

# PAPR Reduction in OFDM System by using Nonlinear Companding Technique

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**Abstract**— A non linear companding technique is proposed to reduce the high peak to average power ratio (PAPR) of orthogonal frequency division multiplexing system. Use of companding for peak-to-average-power ratio (PAPR) control is explored for a link involving a non-linear transmit power amplifier with orthogonal frequency division multiplexing (OFDM). This paper analyses the improvement in bit error rate (BER) and overall system performance by employing non linear companding technique for PAPR reduction in digital video broadcasting (DVB-T) system.

**Index Terms**—*Bit error rate (BER), Digital video broadcasting (DVB-T), Non linear companding, orthogonal frequency division multiplexing (OFDM), Peak to average power ratio (PAPR).*

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## I INTRODUCTION

Orthogonal frequency-division multiplexing (OFDM) is a multicarrier modulation scheme that divides the incoming bit stream into parallel, lower rate sub streams and transmits them over orthogonal subcarriers, so that the bandwidth of each subcarrier is much smaller than channel's coherence bandwidth and hence, each subcarrier will experience relatively flat fade [1]. It is a bandwidth efficient modulation scheme and has the advantage of mitigating inter-symbol interference (ISI) in frequency selective fading channels. OFDM today used in many wireless standards such as terrestrial digital video broadcasting (DVB-T), digital audio broadcasting (DAB-T), and adopted in wireless local area networks (WLANs) (IEEE 802.11a, ETSI Hiperlan2) and wireless metropolitan area networks (IEEE 802.16d). The main drawback of OFDM is its high peak-to-average power ratio (PAPR) which causes serious degradation in performance when nonlinear power amplifier (PA) is used. This high PAPR forces the transmit PA to have a large input back off (IBO) in order to ensure linear amplification of the signal, which significantly reduces the efficiency of the amplifier, Furthermore, high PAPR requires high resolution for the receiver analog-to-digital converter (A/D). Since the

dynamic range of the signal is much larger for high PAPR, a high-resolution quantizer is required to reduce quantization error, which requires more bits and places a complexity and

power burden on the receiver front end Many PAPR reduction schemes based on different techniques , such shaping , block coding , partial transmit sequence (PTS) technique and selective mapping (SLM) technique, phase optimization , tone reservation and injection and non linear companding transform schemes have been proposed in literature [4]. In this paper , we proposed and analyse non linear companding technique to reduce the PAPR of OFDM signal . Non linear companding has good system performance including PAPR reduction and bit error rate , low implementation complexity and no bandwidth expansion

## II PROPOSED METHOD NON LINEAR COMPANDING

One of the most attractive schemes is nonlinear companding transform due to its good system performance including PAPR reduction and BER, low implementation complexity and no bandwidth expansion. The first nonlinear companding transform is the mu-law companding, which is based on the speech processing algorithm -law, and it has shown better performance than that of clipping method [5] .mu-law mainly focuses on enlarging signals with small amplitude and keeping peak signals unchanged, and thus it increase the average power of the transmitted signals and possibly results in exceeding the saturation region of HPA to make the system performance worse. In fact, the nonlinear companding transform is also an especial clipping scheme. The differences

between the clipping and nonlinear companding transform can be summarized as: 1) Clipping method deliberately clips large signals when the amplitude of the original OFDM signals is larger than the given threshold, and thus the clipped signals cannot be recovered at the receiver. However, nonlinear companding transforms compand original OFDM signals using the strict monotone increasing function. Therefore, the companded signals at the transmitter can be recovered correctly through the corresponding inversion of the nonlinear transform function at the receiver; 2) Nonlinear companding transforms enlarge the small signals while compressing the large signals to increase the immunity of small signals from noise, whereas clipping method does not change the small signals. Therefore, clipping method suffers from three major problems: in-band distortion, out-of-band radiation and peak re-growth after digital analog conversion. As a result, the system performance degradation due to the clipping may not be optimistic. However, nonlinear companding transforms can operate well with good BER performance while keeping good PAPR reduction [6]. The design criteria of nonlinear companding transform has also been given in [6]. Since the distribution of the original OFDM signals has been known, such as Rayleigh distribution of the OFDM amplitudes written in (3), we can obtain the nonlinear companding transform function through theoretical analysis and derivation according to the desirable distribution of the companded OFDM signals. For example, we transform the amplitude of the original OFDM signals into the desirable distribution with its PDF  $f_{sc}(s) = ks+b, (k < 0, b > 0)$ . Therefore, the nonlinear transform function can be derived as [7]

