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NONLINEAR COMPANDING SCHEME PAPR REDUCTION OF OFDM SIGNALS

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Abstract
Companding transform is a simple and efficient method in reducing the Peak to Average Power Ratio (PAPR) of Orthogonal Frequency Division Multiplexing (OFDM) systems. In this project, a novel nonlinear companding scheme is proposed to reduce the PAPR and improve Bit Error Rate (BER) for OFDM systems. This proposed scheme mainly focuses on compressing the large signals, while maintaining the average power constant by properly choosing transform parameters. Moreover, analysis shows that the proposed scheme without decompounding at the receiver can also offer a good BER performance. Finally, simulation results show that the proposed scheme outperforms other companding scheme in terms of Spectrum sidelobes,PAPR reduction and BER performance.
Keywords—Introduction, Problem Statement,Existing System,OFDM system, problem formulation, Proposed system Proposed Scheme, Results and Discussion

Introduction

After more than thirty years of research and developments carried out in different places, orthogonal frequency division multiplexing (OFDM) has been widely implemented in high speed digital communications. Due to the recent advancement in digital signal processing and very large scale integrated circuits (VLSI) technologies the initial obstacles of OFDM implementations do not exist anymore. Meanwhile, the use of Fast Fourier transform (FFT) algorithms has eliminated arrays of sinusoidal generators and coherent demodulation required in parallel data systems and made the implementation of the technology cost effective[1,2]. In recent years OFDM has gained a lot of interest in diverse digital communication applications. This has been due to its favorable properties like high Spectral efficiency and robustness to channel fading. Today, OFDM is mainly used in digital audio broadcasting system (DAB) initiated by CCETT in France, and digital video broadcasting system (DVB) enabling an end-to-end digital transmission system which is spectrally efficient and rugged against channel distortions. This can be used for services such as HDTV, offering increased capacity for program broadcasting [3,4]. In the conventional serial data transmission system, the information symbols are transmitted sequentially where each symbol occupies the entire available spectrum bandwidth. But in an OFDM system, the information is converted to N parallel sub channels and sent at lower rates using frequency division multiplexing. The subcarrier frequency spacing is selected carefully such that each subcarrier is located on the other subcarriers zero crossing points. This implies that there is overlapping among the subcarriers but will not interfere with each other, if they are sampled at the sub carrier frequencies. This means that all subcarriers are orthogonal. The OFDM has many advantages such as high bandwidth efficiency, robustness to the selective fading problem, use of small guard interval, and its ability to combat the ISI problem. So, simple channel equalization is needed instead of complex adaptive channel equalization.

Problem Statement

One of the major problems is high Peak-to-Average Power Ratio (PAPR) of transmitted OFDM signals. This high PAPR forces the transmit power amplifier to have a large back-off in order to ensure linear amplification of the signal, which significantly reduces the efficiency of the amplifier.

Existing System.

Many PAPR reduction techniques have been proposed in the existing research work. It should be noted that most of the methods are based on the same idea of selecting the time domain signal to be transmitted from a set of different representations with the constraint of minimization of PAPR which would degrade the performance of system. Nevertheless, PAPR reduction methods can be classified into distortion less and distortion techniques[4]. At present, there are many PAPR reduction techniques of OFDM. The first is distortion technique, such as clipping, companding and so on. This technique is simple, but it is inevitable to cause some performance degradation. The second is coding technique. It is an efficient method to reduce the PAPR for a small number of subcarriers, but it is inefficient transmission rate significantly for a large number of subcarriers[6,7]. The third kind is probabilistic technique or the redundancy technique which is including selective mapping (SLM) and the Partial transmit sequence (PTS**).**

