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The Performance analysis of an OFDM signal in PAPR by using Signal Clipping

Md. Khalid Hossen[1], J.M. Abu Raihan[2], Rajendra Nath Sarkar[3], Md. Shahriar uzzal[4]

Abstract— In Orthogonal frequency division multiplexing (OFDM) technique the 3rd and 4th generation network is also introduced. So many advantages are still in a OFDM technique. There are some disadvantages also. Pick to average power ratio (PAPR) is one of the disadvantages in a OFDM. There are two types in which called Signal distortion techniques, Symbol-scrambling techniques In this paper we will discuss about signal clipping which under signal distortion technique. In signal clipping we will see PAPR performance and BER performance. By changing the threshold level the proper PAPR and BER is observed

Index Terms— BER, IDFT, FDM, OFDM, PSK, QAM

1.Introduction

WITH the rapid growth of digital communication in recent years, the need for high-speed data transmission has increased. New multi-carrier modulation techniques such as OFDM (Orthogonal frequency-division multiplexing) are currently being implemented to meet ever increasing demand for more communication capacity [1] [5] [6]. In an OFDM system, a high-rate serial information-bearing Symbol stream is split into many low-rate parallel streams [2].

Wireless communications has many advantages, such as speed, simplicity, mobility and flexibility, but in the same time it suffers from, inter-symbol interference (ISI) and multipath propagation (frequency selective fading). Supporting high data rates channel of the conventional single carrier system required various modulation techniques.OFDM is the most popular one. The first OFDM scheme was proposed by Chang in 1966[1]. Even though the concept of OFDM has been around for several years, but it has not been recognized as a great method for high speed bi-directional wireless data communication until recent years. (DVB-T) and Asymmetric Digital Subscriber Line (ADSL). These days the OFDM technique is considered as a strong candidate for the fourth generation (4G) of mobile communication systems. OFDM has many advantages: such as, flexibility to the channel conditions without the need of channel equalization, robustness to the fading, and resistance to multipath [1]. On the other hand, OFDM suffers a high Peak to Average Power Ratio (PAPR). A high PAPR makes the signal peaks move into the non-linear region of the RF power amplifier which causes signal distortion. A large PAPR increases the complexity of the analog-todigital and digital-to-analog converters and reduces the efficiency of the RF power amplifier. Recently, researchers have discovered many techniques on PAPR reduction, for instances, clipping, peak windowing, tone reservation, tone injection, random phase updating, coding, and selected mapping (SLM) [4].And we have shown about the PAPR and BER performance of the reduction

2.1 Ofdm theory

Orthogonal Frequency Division Multiplexing is a special form of multicarrier modulation which is particularly suited for transmission over a dispersive channel. Here the different carrier's areorthogonal 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. Since the symbols are formed by rectangular windowing the carrier function, the spectrums of OFDM symbol are basically sinc functions [2]. The comparative bandwidth requirements of FDM and OFDM subcarriers are shown in figure 1.1. Performing OFDM modulation is same as performing IFFT (Inverse Fast Fourier Transform) or IDFT (Inverse Discrete Fourier Transform) on a signal. That's why IFFT block is used to analyze OFDM modulation techniques. The equation of IDFT as shown below

$$x(n) = \frac{1}{L}\sum_{k=0}^{L-1} x(k) e^{j2\pi kn/L} ------- 1$$

Here $e^{j2\pi kn/L}$ are the subcarriers that modulate the parallel bols $X(k)$. Once modulated, these subcarriers shift the bandwidth of the symbol to a frequency Δf apart. Successive modulation of the subcarriers with the L parallel symbols takes the whole bandwidth reserved for the transmission.

2.2 Operational block diagram of OFDM:

Figure 1.1 shows the operational block diagram of OFDM system.First the data bits are PSK modulated. PSK or QAM modulations are mostly implemented in OFDM as baseband modulation techniques. Their choice depends on various factors like the bit rate and sensitivity to errors. Then the signal is serial to parallel converted into L parallel symbols. The output is fed to the L-point IDFT block with required number of zero padding, if required any. Based on the delay spread of the multi-path channel, an adequate guard-interval must be chosen.

Orthogonality of OFDM subcarriers is critical since it prevents inter channel interference. As such, OFDM is highly sensitive to frequency dispersion caused by Doppler shifts [12]. If an OFDM receiver is mobile and moving towards the transmitter, the Doppler shift can cause a corresponding shift in the OFDM spectrum. This frequency shift causes a subcarrier to be sampled at a frequency other than the one corresponding to its peak. As a result, orthogonality is lost and there is a reduction in the signal amplitude as well as intercarrier interference. The solution for this is the cyclic prefix.

