

Reduction of PAPR in OFDM System using A-law Compressing Technique

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Abstract— This paper proposes the use of A-law compressing technique to reduce the PAPR of OFDM system which comes under the category of Signal distortion techniques. In the time domain, OFDM signal is having variation in peaks because at some time instant, sum is different & at other time instant, sum is different one which leads to high PAPR. So, it has been one of the main challenging point of the OFDM system. Several techniques have been proposed in the literature of PAPR reduction in OFDM systems. Here compressing technique is proposed to minimize the PAPR and effects of value "A" are discussed.

Index Terms— A-law Compressing, Bit Error Rate (BER), Complementary Cumulative Distribution Function (CCDF), Orthogonal Frequency Division Multiplexing (OFDM), Peak to Average Power Ratio (PAPR), Simulink.

1 INTRODUCTION

Today, Wireless communication is one of the most important areas in the communication field. Advancement in the age & great demand for serving the large number of users has forced the exponential growth in communication field. Analog signals which were used in the communication system for transmission & reception has been replaced by Digital ones. But now these days, Single carrier systems are now being replaced by Multi carrier systems due to some drawbacks like large bandwidth requirement, more susceptible to interference caused by impulse noise, and less immune to inter-symbol interference [2].

Now a days Multicarrier modulation schemes like CDMA (Code Division Multiple Access), OFDM (Orthogonal Frequency Division Multiplexing) are being used for implementation commonly. There are various advantages of Orthogonal frequency division multiplexing (OFDM) which makes it very attractive modulation technique for high speed data transmission in mobile communications such as high spectral efficiency, robustness to channel fading, immunity to impulse interference, and capability of handling very strong multi-path fading and frequency selective fading without having to provide powerful channel equalization.

In recent years, some industrial standards based on OFDM have been emerged, such as the Terrestrial Digital Video Broadcast (DVB-T) [3], Digital Audio Broadcast (DAB) [5], IEEE 802.11 Wireless Local Area Network (WLAN) scheme, IEEE 802.16 Broadband Wireless Access (BWA), particularly, Wireless Metropolitan Area Networks (IEEE 802.16d), WiMAX, IEEE 802.20 Mobile Broadband Wireless Access (MBWA), 3GPP UMTS and Long-Term Evolution (LTE).

Besides a lot of advantages, there are some disadvantages

which are:

- 1] Inter Carrier Interference (ICI) is high.
- 2] Sensitive to Frequency synchronization problem.
- 3] Peak to Average Power Ratio (PAPR) is very high.

This high PAPR is main drawback in OFDM, which is discussed in the section II.

2 PAPR PROBLEM IN OFDM SYSTEM

High PAPR is one of the major issues occurring in OFDM modulation. When N number of sinusoidal signals get added, the peak magnitude would have a value of N, where at some time instance, the average might be quite low due to the destructive interference between the sinusoids or it could be high due to the constructive interference between the sinusoids.

High PAPR signals are usually undesirable. Due to High PAPR signals, there would be requirement of a large range of dynamic linearity from the analog circuits which ultimately results in expensive devices and high power consumption resulting in lower efficiency (for e.g. Power amplifier will have to operate with larger back-off to maintain the linearity) [1].

In OFDM system, some of the input sequences which are needed to be transmitted would result in higher PAPR than others. So, an input sequence that requires all such carriers to transmit their maximum amplitudes would certainly result in a high output PAPR. Thus by restricting the possible input sequences to a smallest set of values, there might be possibility to obtain output signals with a guaranteed low output PAPR.

The peak to average power ratio for a signal $x(t)$ can be defined as the ratio of the maximum instantaneous power to the average power.

$$PAPR = \frac{\max[x(t)x^*(t)]}{E[x(t)x^*(t)]}$$

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Where \bar{C}^* corresponds to the conjugate operator. (1)

The higher PAPR in an OFDM system essentially arises because of the IFFT operation. Data symbols across subcarriers can add up to produce a high peak value signal.

PAPR of an OFDM system is characterised using the CCDF (Complementary Cumulative Distribution Function).

$$\bar{F}_x(x) = P(X > x) \tag{2}$$

Symbols are random, instantaneous power or peak power for group of symbols is random depending on combination of symbols. Hence, Random variable is best characterised by distribution function. Here we are using CCDF [4]-[6].

$$CCDF = 1 - CDF \tag{3}$$

Ideally we want the PAPR to be 0 dB.