OFDM SYSTEM AND PROBLEM FORMULATION

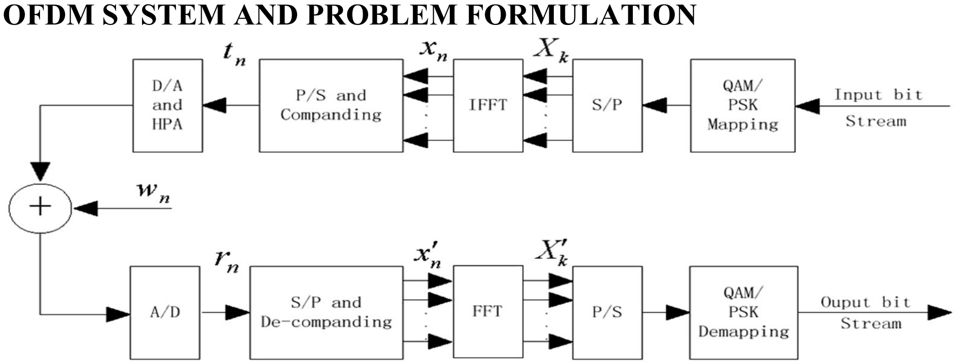


Fig 1 block diagram of an OFDM system with companding transform

Fig. 1 shows a generic OFDM system using the companding technique, the whole system bandwidth is divided into many orthogonal sub-channels (with narrow bandwidth),an data symbols typically modulated by Phase Shift Keying (PSK) or Quadrature Amplitude Modulation (QAM) are transmitted independently on the subcarriers.

Proposed System

In the proposed system, a novel non-linear companding scheme is proposed. This scheme mainly focuses on compressing the large signals, while maintaining the average power constant by properly choosing the transform parameters[1,2,3]. Furthermore, theoretical analysis shows that the proposed scheme without de-companding operation at the receiver can also offer a good BER performance Finally, simulation results show that the proposed scheme offers a better PAPR reduction and BER performance than the EC (exponential companding) scheme[8,9]. This proposed scheme mainly focuses on compressing the large signals, while maintaining the average power constant by properly choosing transform parameters[13,14]. Moreover, analysis shows that the proposed scheme without de-companding at the receiver can also offer a good BER performance. This proposed scheme mainly focuses on compressing the large signals, while maintaining the average power constant by properly choosing transform parameters. Moreover, analysis shows that the proposed scheme without de-companding at the receiver can also offer a good BER performance[15,16]. Let N denote the number of sub-carriers used for Parallel information and transmission $X_K (0 \le K \le N-1)$ denote the K_{th} complex modulated symbol in a block of N information symbols. The outputs x_n of the - point Inverse Fast Fourier Transform (IFFT) x_k are given by

$$x_n = \frac{1}{\sqrt{N}} \sum_{m=0}^{N-1} \sum_{K=0}^{N-1} x_m x_k \exp\left(\frac{j.2\pi kn}{N}\right)$$

Then , the power of OFDM signal x_n can be expressed as

$$\left|x_n\right|^2 = \frac{1}{N} \sum_{m=0}^{N-1} \sum_{K=0}^{N-1} x_m x_k \exp\left(\frac{j.2\pi(m-k)n}{N}\right),$$

PAPR of OFDM signal in terms of power is defined as

$$PAPR = 10\log_{10} \frac{Max\left\{\left|x_n\right|^2\right\}}{E\left[\left|x_n\right|^2\right]} (db)$$

where $\left|x_n\right|$ returns the magnitude of x_n and E[.] denotes the expectation operation. The peak power occurs when the N modulated symbols are added with the same phase.

