Analysis of PAPR for Performance QPSK and BPSK Modulation Techniques

K. Bhagyashree, S. Ramakrishna and Priyatam Kumar

Abstract In both wireless and wired communication environments, there is demand for larger data rates, which is continuously increasing day by day. Hence, OFDM systems have been developed for digital systems. These systems have many advantages over single-carrier transmission systems like resistance to selective fading. But these systems are characterized by large value of PAPR. Many methods have been discussed in the literature for the reduction in PAPR value. Although these methods provide the reduction, they affect the transmission power, data transmission rates, error rates, and complexity in the computational model. One of the simplest ways of measuring PAPR is CCDF. In this paper, CCDF curves are used to measure the amount of PAPR in OFDM systems and are analyzed.

Keywords CCDF—Complementary cumulative distributing function · OFDM—Orthogonal frequency division multiplexing · PAPR—Peak-to-average power ratio · Clipping · Subcarriers · MIMO—Multiple input multiple output

1 Introduction

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 for more advanced modern communication techniques which give good spectral and bandwidth efficiency. 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 band-

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width distributed among many subcarriers. 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 are done. The modulation is done on each subcarrier after the symbol generation. Each subcarrier has a unique central frequency which is orthogonal to the frequency of other subcarriers. Here, orthogonality is maintained using IFFT. Guard bands eliminate interference between the symbols. A wideband 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 among the problems presented in OFDM systems. Many techniques for the reduction in PAPR have already been presented.

2 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 [1]. The first method, wherein 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 [2]. Methods 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 algorithm. The simulations show that the peak-to-average power ratio reduces considerably.

2.1 Need for Orthogonal Frequency Division Multiplexing

In many of the wired and wireless transmission systems, today, Orthogonal Frequency Division Multiplexing is like 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 [3]. 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 [2, 4]. In case of Fast Fourier Transform, cyclic prefix method is favorable than padding zeros because this method periodizes the signal.

2.2 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 [5, 6]. These lower data rate streams are then transmitted at once using many subcarriers, which may overlap with one another. At lower data rates the symbol duration increases causing dispersion in time. 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

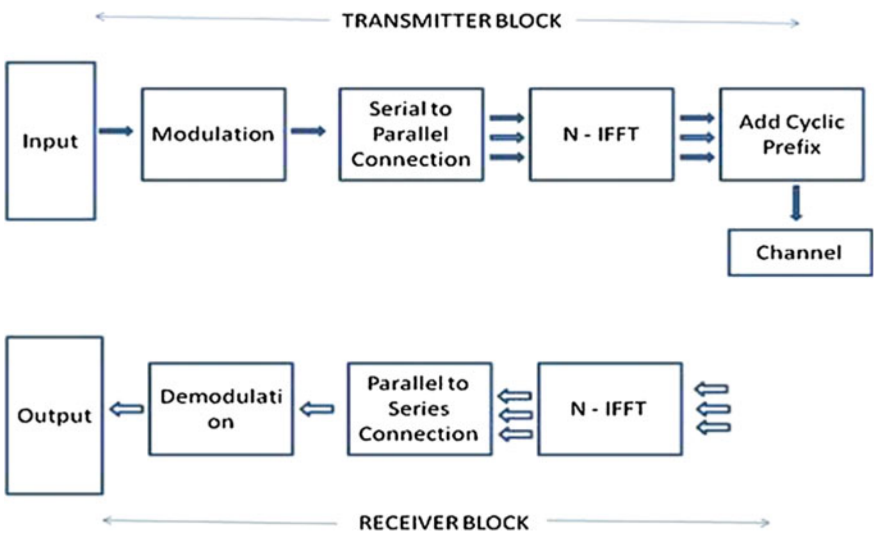

Fig. 1 Basic architecture diagram of the communication system

cables which lead 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 is 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.

3 PAPR

OFDM systems are characterized by the presence of many subcarriers in the system. Hence, the peak value is very large than the average value. This ratio is called peak-to-average power ratio.

$$\mathbf{PAPR} = \frac{\mathbf{maximum}|\mathbf{y}(\mathbf{t})|^2}{\mathbf{E}\left[|\mathbf{y}(\mathbf{t})|^2\right]} \tag{1}$$

Here, numerator gives the peak signal power and denominator gives average power of signal. Let us consider the total number of subcarriers are N, and if all are in the same phase, then the N is the PAPR. Figure 2 shows envelope peaks for the OFDM information signal for N equals 16 which in turn leads to very large peak power [4].

