Study of PAPR in Multicarrier Systems

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Abstract - One of the strongest contenders in the field of 4G and 5G communications is Multiple Input Multiple Output with -Orthogonal Frequency Division Multiplexing (OFDM). This amalgamation leads to dependable communication rates to cater to towering demands for speed. It improves bandwidth by decreasing the effect of multipath fading. In many practical situations, this combo inhibits the performance due to high PAPR. And this effect escalates as the number of sub-carriers increase. As a solution to the above problem many reduction strategies are available for example coding, clipping and phase rotation etc. In this paper, different PAPR -Peak to Average Power Ratio reduction techniques are analyzed in case of OFDM systems.

Keywords - Multipath Fading, Orthogonal Frequency Division Multiplexing, Peak to Average Power Ratio (PAPR), Clipping, Subcarriers, Multiple Input Multiple Output (MIMO).

I. INTRODUCTION

Of late the demand for 4G wireless communication systems has increased exceptionally in the field of multimedia transmission. With the upsurge in the number of users and due to the limited bandwidth, there is a necessity of more advanced modern communication techniques which give good spectral and bandwidth efficiency. And a system which is immune to multipath fading is coined as multicarrier system. This kind of multicarrier transmission systems is highly reliable and facilitates high data transmission rates for large numbers of users. In multicarrier systems the main highlight is bandwidth distributed amongst many sub-carriers .On the contrary single carrier systems have single carrier occupying the whole bandwidth. Now these humungous features of multicarrier systems together with OFDM features provide better performance efficiency.

Audio-video broadcasting and mobile multimedia communications are some of the applications which incorporate features of OFDM. Techniques like modulation and multiplexing both are encompassed in OFDM. So it has many benefits which make OFDM a potential option for 4G communication systems. The OFDM is characterized by subdivision of the available bandwidth into many data streams of low data rate and then transmitting on individual subcarriers. Using fast Fourier t transforms (FFT/IFFT), modulation and demodulation is done. The modulation is done on each sub carrier after the symbol generation. Each sub carrier has a unique central frequency which is orthogonal to the frequency of other sub carrier. Here orthogonality is maintained using IFFT. Guard bands eliminate interference between the symbols. A wide band signal is converted to a number of narrow band signals.

Although there are many advantages, OFDM systems suffer from many problems such as PAPR, synchronization and Bit Error Rate. PAPR is the major amongst the problems presented in OFDM systems. Many techniques for reduction in PAPR have already been presented.

II. LITERATURE REVIEW ON PAPR REDUCTION

The literature on Peak to Average Power Ratio has been reviewed and presented in the following section.

Foomoolijareon and Fernando proposed a solution to the problem caused by Peak to Average Power Ratio in Orthogonal Frequency Division Multiplexing system in the year 2002.Two methods were suggested. The first method, where in a list of input vectors are maintained and an appropriate input are selected from the list. The method is done by initially choosing the subcarriers and reducing the number in the input side and the passing this to the Inverse Fourier Transform. Both the methods are supported by simulation outputs showing considerable reduction in the peak to average ratio .One important observation here is, this was done for restricted channel numbers.

Another work on the same lines was done by Xiadong et al. The work was proposed in the year 1998 which incorporated different techniques to reduce the power ratio in the communication system. Method like filtering and clipping were employed and spectral power density, bit error rate etc were the performance indicators considered. Simulations indicate better results when compared to traditional communication systems.

A reduction algorithm was proposed in the year 2011 by Wei Xeufeng. The new algorithm proposes a new method by incorporating advantages of the conventional method. This is a probability based algorithms. The simulations show that the peak to average power ratio reduces considerably.

III. Need for Orthogonal Frequency Division Multiplexing

In many of the wired and wireless transmission systems today Orthogonal Frequency Division Multiplexing is liken a boon. Figure.1 depicts the block level description of a typical OFDM transmission system, with the Rx and Tx blocks. Symbol interference is caused because of high data transmission rates. A guard band interleaving can be done in two ways, one by padding zeros, which is done by including zeros in between the symbols. The other is cyclic prefix; here the last section of the symbol is copied at the first section of the next symbol. The size of the guard band should be such that it takes into account the response time of the channel to avoid interference. In case of Fast Fourier Transform cyclic prefix method is favorable than padding zeros because this method periodises the signal.

