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RESEARCH ARTICLE

Peak to Average Power Ratio Reduction in OFDM by Exponential Companding Technique

Miss. Sujata P. Jogdand[1], Prof. S.L.Kotgire[2]

[1](ME Electronics, M.G.M's college of Engg./S.R.T.M. University, Nanded, India)

[2](Professor & HOD, M.G.M's college of Engg./S.R.T.M.University, Nanded, India)

[1] sujata1511@gmail.com; [2] kotgire_sl@rediffmail.com

Abstract— One of the major problems of Orthogonal Frequency Division Multiplexing (OFDM) is High-Peak-to-Average Power Ratio (PAPR). In this paper a new Exponential Companding Technique of PAPR reduction is analyzed. The use of Exponential Companding as an effective technique for minimizing the PAPR of OFDM signals is presented. The increase of in-band and out-of band noise due to sampling and compression is considered. The Bit-Error-Rate (BER) performance is also evaluated for transmission is also evaluated for transmission within an Additive White Gaussian Noise (AWGN) channel and Binary Symmetric Channel (BSC) channel. The improvement on Bit-Error-Rate (BER) performance and PAPR is studied and is compared with the performance due to Mu-law and Conventional coding within the OFDM transmission. It shows that the proposed exponential companding technique can offer better PAPR reduction, Bit Error Rate (BER) than the Conventional coding and Mu-law companding technique.

Index Term- Orthogonal Frequency Division Multiplexing (OFDM), Bit Error Rate (BER), Peak- to-Power Ratio (PAPR)

1. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) system is believed to be a suitable technique for broadband wireless communication and has been used and supports for the high-speed digital communications in many wireless standards, such as Asymmetric Digital Subscriber Line (ADSL), Digita1 Audio Broadcasting (DAB), Terrestrial Digital Video Broadcasting (DVB-T), The ETSI HIPERLAN/2 standard, The IEEE 802.16a standard for wireless Metropolitan Area Networks (WMAN), The IEEE 802.11a standard for Wireless Local Area Network (WLAN), High-Definition Television (HDTV) and due to robustness to the narrowband interference and severe multi-path fading, immunity to impulse interference [1], [2]. All most radio systems uses sophisticated high power amplifiers (HPA's) operating in a very large linear range, such as the Solid State Power Amplifier (SSPA), in the transmitter to obtain enough transmit power [3]. For the purpose of achieving the maximum output power efficiency, the nonlinear characteristic of the HPA is very sensitive to variation in signal amplitudes. But, the variation of OFDM signal amplitudes is very wide with large Peak-to-average power ratio (PAPR). Large PAPR also demands a good quality of equalizers, such a analog-to-digital converters (ADC's) with large dynamic range. It is important to reduce the PAPR in OFDM system. In order to obtain effective and distortion free amplification, variations of signal envelope may be reduced before amplification by application of a PAPR reduction technique. Many methods proposed in literature to reduce the PAPR of OFDM signals include several techniques, such as clipping and filtering [4], block coding [5], selective mapping (SLM) technique [6], window shaping [7], partial transmit sequence (PTS) technique [8], phase optimization [9], tone reservation and injection [10],[11] in exponential companding OFDM signal are transformed into uniformly distributed signals (with a specific degree) which are explained in [12].

Out of these PAPR reducing technique clipping the amplifying peak is one of the simplest technique but it causes additional clipping noise and out-of-band interference (OBI) which degrades the system performance [13]. After that, Wang proposed the well-known scheme named Mu-law companding technique (or named conventional companding, Wang scheme) based on speech processing, and it shows better performance than that of clipping method. However, its average signal power increases after the compression, and the compressed signals still exhibit nonuniform distributions. In order to overcome the problem of increases of average power and to have efficient PAPR reduction, Exponential companding technique namely non-linear companding technique has been developed. The proposed Exponential companding technique, which unlike the Mu-law companding scheme, which enlarges only small signals so that it increases the average power level, but the scheme based on exponential companding technique adjust both large and small signals and can keep the average power at the same level. Our Exponential companding technique adjust both small and large signal without bias so that it is able to offer better performance in terms of PAPR reduction. Furthermore, we extend the work to improve the performance of OFDM system in case of Bit-error-rate by using some Network coding technique. In this respect I present a design of Network coding to work in conjunction with new Exponential companding technique.