Proposed Scheme

In this section, propose a novel non-linear companding technique that can effectively improve the BER performance and reduce the PAPR of transmitted OFDM signals. Moreover, the new scheme has the advantage of maintaining a constant average power through the companding operation. Therefore, the efficiency of the amplifier can be improved[9,10]. Assume the input information symbols are statistically independent and identically distributed. Based on the central limit theory, can be approximated as a complex Gaussian process when the number of sub-carriers is large (e.g.). Assume that has zero mean and variance so its magnitude has a Rayleigh distribution with the Probability distribution Function (PDF) given by

$$f_{|x_n|}(x) = \frac{2x}{\sigma^2} \exp\left(\frac{-x^2}{\sigma^2}\right)$$

According to the extension of the Bussgang theorem to complex or real Gaussian inputs can be written as the sum of a useful attenuated input replica and an uncorrelated nonlinear distortion noise. Thus, the companded t_n signal can be modeled as the aggregate of an attenuated signal component and companding noise b_n as expressed by

$$t_n = \alpha x_n + b_{n,}$$

where α is attenuation factor. Though the OFDM signal x_n is not stationary, it has been shown that an OFDM signal guarantees α to be time invariant. In α has been given as

$$\alpha = \frac{E\{t_n \overline{x_n}\}}{E\{x_n \overline{x_n}\}} = \frac{1}{\sigma^2}\int_0^\infty x h(x) f_{|x_n|}(x)\,dx$$

Consider a constant average power level in the companding operation, we have

$$p_{x_n} = p_{t_n} = p_{\alpha x_n} + p_{b_n} = \alpha^2 p_{x_n} + p_{b_n},$$

$$p_{b_n} = \left(1-\alpha^2\right) p_{x_n}$$

This formula illustrates that $\alpha < 1$ and the closer α to1

the smaller will be with the de-companding operation at the receiver, the recovered signal $x_n^{'}$ is given by

$$x_n^{'} = \beta t_n + c_n$$

Where $\beta = \frac{1}{\alpha}, c_n = \frac{-b_n}{\alpha}$,

For simplicity, we consider the OFDM system with the proposed scheme through AWGN channel. Adding guard interval is ignored since it has no bearing on the analysis in this paper. In an AWGN channel, the received signal can be expressed as

$$r_n = t_n + \omega_n$$

where ω_n is the channel noise. With the de-companding operation, the recovered signal $x_n^{'}$ at the receiver is

$$x_n^{'} = \beta r_n + c_n = \frac{t_n + \omega_n}{\alpha} - \frac{b_n}{\alpha} = x_n + \frac{\omega_n}{\alpha}.$$

This formula shows that the de-companding operation amplifies the channel noise ω_n to $\frac{\omega_n}{\alpha}$ .Without the de-companding operation, the equivalent noise iscomposed of two parts: the companding noise and the channel noise ω_n . Then, the equivalent noise in the proposed scheme with and without the de-companding operation can be written as $\frac{\omega_n}{\alpha}$ and $\omega_n + b_n$, respectively.

Let α_n denote the attenuation factor of the proposed scheme. It was calculated that α_n =0.993 (is close to 1). we find that the proposed scheme results in little companding noise. Therefore, it can be concluded that the proposed scheme without the de-companding operation.

Implementation

The implementation phase of any project development is the most important phase as it yields the final solution,

which solves the problem at hand. The implementation phase involves the actual materialization of the ideas,

which are expressed in the analysis document and developed in the design phase. Implementation should be perfect mapping of the design document in a suitable programming language in order to achieve the necessary final product [11,12]. Often the product is ruined due to incorrect programming language chosen for implementation or unsuitable method of programming. It is better for the coding phase to be directly linked to the design phase in the sense if the design is in terms of object oriented terms then implementation should be preferably carried out in a object oriented way[10]. The factors concerning the programming language and platform chosen are described in the next couple of sections.

Results and Disscusion

To get the required results we are making the use of graphical user interface software. Which is used in matlab. From the below layout we have transmitted data and received data and in the left side we have input data for Image, Audio and Bit error rate performance

