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Analysis Of Various Influencing Factors On Peak To Average Power Ratio In OFDM System

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ABSTRACT

Orthogonal frequency division multiplexing (OFDM) has been adopted due to its superior performance. It promise to become key high-speed wireless communication technology and it has provided wireless industry evolution from 3G to 4G system. But there are number of limitation in OFDM system like Bit Error rate, Peak to average Power ratio. These systems are highly sensitive to Doppler shifts which affect the carrier frequency offsets, resulting in ICI. Presence of a large number of sub – carriers with varying amplitude results in a high Peak – to – Average Power Ratio (PAPR) of the system, which in turn hampers the efficiency of the RF amplifier. In this paper, study on PAPR has been done and effect of different influencing factors like modulation schemes, number of subcarriers and oversampling rate on PAPR in OFDM System has been analyzed.

1. Introduction

Orthogonal Frequency Division Multiplexing is a special form of multicarrier modulation which is particularly suited for transmission over a dispersive channel. Here the different carriers are orthogonal to each other, that is, they are totally independent of one another. This is achieved by placing the carrier exactly at the nulls in the modulation spectra of each other.

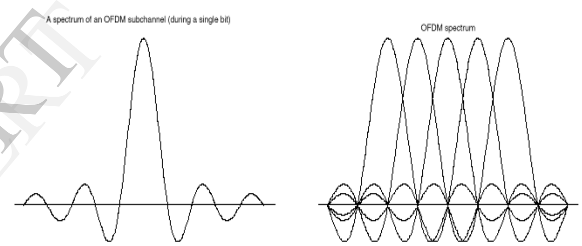

Fig 1: OFDM Spectrum [1]

2. OFDM System Model

In digital communication, information is always expressed in terms of bits.

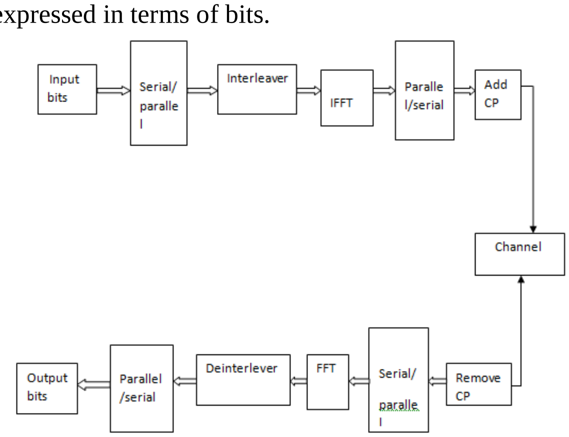

Fig 2: Block Diagram of OFDM System

Symbol is defined as the collection in various sizes of bits. The data in OFDM can be generated by taking symbol in spectral spaces by using M-PSK or QAM etc. and convert that spectra in time domain by taking Inverse Discrete Fourier Transform(IDFT).Inverse Fast Fourier Transform(IFFT) is cost effective so it is used instead of IDFT. Once the OFDM data is modulated to time signal, all carriers are transmitted in parallel to fully occupy the available frequency bandwidth [2]. During modulation, OFDM symbols are divided into frames so that data will be modulated frame by frame in order for the received signal to be in sync with the receiver. Long symbol periods diminish the probability of having Inter Symbol Interference (ISI), but could not eliminate it. To make ISI nearly eliminated cyclic prefix is added to each symbol period. An exact copy of fraction of cycle is taken from the end of cycle is added to front that is about 25% of the cycle. This allows the demodulator to capture symbol period with the uncertainty of up to length of cyclic extension and still obtain the correct information for the entire symbol period. Guard period is another name for the cyclic extension, is the amount of uncertainty allowed for receiver to capture the starting point of the symbol period, so that result of FFT still have the correct information.