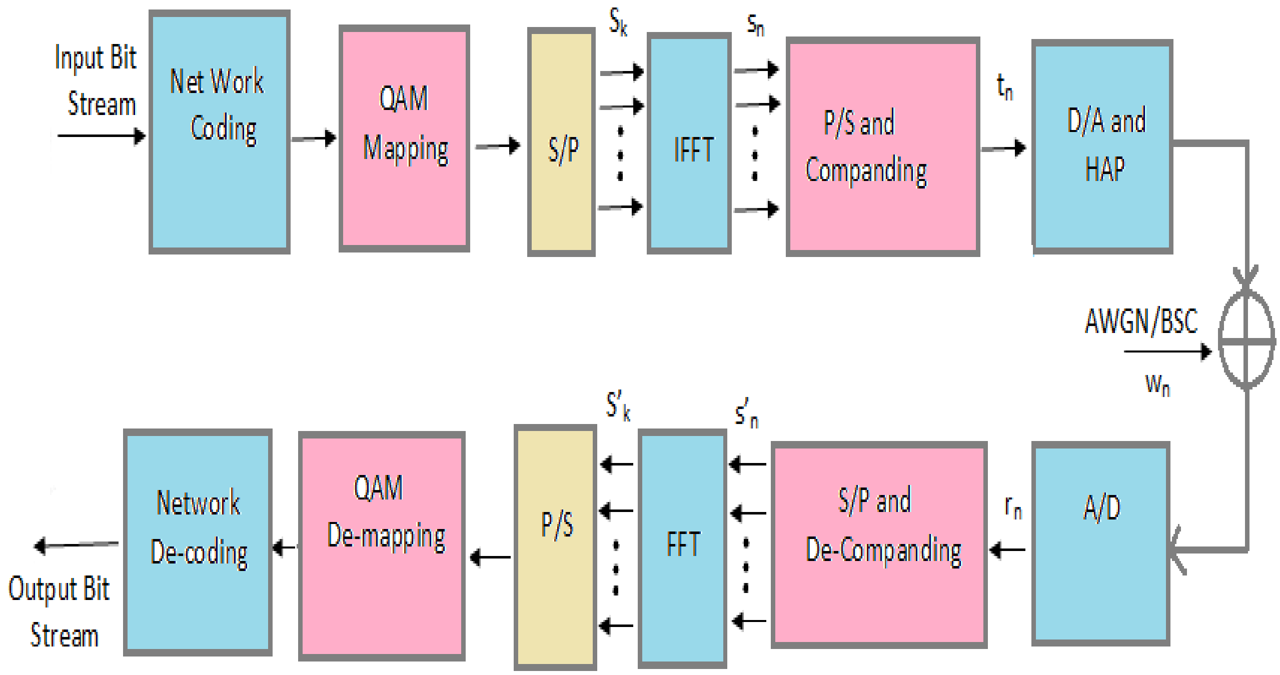

Fig. 1. Block diagram of OFDM system using Exponential companding Technique.

2. PAPR PROBLEMS FORMULATION IN OFDM SYSTEMS

Fig. 1 shows the block diagram of an OFDM system with Exponential companding technique under the Additive White Gaussian Noise (AWGN) channel and Binary Symmetric Channel, where a SSPA is incorporated in the transmitter. Let N denotes the number of sub-carriers used for parallel information transmission and let S_k $(0\leq k \leq N-1)$ denotes the k^{th} complex modulated symbol in a block of N information symbols. Then each group of N symbols are made parallel and the OFDM symbols in the time domain over interval t ∈ [0, Ts] are generated by IFFT operation as:

$$s_n = \frac{1}{\sqrt{N}} \sum_{K=0}^{N-1} Sk \exp\left(\frac{j\,.2\pi kn}{N}\right) \quad (1)$$