3 MATLAB/SIMULINK MODEL

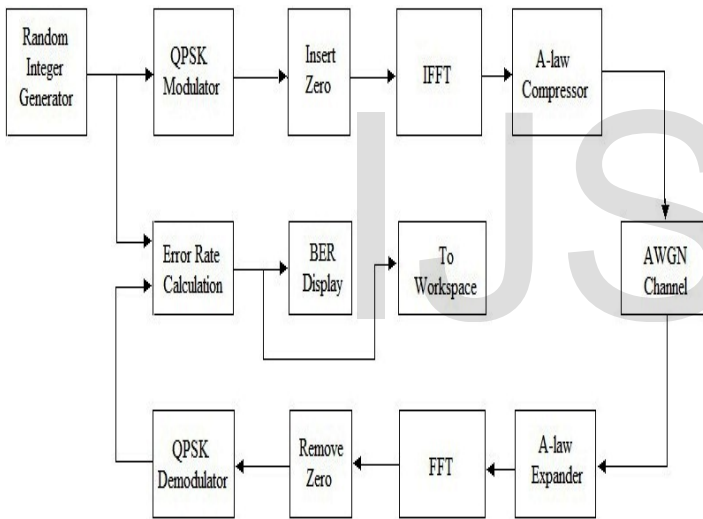


Fig. 1. Simulink model of OFDM system for reduction of PAPR Using A-law Companding technique

4 A-LAW COMPANDING FOR PAPR REDUCTION

In the companding technique, the compression of OFDM signals at the transmitter and expansion at the receiver [9]. In the A-law companding, the compressor characteristic is piecewise, made up of a linear segment for low level inputs and a logarithmic segment for high level inputs. Fig. 2. shows the A-law compressor characteristics for different values of A.

Corresponding to A=1, we observe that the characteristic is linear (no compression) which corresponds to a uniform quantization. A-law has mid riser at the origin. Hence it contains non-zero value. The practically used value of “A” is 87.6. The A-law companding is used for PCM telephone systems.

The linear segment of the characteristic is for low level inputs whereas the logarithmic segment is for high level inputs. It is mathematically expressed as,

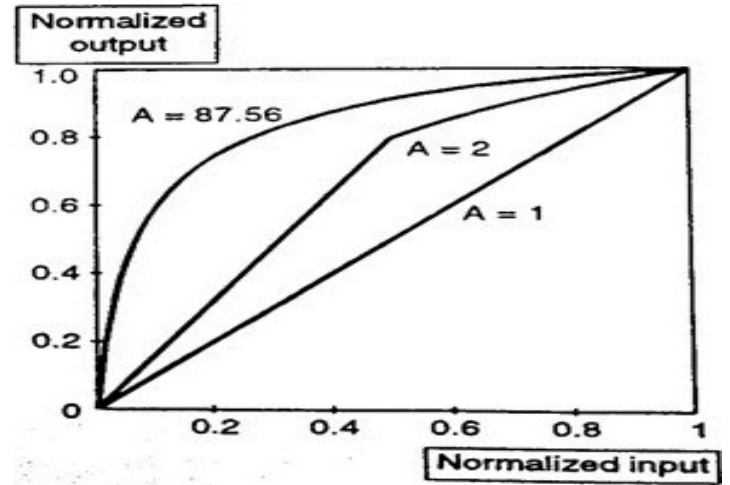


Fig. 2. Characteristic of A-law Compressor

$$y(x) = \begin{cases} A \frac{|x|}{x_{max}} \text{sgn}(x), & 0 < \frac{|x|}{x_{max}} \leq \frac{1}{A} \\ y_{max} \frac{[1 + \log_e(A \frac{|x|}{x_{max}})]}{(1 + \log_e A)} \text{sgn}(x), & \frac{1}{A} < \frac{|x|}{x_{max}} \leq 1 \end{cases} \tag{4}$$

Where

- x=input signal.
- y=output signal.
- Sgn(x) =sign of the input (+ or -).
- |x| =absolute value (magnitude of x).
- A=87.6 (defined by CCITT).

This A-law companding technique is used in Europe, Asia, Russia, Africa, China, etc.