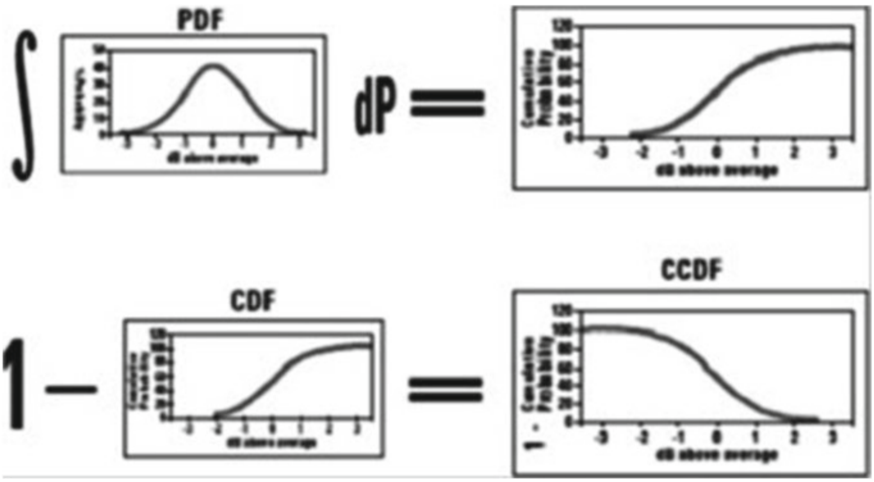

Fig. 2 Relation between PDF, CDF, and CCDF

3.1 PAPR Measurement

To measure and evaluate the performance of PAPR reduction scheme, complementary cumulative disturbing function (CCDF) is a standard candidate. If CDF and CCDF are compared, then it is revealed that what value of the information signal is below a required level is indicated by CDF and what amount of signal is at a given level and above is depicted by CCDF. The probability is defined by the percentage of time the data signal remains at a level or above [7].

The real and imaginary sections of signal in OFDM with many number of subcarriers is considered to be Gaussian. Under such situations, the signal envelope in the case of OFDM has Rayleigh distribution and power is exponential. If one assumes unity power for OFDM signal, then normalized Rayleigh distribution is PDF, that is, Probability Distribution Function [8].

4 Proposed Methodolgy

In the proposed method, a lower order modulation scheme has been incorporated like QPSK as it provides robustness against noise. But it is noted that it provides lower data rates. Here, MATLAB is used for simulation. The following are the steps followed in the method:

i. Select the input size, subcarrier number and symbol number
ii. Generate modulated signals
iii. Assign the symbols modulated to the subcarriers
iv. Compute inverse FFT
v. Calculate PAPR
vi. Plot PAPR versus CCDF graph.

5 Results

In the results, the graphs of PAPR values for different subcarrier numbers are shown. The modulation techniques used here are QPSK and BPSK.

The peak value of the envelope would be directly affected as the subcarrier number is increased, and this is due to large PAPR value. Figure 3, shows the simulated results of CCDF curves in case of an OFDM system with different number of subcarriers. Here. the 16-QAM modulation is used. As there an incremental change in the number of subcarriers, the PAPR value also raises. Major values are in the range 7–10 dB at CCDF 10-2.

Figure 4 depicts for BPSK the values of PAPR are lower than the other modulation schemes. For any value of *M* in M—Quadrature amplitude modulation, the value of PAPR is almost the same.

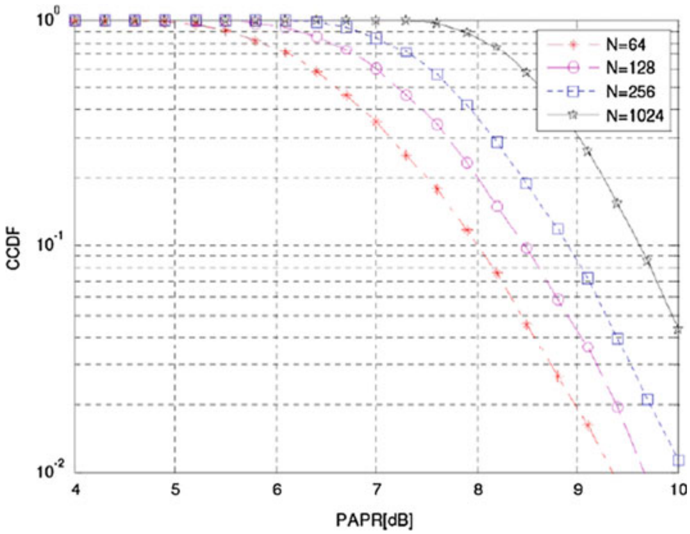

Fig. 3 Plot of CCDF for different values of N

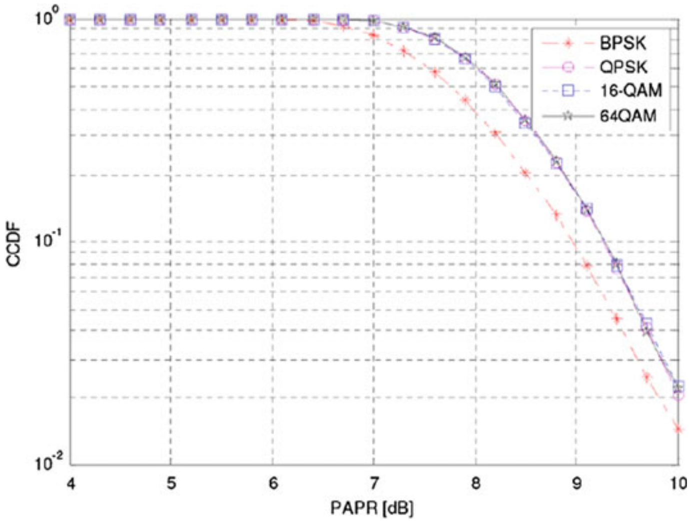

Fig. 4 Plot of CCDF for modulation using BPSK, QPSK in OFDM ($M = 2, 4, 6$ and $N = 512$)

6 Conclusion

In this paper, a method for obtaining the PAPR in transmission systems has been proposed. There are many ways to estimate the PAPR; one of them is based on the probabilistic approach. The reduction of PAPR is the primary issue because of the cost and complexity of different components in OFDM Tx and Rx is affected. The most basic parameter which evaluates the performance of PAPR reduction scheme is CCDF. The PAPR values for a 16-QAM with varying subcarriers range 7–10 dB at CCDF 10-2.

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