The input information symbols are assumed to be statistically independent and identically distributed. So when N is large, the real and imaginary parts of s_n, denoted by Re{ s_n } and Im{s_n}, Gaussian random variables are independent and identically distributed with zero mean and a common variance $\sigma^2 = E[|s_n|^2]/2$. The amplitude of OFDM signal s_n is given by,

$$|\,s_n\,| = \sqrt{Re^2\{sn\} + Im^2\{sn\}} \quad (2)$$

The amplitude has a Rayleigh distribution with the Cumulative Distribution Function (CDF) as follow,

$$F\,|\,s_n|\,(x) = 1 - \exp\left(-\frac{x^2}{\sigma 2}\right),\ x \geq 0. \quad (3)$$

The power of OFDM signal can be calculated as

$$|s_n|^2 = \frac{1}{\sqrt{N}} \sum_{m=0}^{N-1} \sum_{k=0}^{N-1} Xm\, Xk \frac{\exp(j2\pi(m-k)n)}{N} \quad (4)$$

Where m=0,1,…N-1, k=0,1…N-1. Consequently it is possible that the maximum amplitude of OFDM signal may well exceed its average amplitude.

By using the nonlinear companding technique, the OFDM s_n are companded before they are converted into analog waveforms and amplified by the High Power Amplifiers (HPAs). The companded signal t_n ($0 \leq n \leq N-1$) is given by

$$t_n = h(s_n) \quad (5)$$

where h(·) is the companding function that changes only the amplitude of input signals.

The PAPR of OFDM signals in one symbol period is then defined as

$$PAPR = 10\log_{10} \frac{\max[\,|sn|2]}{E[|sn|2]} \text{ (dB)} \quad (6)$$

When N modulated symbols are added with the same phase the peak power occurs. The effectiveness of a PAPR reduction technique is measured by the complementary cumulative distribution function (CCDF), which is the probability that PAPR exceeds some threshold [14, 15], i.e.

$$\text{CCDF} = \text{Probability}(\text{PAPR} > \text{PAPR}_0) \quad (7)$$

Where $PAPR_0$ is the threshold level.

The next section describes Network coding and new exponential companding techniques to reduce the effect of PAPR in independent multicarrier OFDM systems.

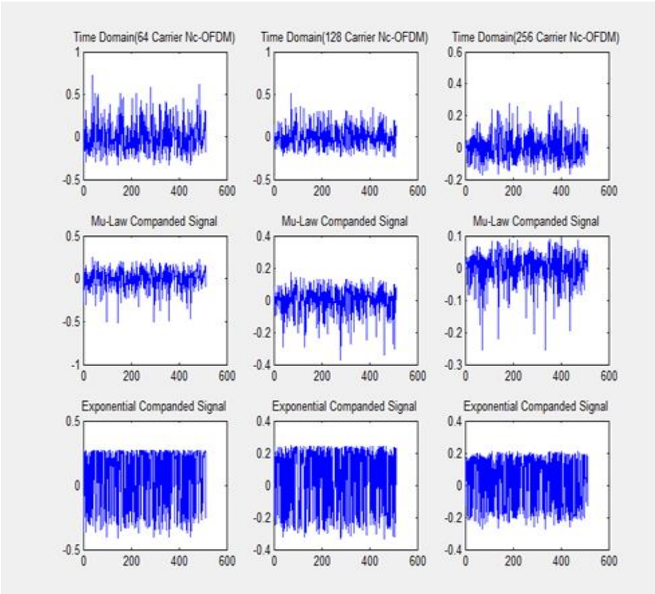

Fig. 2 waveform of original OFDM signal, Mu-law and companded signals having 64,128 and 256 subcarrier.