2.1 Orthogonality

The orthogonality of the carriers must be maintained in OFDM. If the integral of the product of two signals is zero over a time period, then these signals are said to be orthogonal to each other. Orthogonality is defined as

$$\int_0^T \cos(2\Pi n f_0 t)\cos(2\pi m f_0 t)\, dt = 0$$

Where $m \neq n$

where m and n are two unequal integers, f_0 is the fundamental frequency. T is the period over which the integration is taken. For OFDM, T is one symbol period and f_0 is set to one 1/T for optimal effectiveness. One of the most crucial issues in OFDM is subcarrier allocation amongst the active users. The total available bandwidth is firstly subdivided into narrowband channels each having its own sub carrier known as sub carrier and users are subcarriers depends on different criteria[3]. Researchers are investigating different aspects such as BER and PAPR High PAPR means the possibility of BER is high due non linear effects in power amplifier are high.

2.3 PEAK TO AVERAGE POWER RATIO

One of the major drawbacks of the OFDM system is high PAPR. OFDM signal consists of many independent modulated subcarriers, which are created the problem of PAPR. It is impossible to send this high peak amplitude signals to the transmitter without reducing peaks [4]. So high peak amplitude signal should be reduced before transmitting. If there are N subcarriers which are in phase then peak power is N time the average power. For sampled signal PAPR is defined as

$$\text{PAPR}=\frac{\max|s_n|^2}{E\lfloor|s_n|^2\rfloor}$$

where**,** $E\lfloor|s_n|^2\rfloor$ is average power of transmitted signal.

2.4 Cumulative Distribution Function

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 can take a value in the range that is proportional to number of subcarriers. Probability of symbol with maximal PAPR depends on the number of subcarriers. OFDM symbols with high PAPR have small number of probability with the large number of subcarriers [5]. Therefore, Cumulative distribution function is used to formulation of PAPR probability.

$$F(x) = Pr[X \leq x]$$

In case of discrete distribution CDF can be expressed as

$$F(x) = \int_{-\infty}^{x} f(x)dx$$

where, $f(x) = \sum_{k=1}^{K} \delta(x - x_k)P(x_k)$

Therefore, Cumulative Distribution Function is the probability such that variable X takes a value less than or equal to x.

3. Simulation and Results

3.1Simulation for calculation of BER in OFDM System for different Modulation Schemes

Simulation has been done with the MATLAB software. The main procedure of the code contains initialization of parameters and input data. The parameters that are set at the time of the initialization contains nominal bandwidth, CP length, modulation level, coding rate, range of bit energy to signal noise rate value and channel model parameters for simulation. The input data stream is randomly generated. The output variables are stored in MATLAB workspace and BER are stored to draw plots. BER is calculated at the end by using the ratio number of observed errors to the total number of bits transmitted for different modulation schemes with different code rates. Different modulation schemes produced different results.

Parameters that are set at the time of initialization are:

Guard interval: 1/8
Bandwidth: 20
Number of bits: 192
Number of FFT points: 256

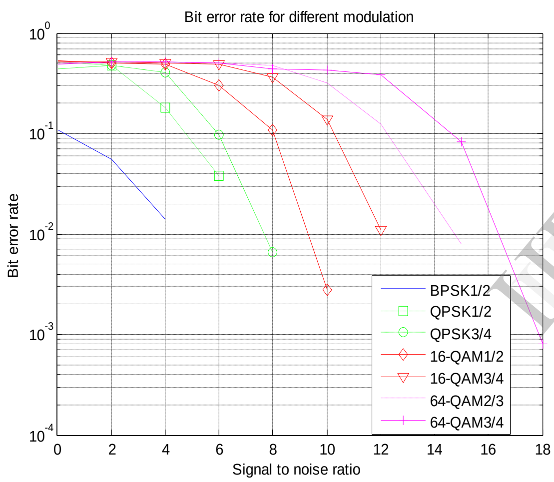

Fig 3: Bit error rate vs. SNR for different modulation schemes in OFDM System

Figure 3 shows the curve for BER vs.SNR for an OFDM System. Results shows that the 64-QAM having code rate ¾ gives the least Bit Error rate as compared to other modulation schemes used for calculating bit error rate.

