Reduction of Peak Power in ofdm Signal Using Cyclic Shifting in Partial Transmit Method

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Abstract. Nowadays, multiplexing the frequency in orthogonal manner is the major concern for high speed data requirements in communication system. It has many advantages like achieving high speed data rate, resilience to frequency fading nature and highly tolerance to interferences and more flexible for implementing with other systems. Also, this OFDM system utilizes maximum bandwidth and will reduce the co-channel interferences. But the main back lock in OFDM system is peak to average power ratio (PAPR) which makes the waveforms more distorted which leads to need of high-power amplifiers in system design. In order to control this back lock, many techniques are proposed, but it has complexity problem. In this work we proposed a partial transmit sequence method along with cyclic shift sequences without performing phase rotation during the process. The simulation results show the high efficiency in PAPR reduction problem when compared to the other systems and it shows the less computation complexity during implementation.

Keywords: OFDM, PAPR, power amplifiers, Delay spread, cyclic shift

1. Introduction
The current technology which is designed to get high speed data rate in wireless and wired communication is OFDM system. This system is used in 4G LTE ie, long term evolution communication, WiMAX, WLAN because of its important properties like achieving high speed data rate, resilience to disappearance of frequency, interferences. OFDM gives the extremely high spectral efficiency and reversing the distortion will be even in this system. Also OFDM system is more flexibility for implementation, fast Fourier transform (FFT) technique is also utilized properly by this system. In addition to this, when compared to other modulation technique OFDM provides many features like utilizing full bandwidth, echoes will be reduced in speech scenario, also has less non-linear distortion. In OFDM narrow band co-channel interference will be reduced and it provides the high system capacity with low latency and high-speed data transmission.

Orthogonal frequency division multiplexing has many applications in communication scenario such as WLAN, WiMAX, Radio broadcast access networks, IEEE802.11, IEEE802.16, digital audio and video broadcasting (DVB & DAB), European telecommunication standard Institute (ETSI), etc. In recent days OFDM getting more attention for next generation framework such as Filtered OFDM, universal filter OFDM, Frequency division multiplexing.
Even though OFDM has many special features but it has main drawback as peak power average ratio (PAPR) which causes distortion of the signal. This makes the system increase in complexity during implementation of analog to digital converter (ADC) and digital to analog converter (DAC) devices. So OFDM needs high power amplifier (HPA) with high input power back off. To overcome these problems, many techniques are proposed which are classified into two categories such as signal distorted techniques and scrambled techniques. One of the category, signal distortion technique includes clipping, filtering, peak windowing, non-linear transforming, active constellation. Second category includes that selective-mapping, partial transmit sequence, block coding, tone reservation and injection methods. In this paper, we proposed an partial transmit sequence method for reduction of PAPR problem. Also, the disadvantages and complexity of the other methods are discussed and the simulation results are shown the partial transmit sequence method gives the optimal solution for the PAPR problem.

In the section II the literature system are analyzed and in section III OFDM system are explained and their mathematical expressions also derived. In section IV detailed explanation is given about the PAPR and its distribution. Section V gives the explanation about the proposed system. In section VI gives the simulation results and section VII conclusion of this work.

2. Literature Survey

In 2016, Wang and Lee gave the detailed review about PAPR conventional reduction technique and their performances. All of the technique have some advantages and disadvantages in its performance like reducing bit rate and increase in computational complexity. In this paper, authors also discussed about choosing correct method based on their impact factor for PAPR problem and comparison between these technique also provided.

At the same side in 2016, Wang and Tellambeera also reviewed about the different PAPR reduction technique and its performance along with its cost for implementation. The cost usage for PAPR reduction technique is also compared with cost of power efficiency degradation in OFDM system. Likewise in 2008, Jiaang and Wuu explained the characteristic and properties of the OFDM signal. This paper also stated the important points about how to select the proper techniques for reduction of power problem in OFDM system.

In 2010, Lim has proposed some modified PAPR reduction technique with low computation complexity and also he discussed about the normal peak power reduction techniques. According to this paper, the conventional reduction technique are not suitable for telecommunication scenario. So some modified techniques are proposed with increased bit rate in OFDM system.

In 2012 Seyed and Shabhani, proposed the clipping technique along with its compressive sensing for PAPR problem. In this paper, authors compared the original OFDM signal and precoding the signal for PAPR reduction. They showed the high bit rate performance in simulation results but it high
computational complexity problem and also in band, out band interferences during clipping technique is observed.

After some time Taspinar at 2015 has proposed partial transmit sequence based on swarm intelligence with artificial honey bee colony algorithm, it reduces the computational complexity with increased bit rate. The main backlock of this method is over computing complexity and high degradation in bit rate is observed.

In 2016 Ezminandnabil proposed the selective mapping method for MIMO-OFDM system in space time block coding method. PAPR is calculated in cumulative distributed function (CCDF) from spatial multiplexing to space time block codes. Its simulation shows the improvement in peak power efficiency for each symbol in the OFDM signal and less degradation in bit rate but it also have high computing complexity in OFDM system.