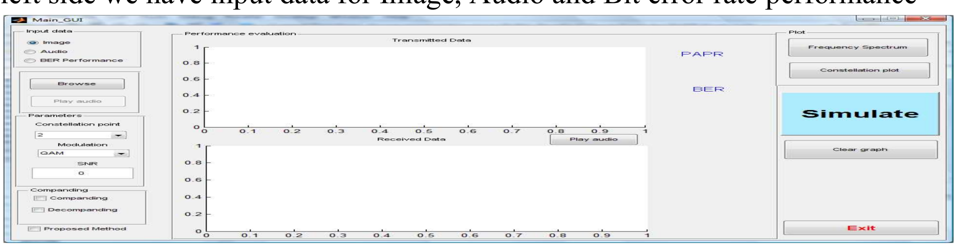


Figure 1. Transmitted data and Received data and in the left side we have input data for Image, Audio and Bit error rate performance

1.For image file:To find the peak to average power ratio of the input image of reducing bit error rate. For image transmitting we browse the image that has to be transmitted and we select the parameters such as constellation points as 2 or 4 or 6 or 16 or 20 etc, And we select the modulation as QAM/PSK and we select the SNR ratio from 0 to 20 any value and we have to select the proposed method from the left side of the block diagram.And then we go for simulation to get the received data, The PAPR value depends on SNR Ratio as SNR ratio increases the noise decreases and we get the better output data that is received data.

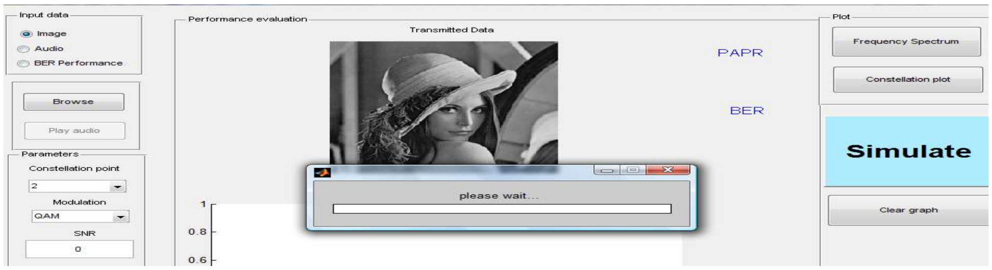


Figure. 2 For PAPR performance once we select the companding and for simulation the proposed method and we go for simulation and proposed method has less noise compared to companding method.

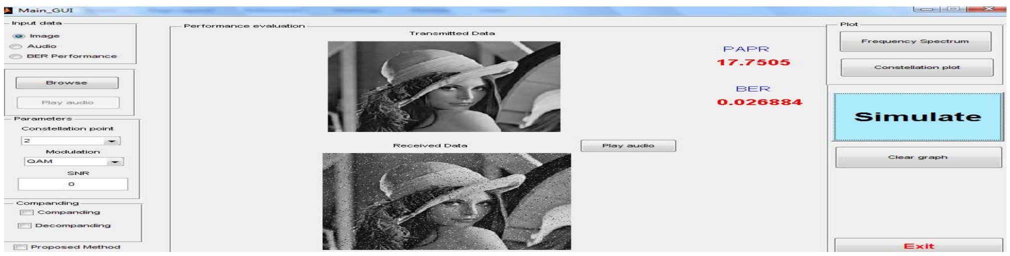


Figure3. The above output we have selected SNR = 0 (zero), so there is distortion in output image because of the presence of noise in signal and have BER as 0.026884

For audio we record the voice from mike set as transmitted data and we select the parameters such as constellation points as 2 or 4 or 6 or 16 or 20 etc, And we select the modulation as QAM/PSK and we select the SNR ratio from 0 to 20 any value we have to select the proposed method from the left side of the block diagram.And then we go for simulation to get the received data, The PAPR value depends on SNRRatio as SNR ratio increases the noise decreases and we get the better output data that is received data.BER performance:implement BER to reduce the noise level for receiving superior quality of the output .And for BER performance we must get the output such that the proposed output must be better then the companding, To show PAPR performance once we select the companding and we go for simulation and for next result we select the proposed method and we go for simulation and proposed method has less noise compared to companding method.