3.2 PAPR performance in OFDM system by considering different influencing factors

In this section, Peak to average ratio is measured and effect of different modulation schemes, number of subcarriers and oversampling rate is analyzed by obtaining CCDF curves for the same.

3.2.1 Modulation schemes

Different modulation schemes produce different PAPR performance. Different Figures displays a set of CCDF curves which are processed by several commonly used modulation schemes like BPSK, QPSK, and QAM with different code rate.

I. Parameters for calculation of PAPR

Modulation Scheme: BPSK
Code Rate: 1/2
Cylic Prefix: 1/8
Number of OFDM Symbols: 50

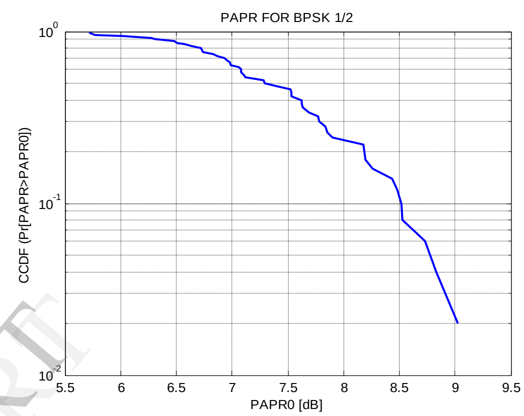

Fig 4: PAPR for BPSK modulation scheme

II. Parameters for calculation of PAPR

Modulation Scheme: QPSK
Code Rate: 1/2
Cylic Prefix: 1/8
Number of OFDM Symbols: 50

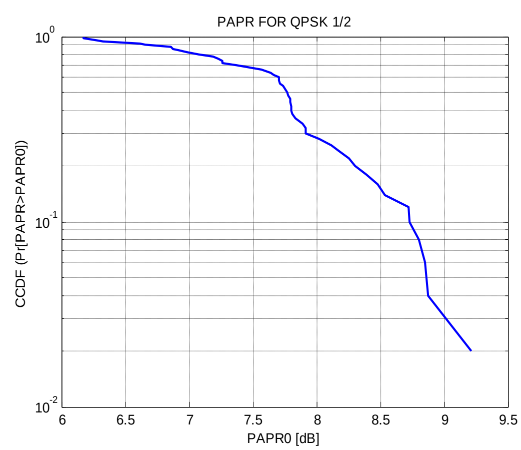

Fig 5: PAPR for QPSK 1/2 modulation scheme

III. Parameters for calculation of PAPR

Modulation Scheme: QPSK
Code Rate: 1/4
Cylic Prefix: 1/8
Number of OFDM Symbols: 50

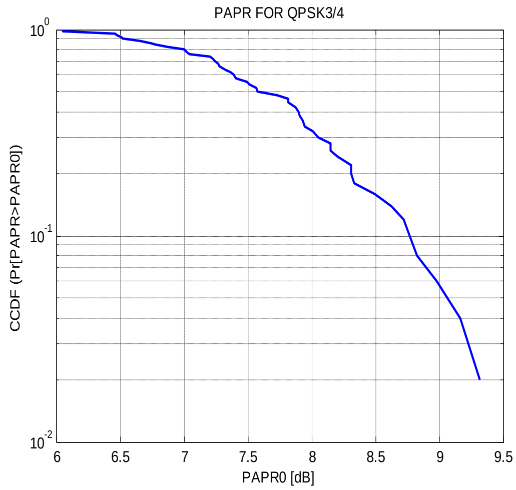

Fig 6: PAPR for QPSK3/4 modulation scheme

IV. Parameters for calculation of PAPR

Modulation Scheme: 16-QAM
Code Rate: 1/2
Cylic Prefix: 1/8
Number of OFDM Symbols: 50

