(x_k < PAPR_m) < 1$$

When the number of subcarriers tends to ¥ this probability gives

$$\lim_{N\to\infty} \prod_{k=1}^{N} P(x_k < PAPR_m) = 0$$

If the above statement represents the probability of a signal *xk* to have a smaller *PAPR* than the given one *PAPRm*, the probability of the signal to have a *PAPR* greater than *PAPRm* is

$$\lim_{N\to\infty}(1 - \prod_{k=1}^{N} P(x_k < PAPR_m)) = 0$$

The above statement can be better understood shows the complementary cumulative distribution function (CCDF) of an OFDM signal. The CCDF denotes the probability of a signal to have a higher *PAPR* than a threshold *PAPRm*, so in the figure, horizontal and vertical axes represent the threshold values of *PAPR* and the CCDF respectively.

III. PROPOSED METHODOLOGY

The implementation of proposed PAPR elimination scheme has done on Matlab Simulink. The PAPR of the OFDM based wireless communication system is reduced to achieve better performance of the system. The proposed methodology is shown in the figure below. The major sections (blocks) of the OFDM based wireless communication system considering AWGN channel displayed in the Fig. 3.1.

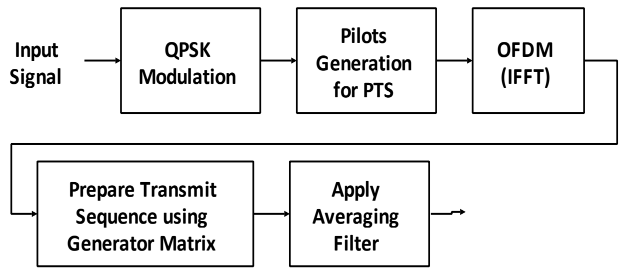

Fig. 3.1 Block Diagram of Proposed Lower PAPR OFDM System.

The first block modulates the data using QPSK-modulation. The modulated signal followed by pilot generation block and pass through OFDM system in which IFFT operation is performed after that transmitting signal is generating with the help of generator matrix followed by filtering. After that all the powers are calculated to get the PAPR.

The flowchart of the proposed system is explained in the Fig. 3.2 where execution of the simulation model to reduce PAPR is shown. The steps are as follows:

Step 1: Variables need to be initialized to create simulation environment

Step 2: Generate random data to transmit through system

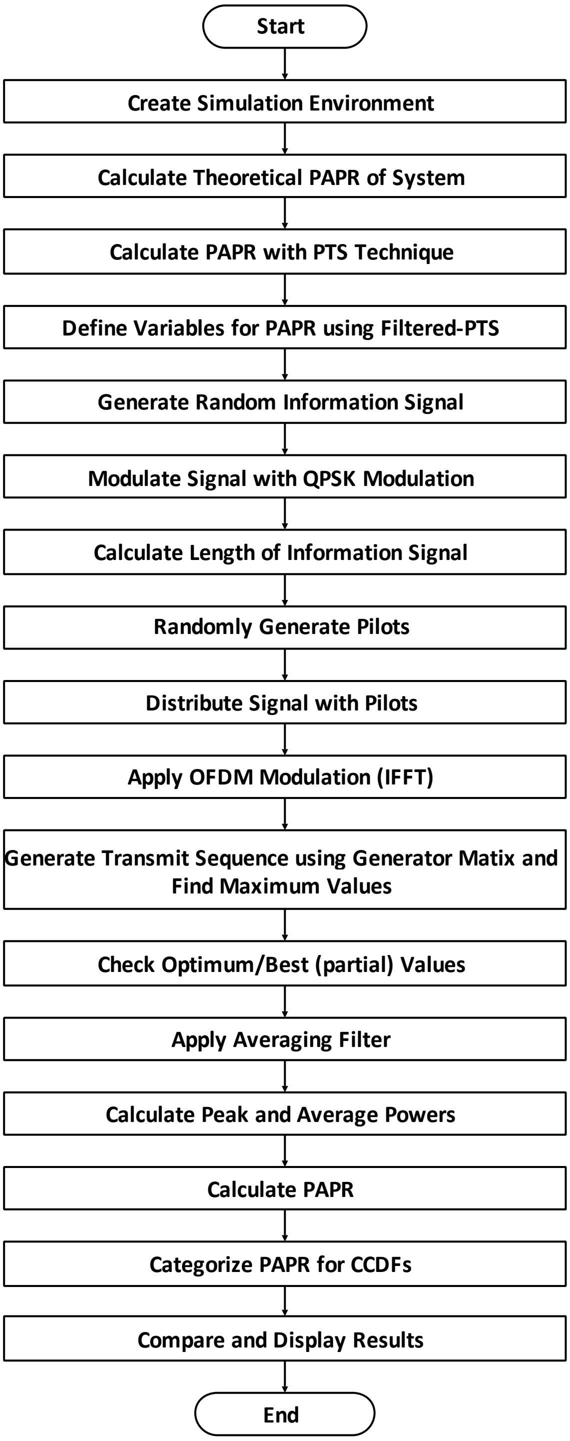

Figure 3.2 Flow chart of proposed methodology to reduce PAPR.

Step 3: QPSK modulation is applied on Signal

Step 4: Randomly Generate Pilots

Step 5: Distribute Signal with Pilots

Step 6: Apply IFFT operation i.e. OFDM Modulation

Step 7: Generate Transmit Sequence using Generator Matrix

Step 8: Find Optimum/Best (partial) Values

Step 9: Applying Averaging Filter

Step 10: Calculate Peak and Average Powers

Step 11: Calculate PAPR

Step 12: Categorize PAPR for CCDFs

Step 13: Compare and display results

IV. SIMULATION RESULTS

The proposed system is explained in the previous section is simulated on the simulation tool and shown performance of the system in terms of peak to average power ratio (PAPR) vs. complementary cumulative distribution function (CCDF).

The CCDF computes the power complementary cumulative distribution function (CCDF) from a time domain signal. The CCDF curve shows the amount of time a signal spends above the average power level of the measured signal, or equivalently, the probability that the signal power will be above the average power level.

$$CCDF = P(PAPR > PAPR_0) = 1 - (1 - \exp(PAPR_0))^N$$

The *PAPR* is calculated by the following equation

$$PAPR = 10\, log_{10}\left[\frac{max(x^2(t))}{mean(x^2(t))}\right]$$

Where *x(t)* is the amplitude of the signal.

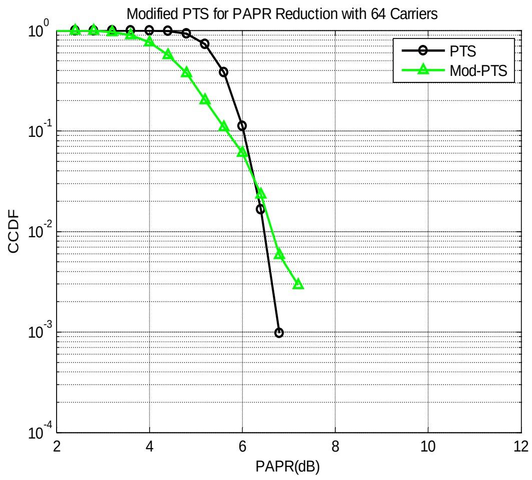

Fig. 4.1 PAPR Curve of Proposed Methodology using Partial Transmit Sequence with 64 Carriers and 1024 Symbols

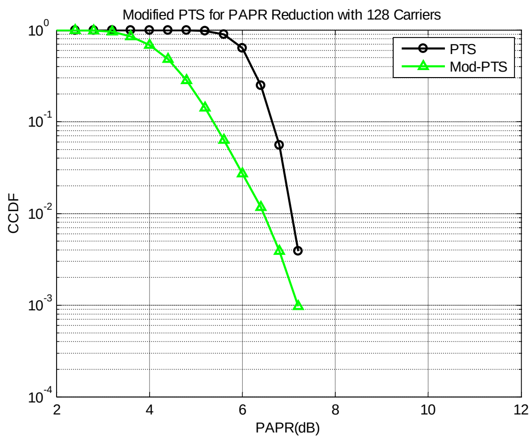

Fig. 4.2 PAPR Curve of Proposed Methodology using Partial Transmit Sequence with 128 Carriers and 1024 Symbols