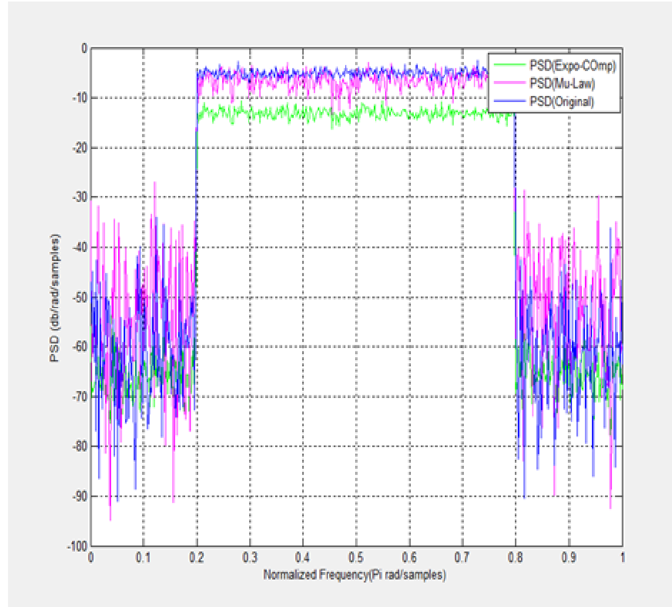

Fig. 3 The spectrums of original OFDM signals and companded signals.

3. DESCRIPTION OF THE PROPOSED SCHEME

We propose in this section a new Exponential companding technique with network coding, that can effectively reduce the PAPR of transmitted it means companded OFDM signals transforming the statistics of the amplitudes of these signals into uniform distribution. The new technique also has the advantages of maintaining a constant average power level in exponential companding operation. The strict linearity requirements on HPA can then be partially relieved. 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.

The original OFDM signal is converted into the companded signal by using the proposed exponential companding scheme is given by

$$h(x) = \mathrm{sgn}\,(x)\ \sqrt[d]{\alpha\,[\,1-\exp(-\frac{x^2}{\sigma 2})} \tag{8}$$

Where, h(x) is companded signal obtained by exponential companding technique, sgn(x) is sign function. The average power of the output signals, denoted by α, is required in order to maintain the average amplitude of both the input and output signals at the same level. The average power of the output signals is given by,

$$\alpha = \left(\frac{E\,[|sn|2]}{E\,[\sqrt[d]{[1-\exp(-\frac{|sn|2}{\sigma 2})]2}}\right)^{\frac{d}{2}} \tag{9}$$

The original OFDM signal is companded i.e., the peak signals of the OFDM signal are compressed and the small signals of the OFDM signal are expanded by using the exponential companding technique for different powers of the amplitude of the companded signals. The linear network coding has recently received much attention the communication industry because of their excellent error-correcting performance. It is a technique which can be used to improve a network's throughput, efficiency and scalability, as well as resilience to attacks and eavesdropping. Instead of simply relaying the packets of information they receive, the nodes of a network take several packets and combine them together for transmission. This can be used to attain the maximum possible information flow in a network.

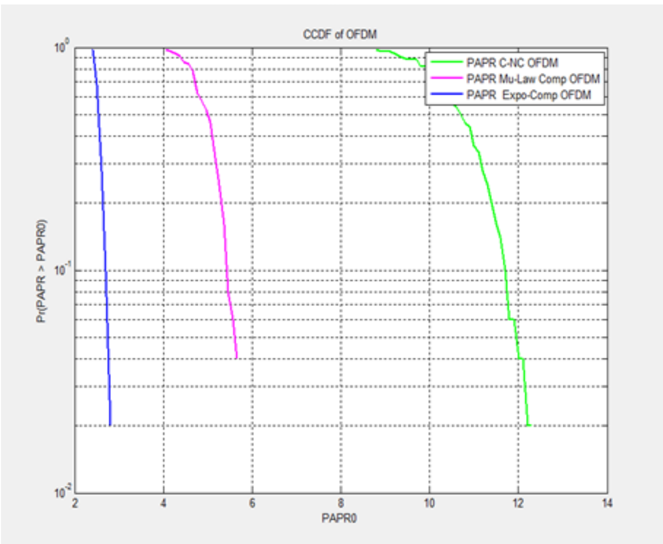

Fig. 4 The complementary cumulative distribution function of original OFDM signals, Mu-law and companed signals.