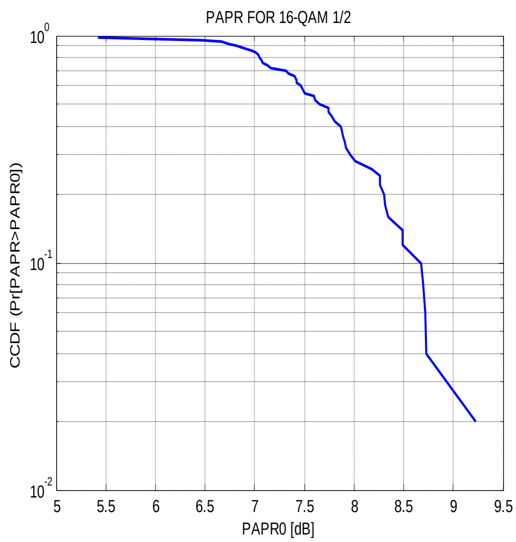

Fig 7: PAPR for 16-QAM1/2modulation scheme

V. Parameters for calculation of PAPR

Modulation Scheme: 16-QAM
Code Rate: 3/4
Cylic Prefix: 1/8
Number of OFDM Symbols: 50

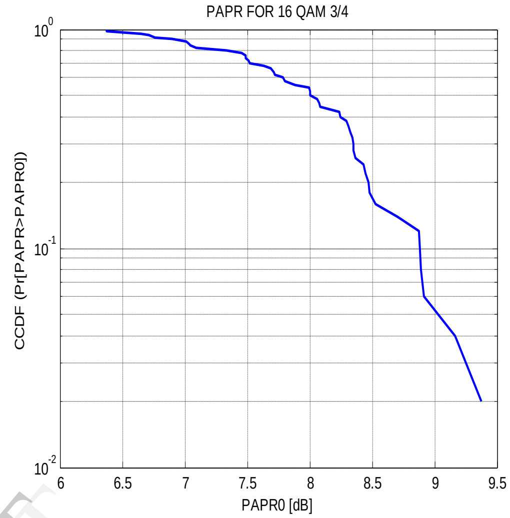

Fig 8: PAPR with 16 QAM3/4 modulation scheme

VI. Parameters for calculation of PAPR

Modulation Scheme: 64-QAM
Code Rate: 2/3
Cylic Prefix: 1/8
Number of OFDM Symbols: 50

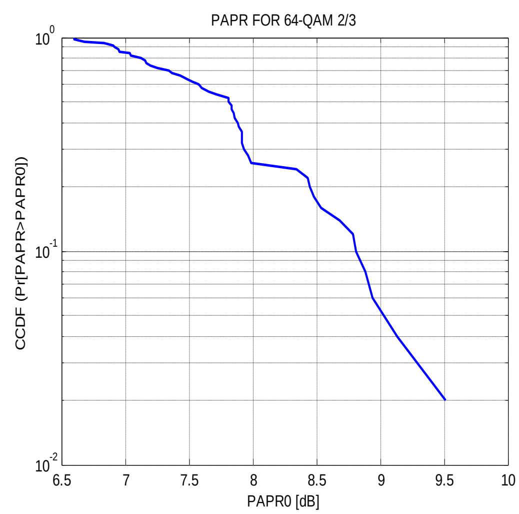

Fig 9: PAPR with 64 QAM2/3 modulation scheme

VII. Parameters for calculation of PAPR

Modulation Scheme: 64-QAM

Code Rate: 3/4

Cylic Prefix: 1/8

Number of OFDM Symbols: 50

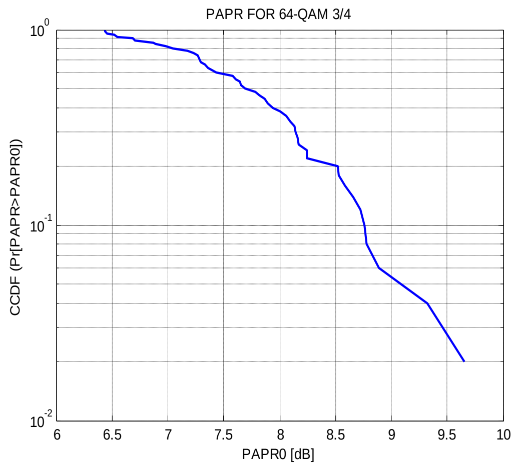

Fig 10: PAPR with 64-QAM 3/4 modulation scheme

3.2.2 Number of sub-carriers

Different number of sub-carrier results in different PAPR performances due to the varying information carried. When the number of sub-carriers increases, the PAPR also increase. Here modulation used is QPSK, when we use number of subcarriers equal to 1024 and 256, the PAPR exceeds 11dB.But for Number of subcarriers equal to 52, and the PAPR is up to 10 dB.