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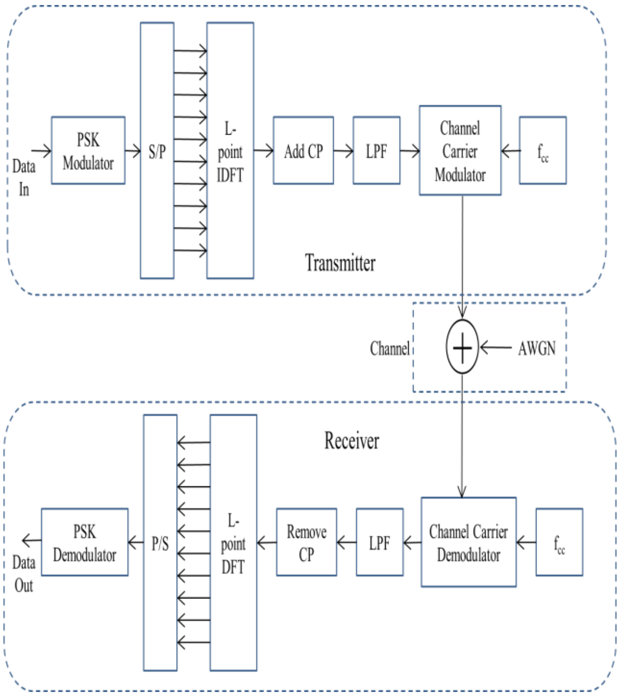

Fig: 1.1 Block diagram of OFDM system

Figure 1.1 also shows the operational block diagram of OFDM receiver. At the receiver, first the received signals are demodulated by the channel carrier and low pass filtered. These are parallel to serial converted and then PSK demodulated [1]..
The PAPR effect is shown in figure 1.2. And it can be seen that the peak power is about 17 times the average power [4].
The peak to average power ratio (PAPR) of a continuous time signal is given by [4],

$$PAPR[X] = \frac{Max_t\ [X(t)]^2}{E_t[X(t)]^2} - - - 2$$

And for the discrete time signal PAPR And for the discrete time signal PAPR

$$PAPR[X] = \frac{Max_n\ [X(n)]^2}{E_n[X(n)]^2} \text{----------}3$$

Here X is the symbol streams coming from the IDFT block. Max[X]2 is the maximum value in the modulated stream in the power form. E[X]2 is the average power of that stream. The high PAPR is a problem. The main reason is as shown in the figure 1.2. This happens linearly till the output is smaller than the saturation power level. As soon as the output crosses that level, the output varies non-linearly with the input power. That is the output power of the signal will no longer follow that of input [1]. This results in signal distortion at the transmitting end. At the receiving end, the bit error rate achieved will increase. Bit error rate will be intolerable when the PAPR of the signal is too large.

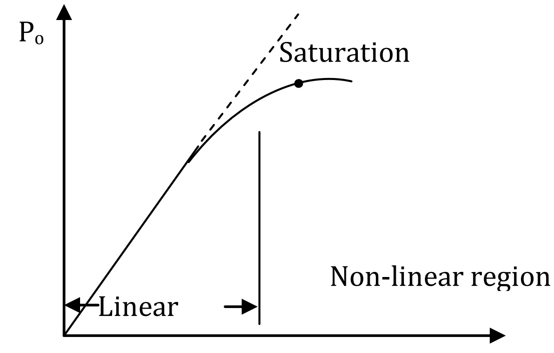

Fig1.2: For High PAPR problem in OFDM P_i

The input signal to the amplifier in the OFDM system is an analog signal and the time domain samples of the output from the inverse fast Fourier transform (IFFT) is [4]

$$[n] = \frac{1}{\sqrt{N}} \sum_{i=0}^{N-1} X[i] e^{\frac{j2\pi in}{N}}, \qquad 0 \le n \le N-1$$

If the number of subcarriers (N) is large are zero mean Gaussian random variables. And for complex Gaussian the OFDM signal is Rayleigh distributed with variance and the phase of the signal is uniform.Thus the probability of the PAPR of the discrete signal exceeds a threshold is given by [4]:

$$p(PAPR \ge P_0) = 1 - (1 - e^{-p_0})^N - - - -4$$

Let us show how PAPR increases by increasing the number of subcarriers N. Assume N Gaussian independent and identically distribute random variables *x(n)* with zero mean and unit power. The average signal power --

$$E\left[\frac{1}{\sqrt{N}}(|X_0 + X_1 + \cdots \dots \dots \dots + X_{N1}|)^2\right] = \frac{1}{N} E(|X_0 + X_1 + \cdots + X_{N1}|)^2$$

$$= \frac{E|x_0{}^2|}{N} + \frac{E|x_1{}^2|}{N} + \cdots \dots \dots \dots . + \frac{E|x_{N-1}{}^2|}{N} = 1$$

The maximum value occurs when all the $X_i$add coherently, which is

$$max\left[\frac{1}{\sqrt{N}}(|X_0 + X_1 + \cdots \dots \dots \dots + X_{N1}|)^2\right] = [\left|\frac{N}{\sqrt{N}}\right|]^2$$
$$= N - - - - - - - - - 5$$

Thus, the maximum PAPR is N for N subcarriers.
One of the major disadvantages of OFDM systems is that the OFDM signal has high Peak to Average Power Ratio (PAPR), and to deal with this problem many typical techniques have been proposed. Each one is different from others in complexity and performance, and can be divided into three major categories [6]:

3.1 Signal distortion techniques

- Signal Clipping
- Peak windowing
- Peak cancellation

3. 2 Coding Schemes

3. 3 Symbol-scrambling techniques .