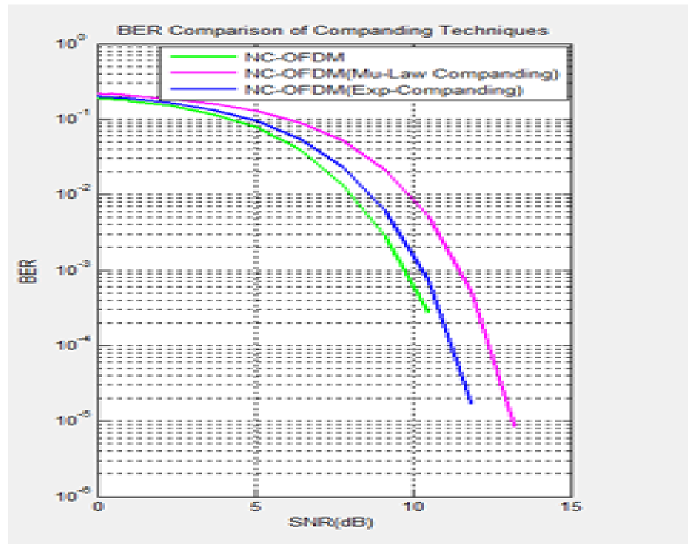

Fig. 5 Bit Error Rate with Network Coding and different Companding technique.

Table 1 Improvement in SNR and BER for PAPR of 10^{-4}

Different Techniques	Number of sub-carriers	BER	SNR (dB)
Mu-Law companding	128	10^{-4}	13
Exponential companding	128	10^{-4}	11.8
Network coding	128	10^{-4}	11.0

4. SIMULATIONS AND RESULTS

Small signals are enlarged which can improve the small signals to robustness to the noise. In order to verify the performance of the proposed new exponential companding technique in the reduction of PAPR and BER, we consider a base-band OFDM system with the number of subcarrier N = 64, 128 and 256 throughout computer simulation, which sub-carrier modulator and demodulator were implemented by using 256 point IFFT and FFT respectively and the oversampling factor is set to be 4 and assume that randomly generated data are modulated by means of Quadrature Phase Keying (QPSK) and 16QAM. Moreover, we assume AWGN BSC channel with a HPA of SSPA.

Table 1 summarizes the performance of different peak reduction technique for BER and SNR of 10^{-4}. It shows that the simulation results, the Signal-to-Noise Ratio (SNR) of the original OFDM signal is equal to 12 dB at a BER of 10^{-4} but for improvement of Bit Error Rate verses Signal-to-Noise Ratio for proposed scheme the Network coding gives better Signal-to-Noise Ratio as compared with Mu-law Companding and Exponential Companding.

Fig.2 compares the temporal waveforms of original OFDM signals, Mu-Law companding signals, and new exponential companded signals. The spectrums of the uncompressed and compressed OFDM signals by the proposed scheme are illustrated in fig 3. From the simulation results, it is observed that the proposed technique gives much less impact on the original power spectrum comparing to the Mu-law companding technique.

Fig. 4 shows respectively the Complementary Cumulative Distribution Function (CCDF) of PAPR for original OFDM signal. The Mu-law companding signals still exhibit some quasi-Gaussian nature. While the exponential companding signals have more uniform –alike distributions, and therefore can offer much smaller PAPR.

The BER vs. SNR is plotted in fig. 5 proposed scheme has improved bit error rate compared with original and Mu-law companding schemes. The amount of improvement increases as SNR becomes more. The performance bounds are obtained by ignoring the effect of SSPA and directly transmitting the original OFDM signals directly through the AWGN channels. Comparing to the Mu-law companding and conventional coding, our exponential companding technique can offer much smaller BER.