$$C(x) = \sqrt{6\sigma} \left[ 1 - \exp\left(-\frac{x^2}{2\sigma^2}\right) \right]$$

Obviously, this nonlinear companding transform of (23) belongs to the exponential companding scheme. Based on this design criteria, two types of nonlinear companding transform, which are based on error function and exponential function, respectively, have been proposed in [8], [9]. It is well-known that original OFDM signals have a very sharp, rectangular-like power spectrum as shown in Fig. 4. This good property will be affected by the PAPR reduction schemes, e.g. slower spectrum roll-off, more spectrum side-lobes, and higher adjacent channel interference. Many PAPR reduction schemes cause spectrum side-lobes generation, but the nonlinear companding transforms cause less spectrum side-lobes. The error and exponential companding transforms have much less impact on the original power spectrum comparing to the mu-law companding scheme. It is the major reason that the error and exponential companding schemes not only enlarge the small amplitude signals but also compress the large amplitude signals, while maintain the average power unchanged by properly choosing parameters, which can increase the immunity of small amplitude signals from noise. However, the -law companding transform increases the average power level

and therefore requires a larger linear operation region in HPA. Nonlinear companding transform is a type of nonlinear process that may lead to significant distortion and performance loss by companding noise. Companding noise can be defined that the noises are caused by the peak re-growth after DAC to generate in-band distortion and out-band noise, by the excessive channel noises magnified after inverse nonlinear companding transform etc. For out-of-band noise, it needs to be filtered and oversampled. For in-band distortion and channel noises magnified, they need to iterative estimation. Unlike Additive White Gaussian Noise (AWGN), companding noise is generated by a process known and that can be recreated at the receiver, and subsequently be removed. In [10], the framework of an iterative receiver has been proposed to eliminate commanding noise for companded and filtered OFDM system.

### III PROPOSED MODEL DVB-T SYSTEM

Digital video broadcasting (DVB-T) is the name of the terrestrial transmission system which was developed by DVB project that was first broadcast in the UK in 1997. DVB-T is in operation in many countries around the world. DVB-t can be used for stationary, portable and mobile reception. This system transmit compressed digital audio, video and other data in moving picture expert group (MPEG) transport stream, using orthogonal frequency division multiplexing (OFDM) modulation. In order to analyse how an MPEG transport stream at the input of a DVB-T modulator is turned into a DVB-T signal, the channel coding and modulation used must be considered. DVB-T offers three different modulation schemes (QPSK, 16 QAM, 64QAM).

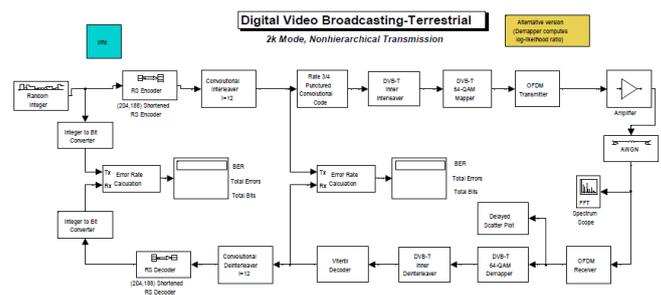


FIG 1 : DVB-T BLOCK DIAGRAM

As shown in the figure random integer generate randomly uniformly distributed integer in the range [0, M-1], where M is the M- array number. RS encoder encodes the message in the input vector using an (N, K) Reed Soloman encoder with narrow sense generator polynomial. The input must be a frame based column vector with an integer multiple of k elements. The high power amplifier is a complex baseband model of amplifier with noise. The amount of noise added to the output