Similarly Azlina Idris in 2018 gave an idea such as block coding technique for PAPR problem. He proposed two types of coding such as arithmetic coding and Reed solomon code to improve the power efficiency and also its performance is compared between each other. The simulation results show that arithmetic coding is best suited for PAPR problem. Also various modulation techniques is discussed in this paper. The main drawback of this coding technique is it requires more number of iterations and choosing the proper code is difficult task in OFDM system.

The OFDM Sequence aggregates all N Modulated Subframes when executing a given IFFT Operation, subframes may be orthogonal to each other.

Here, $X = [0, 1, \ldots, N-1]$ shows the input symbols.

The complex base band for sub frames is given as,

$$X(t) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k e^{j2\pi ft} \quad , 0 \leq t \leq T$$
Then the OFDM signal is expressed in time domain manner which is given as

\[ x(n) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k e^{j2\pi kn/N}, \quad 0 \leq n \leq N-1 \]

### 2.1 PAPR

PAPR is expressed as that ratio of Maximum power to the average power in the input signal. It can be expressed as,

\[ PAPR = 10 \log_{10} \frac{\text{MAX}|x(n)|^2}{\mathbb{E}[|x(n)|^2]} \]

OFDM Signal time is kept as constant during the operation captures some of the signal peaks that are not visible in the PAPR Calculation. The accuracy of PAPR Calculation, it is sufficient to separate the signal from the main frequency band using \( L \geq 4 \) and by adding a zero-filled. Then, the oversampling of OFDM Signal is given as follows

\[ x(n) = \frac{1}{\sqrt{NL}} \sum_{k=0}^{NL-1} X_k e^{j2\pi kn/NL}, \quad 0 \leq n \leq NL \]

Then, \( \max |x(n)|^2 \)

\[ PAPR = \frac{0 \leq n \leq NL - 1}{p_{\text{avg}}x(n)} \]

### 2.2 PAPR DISTRIBUTION

One of the most common methods of measuring PAPR Performance is the Chronic Cumulative Distribution Function (CCDF). In the OFDM signal number of \( N \) sub vectors will follow the time domain based on Gaussian random value, it varies from 0 to 0.5. Nyquist sampling rate is calculated by using distributive function based on time

\[ \Pr(papr \geq papr_0) = 1 - (1 - \text{ex}(-papr_0))^N \]

\( PAPR_0 \) can be written as threshold value. Then \( L \) is the over sampling of the symbol, it is given as,

\[ \Pr(papr \geq papr_0) = 1 - (1 - \text{ex}(-PAPR_0))^{NL}, \quad N \geq 128 \]

### 3. Proposed Method

In OFDM system many methods are proposed for PAPR reduction. In this work partial transmits sequence with cyclic shift sequence is proposed. This system divides the \( N \) number of symbols into many sub-blocks and the last sequence block is cyclically shifted in time domain. In cyclic shifting
OFDM system the input signal is given to the partitioning sub block then these input signal is divided into number of sub blocks i.e., X1, X2, ..., Xn. Then these divided subblocks is given into inverse Fourier transform and then cyclic shift process takes place, during this process it will generate possible number of sequences and shift the sequence without any multiplication operation takes place and also it is independent of phase rotation factor. Then shifted samples (X1, X2, ..., Xn) is added together as \( X' \). Then the OFDM signal is obtained with minimum PAPR ratio. The following block diagram shows the sub block division and cyclic shift sequence method.

In this cyclic shift method, we can see the high performance when compared to other techniques. Moreover, computational complexity also low in this method because it does not perform multiplication process during the generation of possible sequence.

![Fig2: Block diagram of partial transmitting sequence using cyclic shift method](image)

### 3.1 Simulation Results

The simulation results are performed using MATLAB simulation, it shows that the performance of proposed system shows high efficiency when compared with other methods like clipping and selective mapping methods. Also OFDM time signal along with its spectral magnitude and phase results are plotted.
Fig 3: OFDM carrier frequency

Fig 4: OFDM carrier phase
Fig 5: OFDM Time symbol

Fig 6: signal-Time
Fig 7: signal-spectrum

Fig 8: Magnitude spectrum at Receiver side
Original signal with high peak power is plotted for its cumulative distribution function (ccdf) and PAPR value is plotted in the fig 10 and 11, the proposed technique is compared with clipping and selective mapping method (SLM), results shows high efficiency in PAPR reduction in proposed method.
1. Conclusion

In this we conclude that OFDM is one of the recent techniques which is most probably used in many application. The main issue of this technique is peak power average which makes the big challenge to the designer. To overcome these issue we proposed an partial transmit sequence technique along with cyclic shift method which generates the possible sequence without using phase rotation ie, multiplication process .so it shows that this method gives less computational complexity and optimal solution for the PAPR problem. Its simulation results shows that when comparing with other techniques, partial transmits sequence technique gives the best results.

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