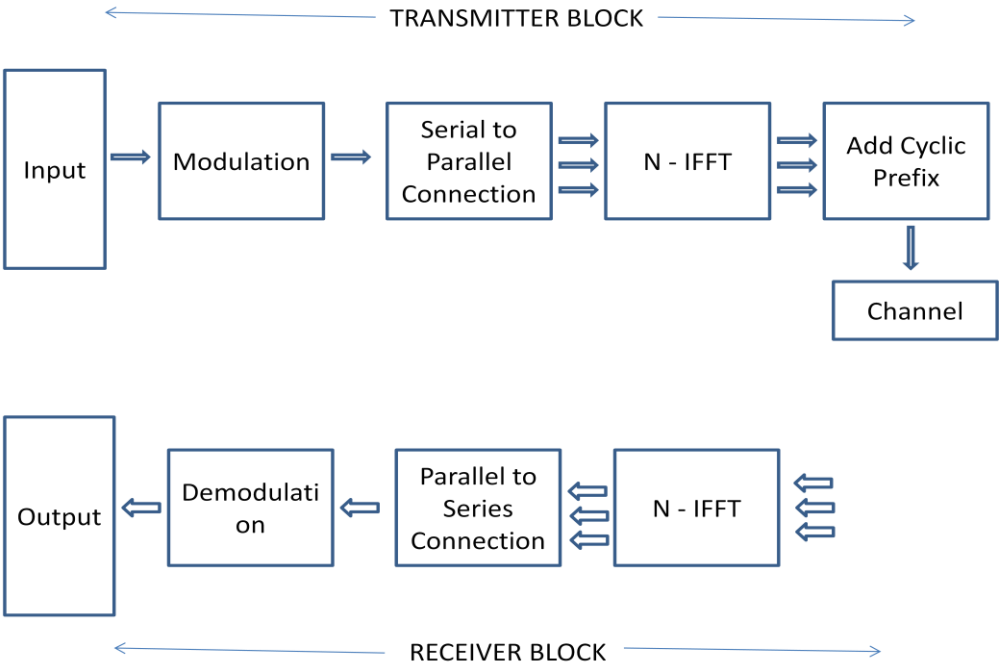

Fig. 1 Basic architecture diagram of the communication system

IV. Effect of Peak to Average Power Ratio in case of Orthogonal Frequency Division Multiplexing systems

Basically in Orthogonal Frequency Division multiplexing a data stream of high data-rate is partitioned into data streams of lower rate. These lower data rate streams are then transmitted at once using many sub-carriers, which may overlap with one another. Due to the increase in the symbol duration in case of lower data rate streams dispersion in time because of multipath fading also decreases relatively. The main characteristic feature of OFDM systems is large number of subcarriers. And high PAPR which offers problem in real time transmission on the optical fiber cables which leads to distortions in the communication bands. This effect elevates with the use of data converters in the system design. This leads to reduction in the performance of the circuit. The main cause for PAPR in the transmission is the presence of the large number of subcarrier which are not in phase. When these signals, which are not in phase, shoot up to maximum value simultaneously the output also raises this causes peak in the output value. In orthogonal communication systems due to many subcarriers large peak is present as against the average value. These demands for sophisticated transmitters which further increase the cost of the entire system.

V. PAPR Reduction Approach

OFDM systems are characterized by presence of many sub-carriers in the system. Hence the peak value is very large than the average value. This ratio is called Peak to Average Power Ratio.

$$PAPR = \frac{\text{maximum } |y(t)|^2}{E[|y(t)|^2]}$$

One of the effective methods for the reduction of PAPR in a communication system which has multicarrier transmission signal. Here in this technique, a time domain signal which is a data dependent block is fused with the actual multicarrier transmission signal; this procedure is followed to cut down on peak values in the signals. This communication signal which is in the time domain can be conveniently calculated on the transmitter side and at the receiver side it can taken off.

The method is governed by an important step that is taken up by the transmitter of choosing amongst many subcarriers. The chosen set of subcarriers will give a considerable reduction in the PAPR.The method mainly aims at finding a signal in the time domain that can be added with the actual original signal in the time domain. Let us consider it as y. Consider the following equation.

$$y+b=IDFT(Y+B)$$

Here B=[B0+B1….+BLN-1] is a vector in frequency domain. Now, this vector is added with the signal of the concern Y. The block size of data Y is restricted in TR method and also there is a limitation of vector B which makes data as well as vector to be in different frequency spaces.

$$Ym=0, m \in \{j1,j2…..jw\}$$
$$Bm=0, m \in \{j1,j2…..jw\}$$

The w indicates the places in the vector B which are not zeros and these are the carriers which reduce the peak. The extra subcarriers don't make any distortion on data that is useful; this is because of the orthogonality property. One can optimize the process of finding appropriate subcarriers using linear programming.