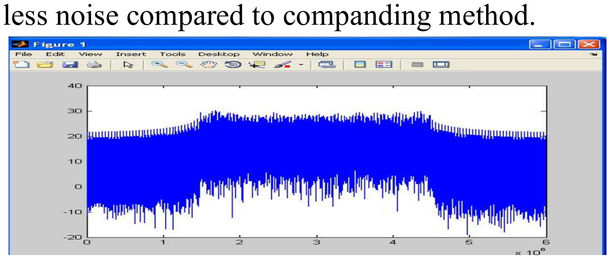


Figure 4.The frequency spectrum of the image when SNR=0

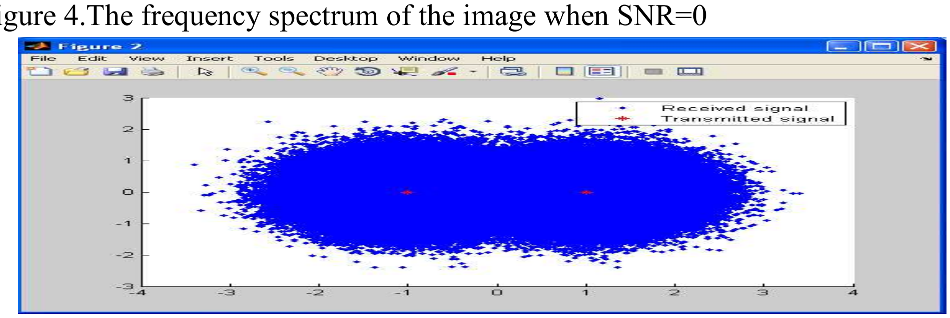


Figure 5. shows the two constellation points and have selected for simulation the red spot indicates the transmitted signal and blue indicates the received signal

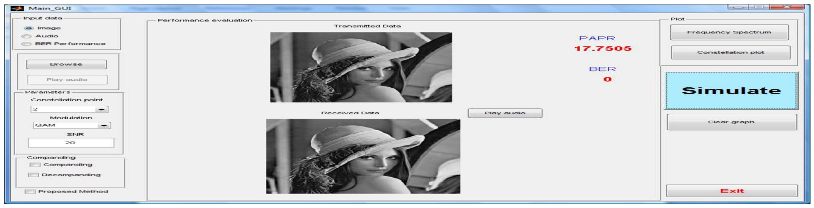


Figure 6: From the output as the SNR=20 and good quality signal ratio is more and noise is less and BER as zero.

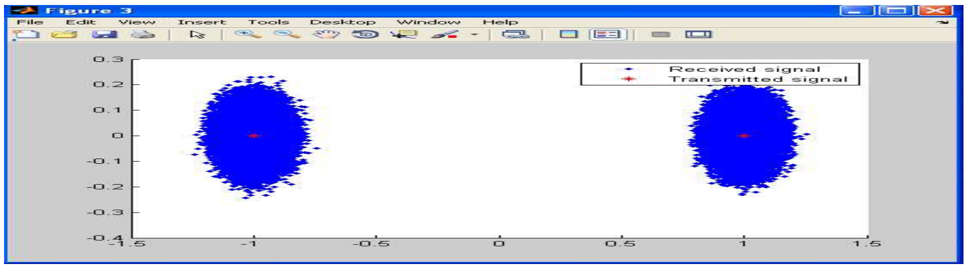


Figure 7. Figure shows the two constellation points as we have selected for simulation the red spot indicates the transmitted signal and blue indicates the received signal .In this figure we find that there is no distortion because as we have taken SNR=20, the noise ratio is less then the signal ratio, so there is no interference of the signal. Constellation points are for evaluating values of bit error rate