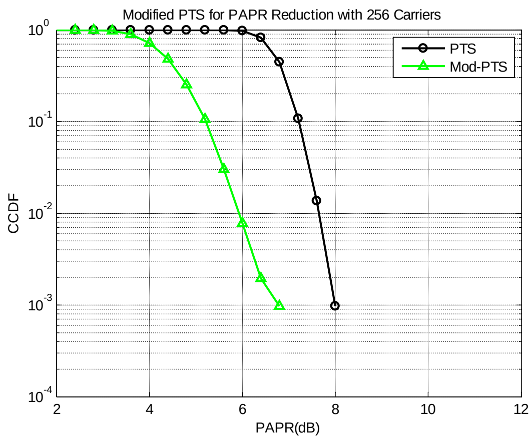

Fig. 4.3 PAPR Curve of Proposed Methodology using Partial Transmit Sequence with 256 Carriers and 1024 Symbols

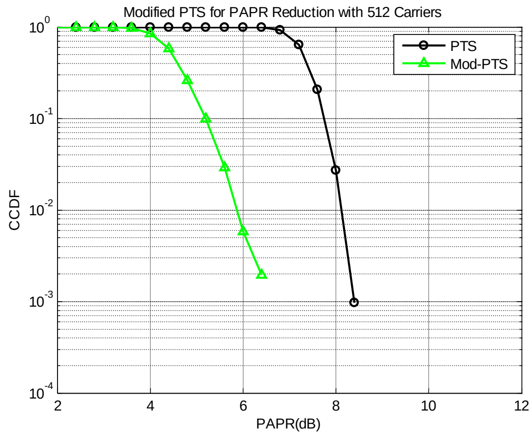

Fig. 4.4 PAPR Curve of Proposed Methodology using Partial Transmit Sequence with 512 Carriers and 1024 Symbols

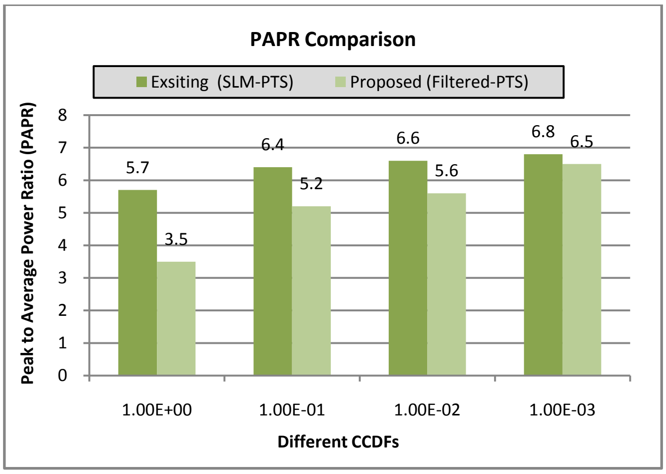

Fig. 4.10 PAPR Comparison with Existing Work.

Table 1: Comparison of PAPR

CCDFs	Previous using SLM-PTS	Proposed Technique
10^0	5.7	<= 3.5
10^{-1}	6.4	5.2
10^{-2}	6.6	5.8
10^{-3}	6.8	6.4

V. CONCLUSION AND FUTURE SCOPE

The problem of high peak-to-average-power ratio (PAPR) in orthogonal frequency division multiplexing (OFDM) systems and PAPR reduction schemes with very low complexity have been reviewed in this work and a novel modified filtered PTS scheme to reduce PAPR in OFDM system has been proposed in this work. The simulation and implementation of proposed work has done in Matlab. The simulation analysis of proposed system and its performance graphs are shown. From the simulation results it can be concluded that the PAPR of the system is lower with the increase in the number of carriers not symbols.

Because from the graphs when number of symbols increases PAPR decreases but performance does not drop that much. The modified partial transmit sequence definitely the future methodology to improve PAPR further with integration with the other techniques.

This work has focused only on some modified PTS filter schemes. However, there are many different kinds of PAPR reduction techniques, which have different advantages and disadvantages. In a future study, more different PAPR reduction techniques such as clipping, coding can be combined.

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