VI. Results and Discussion

Figure 2 indicates the plot of distribution function of PAPR and QPSK signals considered are randomly produced. Here the subcarrier number is restricted to 256.The plot reveals that the PAPR has been lowered by 7.2dB.This has been considered without any constraint on mean power.

Figure 3 depicts that for the design of communication systems power amplifier is the main component and γ is a constant of the characteristic of power amplifiers. Hence for different value of γ simulations are done and at $\gamma = 0.21$dB an additional percentile of PAPR reduction is obtained. Hence PAPR is inversely proportional to γ. The above is considered by using a limitation on mean power.

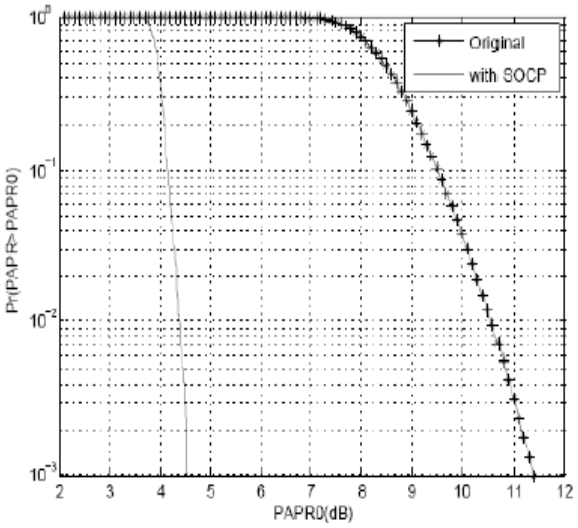

Fig. 2 Reduction in PAPR using TR with no constraint

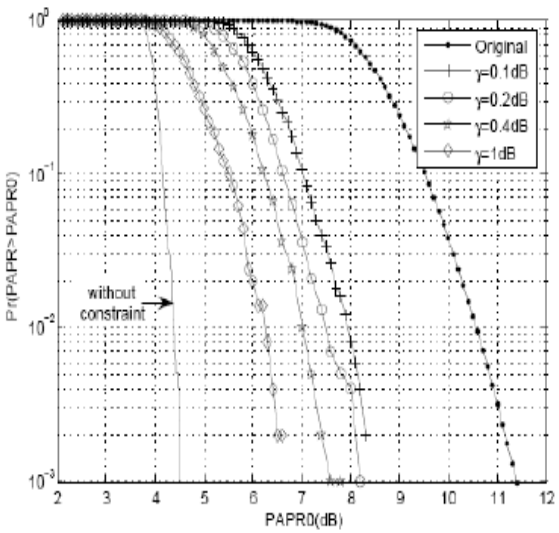

Fig. 3 Reduction in PAPR applying power constraint

Figure 4 shows a comparison between the two methods where in the first one takes into account power constraint only and the other considers both limitation on spectral mask and power limitation. In the first case as well as the second case power limitation is the same for $\gamma = 0.21$dB

VII. Conclusion

In the presented paper, a method for lowering the PAPR in transmission systems has been proposed. This is done using a tone reservation method which aims at considerable reduction in PAPR but no side band signals

are transmitted as well as it does not deteriorate data transmission rate and BER. It is also indicated that PAPR reduction can be achieved up to 7.2dB.And subcarriers under consideration lie in standard spectral mask.

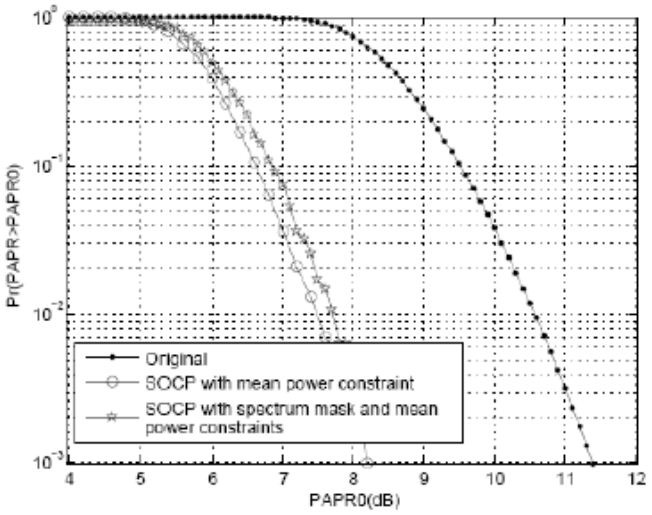

Fig. 4 Comparison of reduction in PAPR with spectral mask and power constraint

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