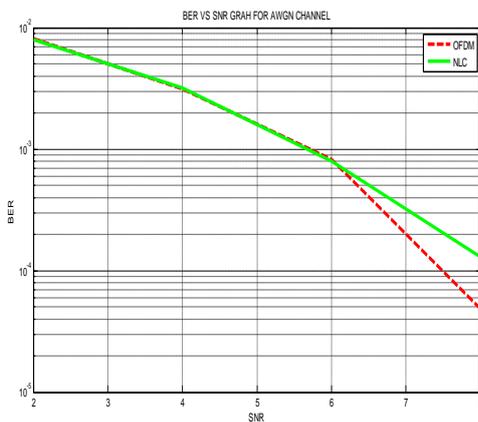
signal may be specified in terms of noise temperature, noise figure or noise factor. The white Gaussian noise is added to the input signal. The received input signal is decoded by Rs decoder. Integer to bit converter map a vector of integer valued.

The outer error protection is implemented with a byte-oriented block code. For each block—i.e., the TS packet—error correcting bits are calculated. The result is a block of correction bytes that is appended to the TS packet. The block code that is used is a Reed–Solomon (255 239) code. That means that 16 correction bytes are appended to the 239 information bytes. Since the TS packet has a length of only 188 B, the first 51 B are set to zero and are not transmitted. In this way a Reed–Solomon (204 188) code has been created.

If the input bit-error rate is less than  $2 \cdot 10^{-2}$ , this code is able to reduce the bit-error rate to about  $10^{-4}$  while in the simplest case correcting up to 8 B per TS packet [11]. The outer interleaver that follows does not provide any additional error correction capability but rearranges bytes in order to facilitate the correction of long burst errors. A block interleaver that reads the bytes into a storage matrix line by line and is read out column by column would be one possible implementation. Such a block interleaver shows disadvantages regarding storage capacity required, synchronization, and sensitivity against periodic disturbances [11].

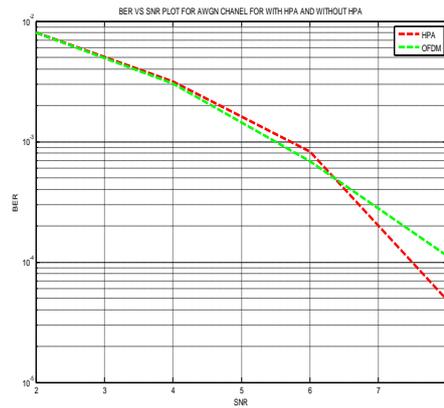
#### IV RESULT

Graph for AWGN Channel



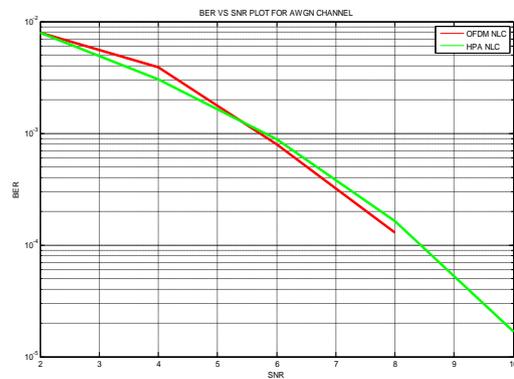
Graph 1: BER vs. SNR value for AWGN channel.

Graph for AWGN channel with HPA



Graph 2 : BER vs. SNR value for AWGN channel for with and without HPA for OFDM system

Graph for AWGN channel for NLC and NLC with HPA



Graph 3 : BER vs. SNR value for AWGN channel with HPA for OFDM with NLC and NLC with HPA system.

#### V CONCLUSION

In this paper we have proposed a PAPR reduction scheme to improve the bit error rate performance of DVB-T system. The PAPR can be reduced by applying non linear companding technique. The 1-1.5db reduction in PAPR with the companding technique is achieved. There is no dominant propagation along a line of sight between transmitter and receiver for Rayleigh channel. But a line of sight signal is much stronger for Rican channel. AWGN is a additive white Gaussian noise, for this channel the noise is already added in the signal.

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