5. CONCLUSION

Peak to Average Power Ratio Reduction in OFDM by Exponential Companding Technique improves the PAPR as well as Bit Error Rate (BER) and minimize the Out-of-Band Interference (OBI) in the process of reducing the Peak-to-Average power Ratio (PAPR) effectively by compressing the peak signals and expanding the small signals. For reduction of BER we use the network coding it gives better performance than the conventional coding and Mu-law companding. Simulation results have shown that our exponential companding schemes could offer better system performance in terms of PAPR reduction, power spectrum and BER than the Mu-law companding scheme. Specifically, to achieve a BER of 10^{-4}, the minimum required SNR is 11.06 dB. The required SNRs under the proposed scheme Network coding, exponential companding and the Mu-law companding schemes are 11.00 dB, 11.08 dB and 13.00 dB respectively.

REFERENCES

[1] S. Hikmet, K. Georges, and J. Jsabelle, "Transmission techniques for digital terrestrial TV broadcasting," IEEE Comm. Magazine, pp. 100-109, Feb. 1995.

[2] S.H.Han and J. H. Lee, "An Overview of peak-to-average power ratio reduction techniques for multicarrier transmission," IEEE Wireless Commun. , vol. 12,pp.56-65, Apr. 2005.

[3] M. G. Di Benedetto and P. Mandarini, "An application of MMSE predistortion to OFDM systems," IEEE Trans. Commun., vol. 44, pp.1417-1420, N0v. 1996.

[4] J. Akhtman, B.Z.Bobrovsky, and L. Hanzo, "Peak-to-average power ratio reduction for OFDM modems," in proc. 57th IEEE Semi- Annual Vehicular Technology Conf. (VTC'03), vol.2, Apr. 2003, pp. 1188-1192.

[5] A.E. Jones, T.A.Wilkinson, and S.Barton, "Block Coding Scheme for reduction of peak to mean envelope power ratio of multicarrier transmission schemes," IEE Electron. Lett. , vol. 30,pp. 2098-2099, Dec. 1994.

[6] R.W.Bauml, R.F.H.Fischer, and J.B. Huber, "Reducing the peak-to-average power ratio of multi carrier modulation by selective mapping," IEE Electron. Lett.,vol.32, pp. 2056-2057, Oct.1996.

[7] S.H.M.Weinfurtner, "Optimum nyquist windowing in ofdm receivers," IEEE Trans. Commun. , vol.49, PP. 417-420, Mar.2001.

[8] S.H.Muller and J.B.Huber, "OFDM with reduced peak-to average power ratio by optimum combination of partial transmit sequences," IEE Electron. Lett., vol.33,pp.368-369, Feb.1997.

[9] H.Nikookar and K.S.Lidsheim, "Random phase updating algorithm for ofdm transmission with low papr," IEEE Trans.Broadcast., vol. 48,pp.123-128,Jun.2002.

[10] O.J.Kwon and Y.H. Ha, "Multi-carrier pap reduction method using sub-optimal pts with threshold," IEEE Trans. Broadcast. , vol. 49, pp. 232-236, Jun. 2003.

[11] R.W.Bami, R.F.H.Fischer, and J.B. Hber, "Reducing the peak-to average power ratio of multicarrier modulation by selective mapping," IEE Electron. Lett., vol.32,pp.2056-2057, Oct.1996.

[12] T.Jiang, Y.Yang, and Y.Song, "Exponential companding technique for PAPR reduction in OFDM systems," IEEE Trans. Broadcast., vol. 51,no.2,pp.244-248,June 2005.

[13] J.armstrong, "Peak-to-average reduction for OFDM by repeated clipping and frequency domain filtering," IEE Electron.lett.,vol.38,pp.246-247, May 2002.

[14] R. Van Nee and A. de Wild, "Reducing the peak- to-average power ratio of OFDM," Proc. IEEE vehicular technology Conf.(VTC'98), pp. 2072-2076, May 1998.

[15] H. Ochiai and H. Imai, "On the distribution of the peak-to-average power in OFDM signals," IEEE transaction on Communications, vol.49, pp.282-289, Feb.2001.