FOR AUDIO

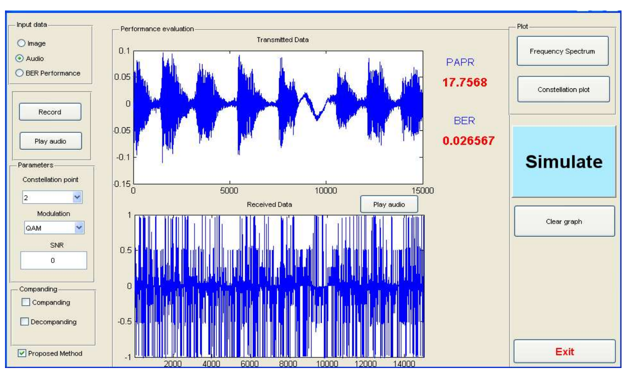


Figure 1.The above figure shows the transmitted data and the received data, the received data is more distorted then the transmitted data, because the SNR=0, the PAPR is 17.7568 and BER is 0.026567 so the noise ratio is greater. Then the signal ratio,and play the audio the audio is not same as recorded , the audio is distorted as noise ratio is more.

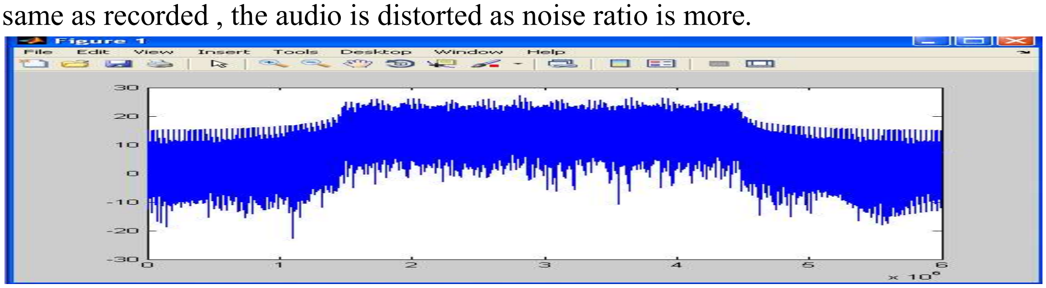
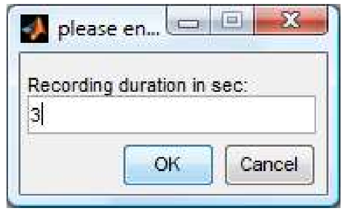


Figure2 shows the frequency spectrum of the Audio When SNR=0



For recording Audio upto 3 sec

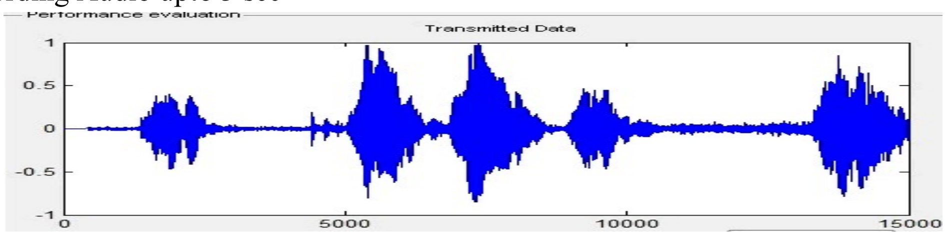


Fig1.The above figure shows the frequency spectrum of the audio when SNR=20

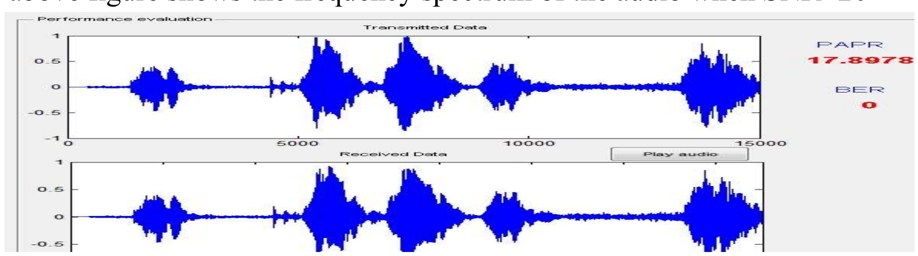


Figure2.The transmitted data and the received data and the received data is same as the transmitted data , because the SNR=20 ,the PAPR is 17.8978 and BER is 0 so the signal ratio is greater then the noise ratio.