Signal Clipping:

Clipping is the simplest technique that is used to reduce PAPR in OFDM system. The basic idea of this technique is to clip the parts of the signals that have high peak outside of the allowed region. The following equation shows the amplitude clipping [5],

$C(X) = \{x \quad , |x| \leq A \; ; A$-------------------------------7

Where A is a positive real number and it presents the clipping level.

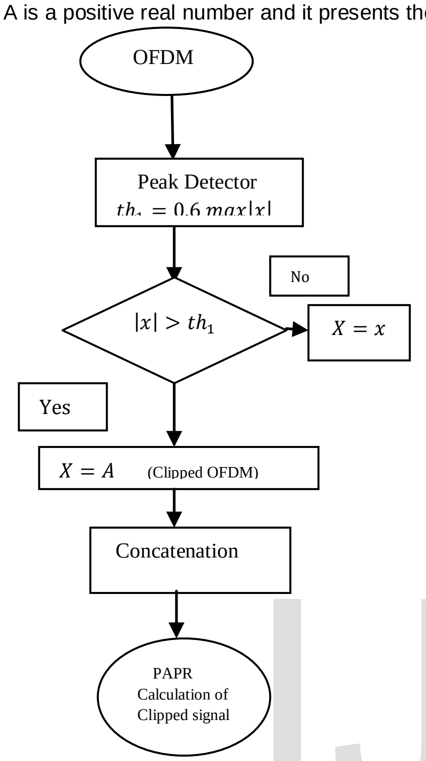

Fig 1.3 Flow Chart for Signal Clipping

The data can transmit from one step to the other data transmission is shown in the figure. On this figure we can observe that data transmit at first serial to parallel. Then it modulated PSK modulation. After the PSK modulated the data signal OFDM modulated. Then scaling the peak power data will be IFFT. After the completion of IFFT the signal is clipped from the threshold level. From the threshold level signal is clipped.