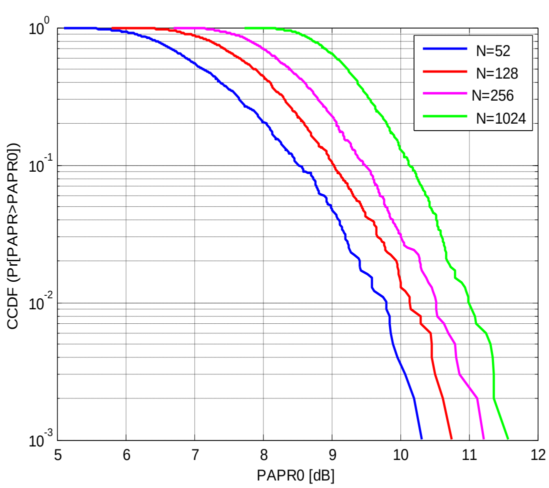

Fig 11: PAPR with different number of subcarriers

3.2.3 Oversampling rate

In real implementation, continuous-time OFDM signal cannot be described precisely due to the insufficient N points sampling. Some of the signal peaks may be missed and PAPR reduction performance is unduly accurate. To avoid this problem, oversampling is usually employed, which can be realized by taking L·N point IFFT/FFT of original data with (L-1).N zero-padding operation, where L is oversampling rate. Over-sampling plays an important role for reflecting the variation features of OFDM symbols in time domain. Higher oversampling factor leads to higher PAPR.

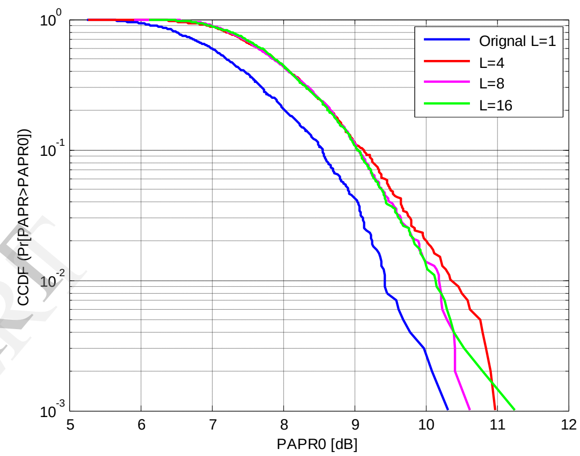

Fig 12: Comparison of PAPR with different oversampling factor

4. Conclusion

OFDM is one of the many multicarrier modulation techniques, which has several advantage of high spectral efficiency, low implementation complexity, less vulnerability to echoes and non – linear distortion. But it has one major drawback of high Peak to average Power Ratio which causes saturation in power amplifier. So there is need to minimize this problem of high PAPR for better performance of OFDM system. Many techniques have been introduced in literature to minimize PAPR In this paper we have analyzed that PAPR varies depending on modulation schemes, number of sub carriers and oversampling factors used. We have analyzed that every influencing factors, such as modulation scheme, number of sub carriers and oversampling rate has its own effects and results. We have also seen that modulation schemes play an important role in case of bit error rate in OFDM system. Modulation scheme with high coding rate and order reduces BER to a minimum value which is efficient for the better performance of OFDM system. So modulation scheme, number of sub carriers and oversampling rate should be carefully chosen for better results in terms of Peak to average Power ration and bit error rate in OFDM system.

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