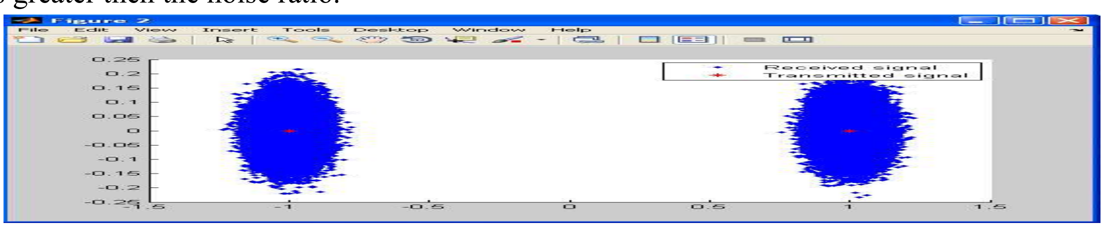


Figure2 shows the **two constellation** points as we have selected for simulation the red spot indicates the transmitted signals and blue indicates the received signals .In this figure we find that there is no distortion because as we have taken SNR=20, the noise ratio is less then the signal ratio, so there is no interference of the signal. Constellation points are for evaluating values of bit error rate.

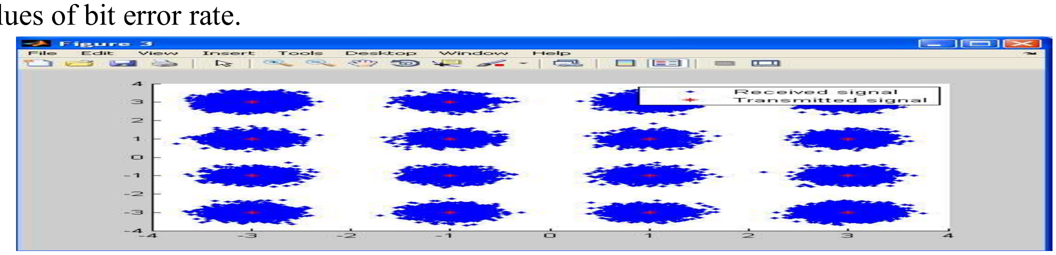


Figure3.The above figure shows the **16 constellation** points as we have selected for simulation the red spot indicates the transmitted signals and blue indicates the received signal .In this figure we find that there is no distortionbecause as we have taken SNR=20, the noise ratio is less then the signal ratio, so there is no interference of the signal. Constellation points are for evaluating values of bit error rate.

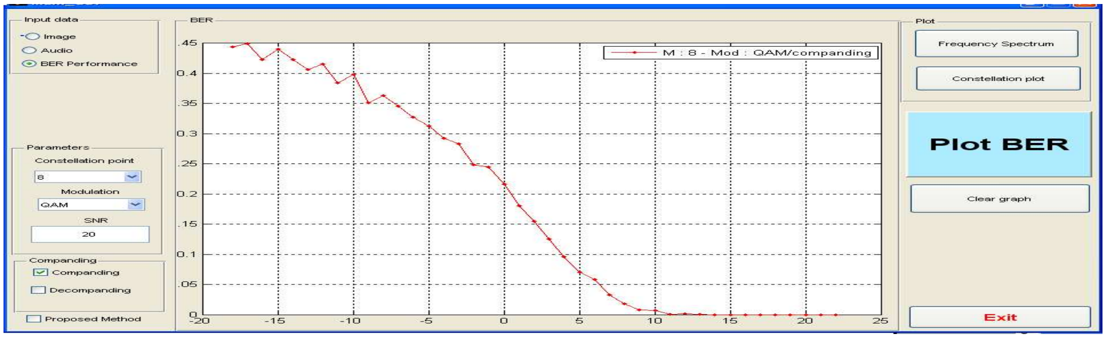


Figure 4 In the above figure we have considered the BER performance. In this we have to prove the proposed scheme has less noise ratio compared to companding output, in above we have output as 0.45