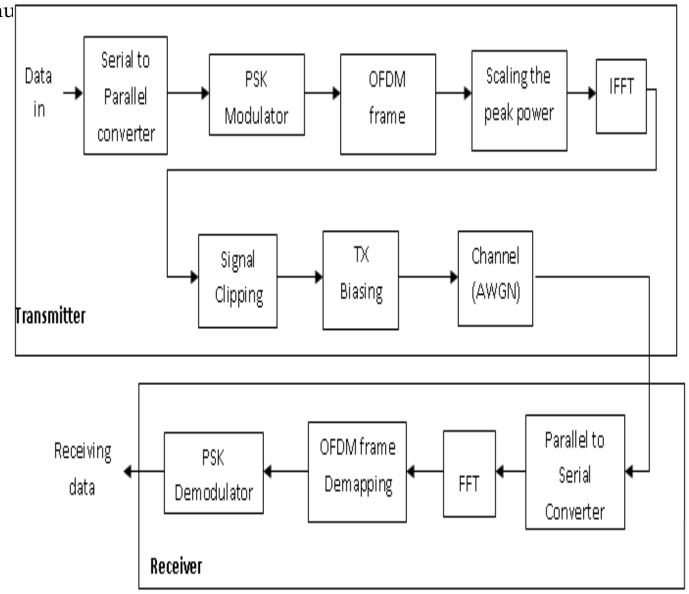

Fig 1.4 Block Diagram for Signal Clipping

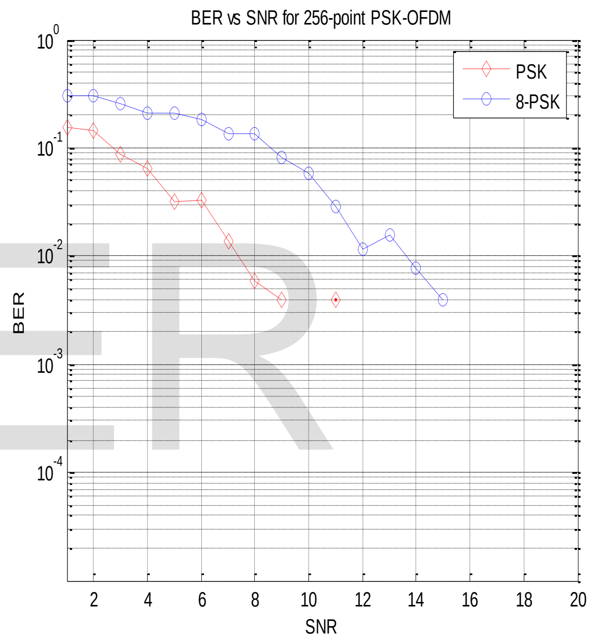

Fig 1.5: BER vs SNR for 256 point PSK-OFDM

4. **Mathematical Expression**

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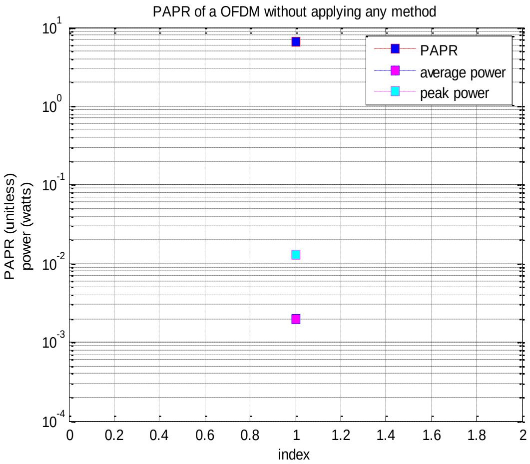

Fig 1.6 PAPR withiut applying any technique

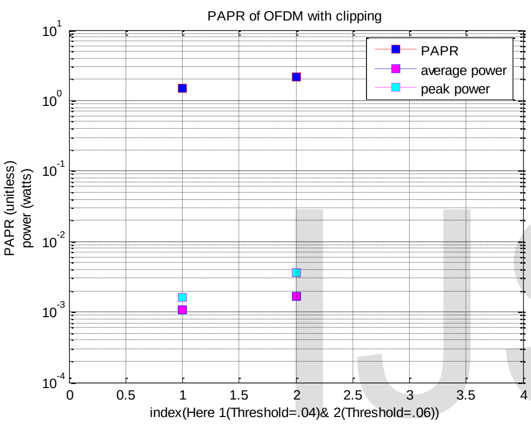

Fig 1.7: PAPR of OFDM with Clipping

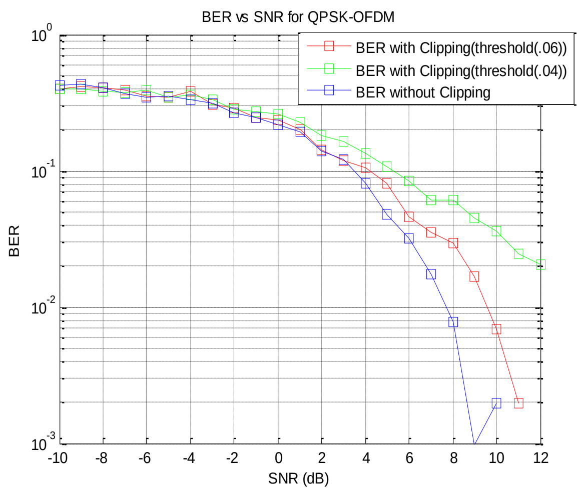

Fig 1.8: BER using Clipping for different threshold level

5. Conclusion:

The BER comparison between the system with clipping and without clipping is shown in figure 2.1. It is observed by varying the signal to noise ratio from 1 to 22 dB and also calculating the bit error rate every time Both the curves gradually drop near 3x10-3 near the signal to noise ratio of 20 dB. So modulation at different points in the constellation diagram does not change the BER performance which is expected. In this curves the signal clipping which is just below 2x10- 1.From the figure it is observed that clipping signal BER performance is better than other.

Now the better BER will be taken by choosing the appropriate threshold level. On this figure 2.1 it is shown that the threshold level 0.06 the BER rate is more appropriate than the threshold level 0.04

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1. Md. Khalid Hossen has completed his undergraduate in Electronics & Communication Engineering from Khulna University in Bangladesh. He has deep inclination on research from university level.Now he works as a System engineer in a Telecom company.His email ID:ece090913@gmail.com.mobile-+8801723035349

2. J.M Abu Raihan has completed his undergraduate in Electronics & Communication Engineering from Khulna University in Bangladesh. Now he works as a System engineer in a Telecom company.His email ID:ece090923@gmail.com

3. Rajendra Nath Sarkar has completed his undergraduate in Electronics & Communication Engineering from Khulna University in Bangladesh. His email ID:rajensarkar09@gmail.com

4. Md.Shahriar Uzzal has completed his undergraduate in Electronics & Communication Engineering from Khulna University in Bangladesh. His email ID shahriarece09@gmail.com