TABLE 1
SIMULATION PARAMETERS

Sr. No.	Descriptions	Specification
01	Modulation scheme	QPSK / M=4
02	No. of IFFT size	512
03	Value of A	87.6
04	Channel	AWGN

05	Number of bits per symbol	1
06	Input signal power referenced to 1ohm	1 watts

5 SIMULATION RESULTS

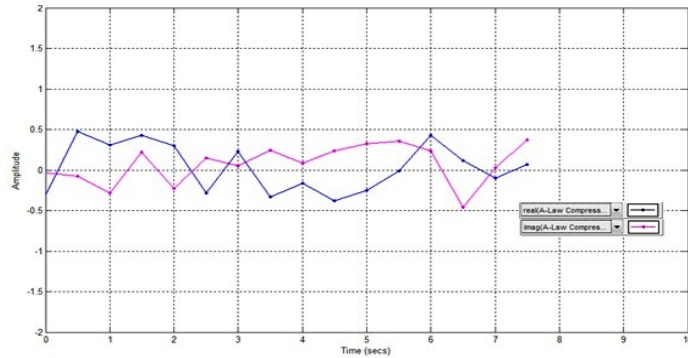


Fig. 3.Output of A-law Compressor

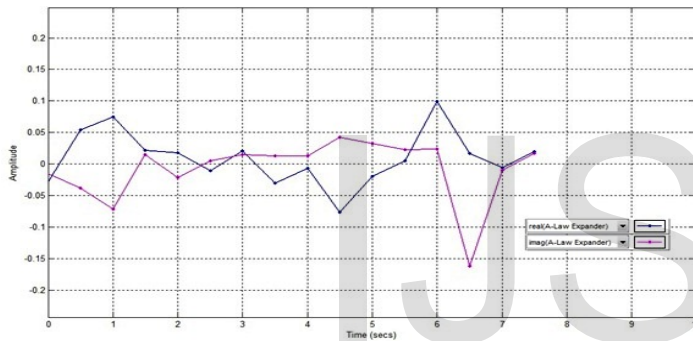


Fig. 4.Output of A-law Expander

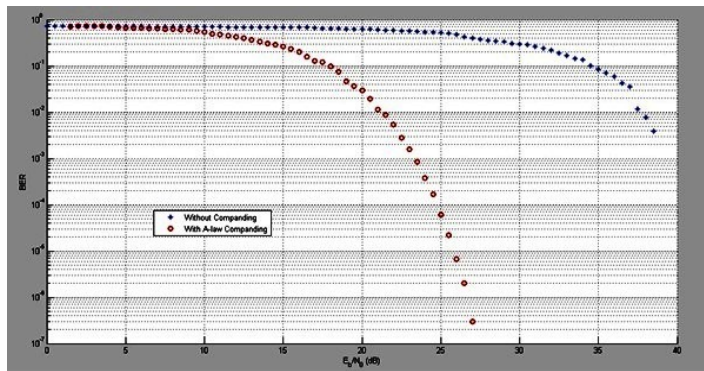


Fig. 5.comparison of A-law companding & non-companding method

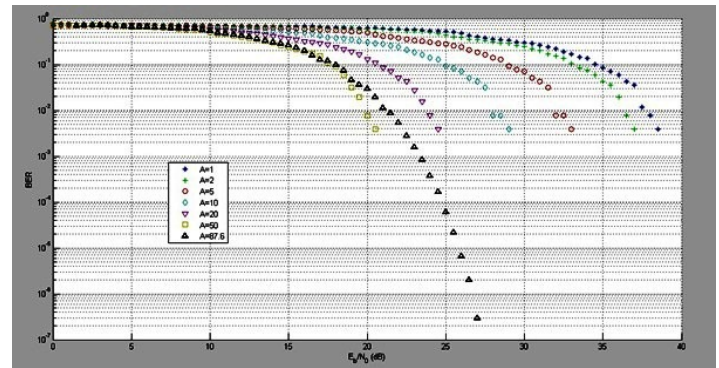


Fig. 6. Response of system to various values of "A"

6 CONCLUSION

In this paper we considered the PAPR reduction problem in the OFDM system. The proposed PAPR reduction technique was based upon the companding method.

Then performance of the OFDM system is simulated by using A-law Companding, it is observed that as the value of "A" increases shown in Fig. 6. there is a significant reduction in the PAPR value. And it is clear that by choosing the appropriate value of A, we can get the desired PAPR value. Also we found that to achieve the Bit Error Rate (BER) of 10⁻² shown in Fig. 5. A-law technique requires approximately 16.4 dB reduced SNR value as compared to the OFDM system without companding method.

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