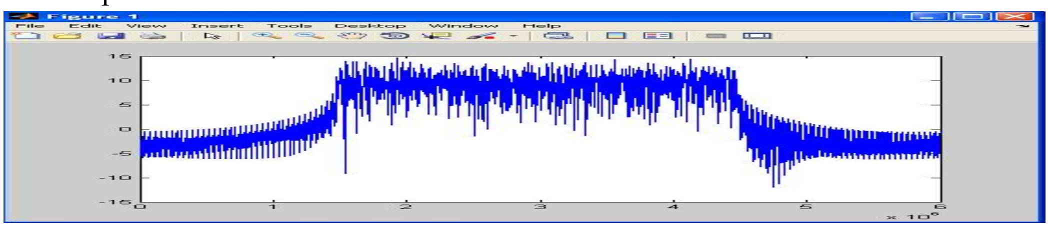


Figure 5 The above figure shows the frequency spectrum of BER performance.

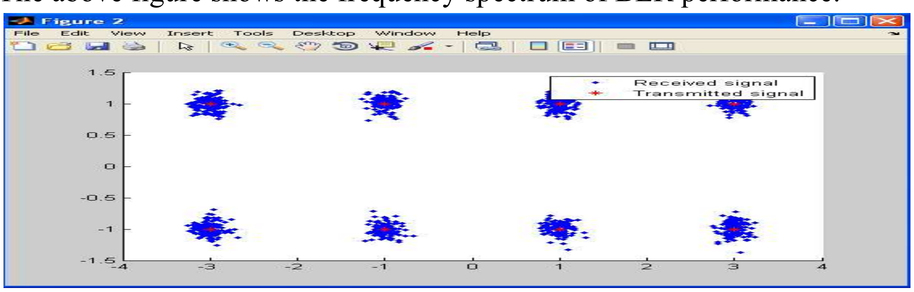


Figure 6 we have selected 8 constellation points we have 8 transmitted and 8 received signals as shown above.

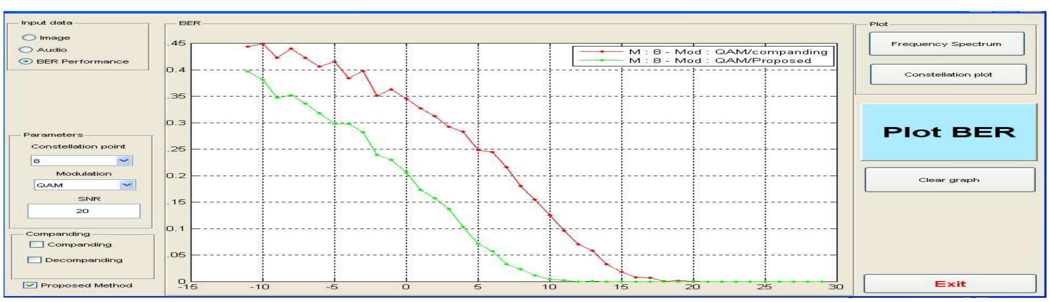


Figure7. output of both companding and proposed, from above we find that the proposed output is 0.4 and companding is 0.45.So we can say that the proposed scheme is better and efficient then the companding scheme.

Conclusion

a novel non-linear companding scheme is proposed. This scheme mainly focuses on compressing the large signals, while maintaining the average power constant by properly choosing the transform parameters. Furthermore, theoretical analysis shows that the proposed scheme without de-companding operation at the receiver can also offer a good BER performance. Finally, simulation results show that the proposed scheme offers a better PAPR reduction and BER performance than the EC scheme. These simulation results demonstrate that the proposed companding scheme without de-companding operation can offer a good BER performance.

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