PAPR REDUCTION WITH ERROR CONTROL CODING IN OFDM

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ABSTRACT

In this paper Error control (EC) codes like BCH and Reed Solomon (RS) code with interleaving and μ law Companding is proposed to reduce PAPR in OFDM system. The transmitter is designed to select input block mapped with PSK modulation and encoded with RS or BCH codes, having least PAPR for transmission. Side information is sent to indicate the encoding used at the transmitter, to the receiver for decoding purpose. Simulation results shown with CCDF graph indicates improved performance in PAPR with EC coding and companding rather than without companding. Further the advantage gained using coding technique is to overcome burst errors in multipath wireless environment. RS codes have better BER performance than BCH and selected more number of times for transmission.

KEYWORDS: *OFDM, PAPR, RS codes, BCH codes, SLM.*

I. INTRODUCTION

In present 3G and 4G wireless systems high-bit-rate transmission is required and OFDM has been proved to be an effective multicarrier modulation scheme that improves the bandwidth efficiency. In wireless fading environment, to improve system error performance channel coding has been proved to be an efficient way to achieve the reliability of communication systems. In OFDM, the number of symbols is chosen to ensure that each sub-channel has a bandwidth less than the channel coherence bandwidth. As bandwidth of subcarriers are small , variation of channel frequency response over theses bandwidth becomes significantly less and flat requiring simple equalization [1][2].

However OFDM signal consists of number of independently modulated subcarriers which can give a large peak to average power ratio (PAPR) at times when added coherently [2]. There is possibility of PAPR exceeding certain threshold value leading Power amplifiers to saturate. This causes signal distortion such as in-band distortion and out-of band radiation due to the nonlinearity of the high power amplifier (HPA) and lead to worse bit error rate (BER) performance. PAPR reduction schemes can be categorized as multiplicative and additive schemes with respect to the computational operation in the frequency domain. Selected mapping (SLM) and partial transmit sequences (PTS) are the multiplicative scheme as the phase sequences are multiplied by the input symbol vector in the frequency domain. COFDM system is combination of error control coding and OFDM where the redundancy is added by code bits prior to IFFT. The purpose is to spread source bits which are adjacent across the subcarriers. Even though one of the subcarriers is lost due to burst errors, use of error control code helps to maintain BER performance and to reduce PAPR. [3-7]

$$PAPR = \frac{\max|x(t)|^2}{\frac{1}{Ts}\int_0^{TS}|x(t)|^2\,dt} \quad [1]$$

Complementary cumulative distribution function (CCDF) indicates the probability of given data block that exceeds a given threshold of PAP Ratio.

$$(PAPR \le Z) = F(Z)^N = (1-\exp(-z))^N \quad [2]$$

There are many error-correcting codes applied to OFDM based on Fourier Transform, such as convolutional codes, turbo codes, Low - density parity-check codes. In this paper BCH and RS coded OFDM for PAPR reduction is proposed. The proposed scheme uses PSK modulation in AWGN channel environment. Each input block is encoded with RS and BCH codes and one with least PAPR is transmitted. The coded OFDM frame with least PAPR is selected for transmission. In addition, random interleaving is used to reduce burst errors. As peak power depends on each input frame, selection of either BCH or RS which gives least PAPR depends on each input frame. The paper is organized as follows. RS and BCH codes are discussed in section 2, System model is given in Section 3. Simulation results are presented in Section 4 and the last section summarizes conclusions.

II. BCH AND RS CODES

2.1. BCH codes

BCH (Bose Chaudhuri Hocquenghem) Codes form a large class of multiple random error-correcting codes. This codes is a remarkable generalization of the hamming codes for multiple error Correction. For any positive integer m ($m \geq 3$) and t ($t < 2m-1$), there exists a binary BCH code with the following parameters

Block length = n,

Parity check size = $n-k \leq m$.
Minimum Distance = $d_{min} \geq 2t+1$

This code is capable of correcting any combination of 't' or fewer errors in a block of $n = 2^m - 1$ digits. The generator polynomial of this code is specified in terms of its roots from the Galois field GF (2^m). [8]

2.2 RS Codes

Reed-Solomon codes are non binary cyclic codes with symbols made up of m bit sequences, where m is an any positive integer having a value greater than two. RS (n, k) codes on m bit symbols exist for all n and k for which $0 < k < n < 2^m + 2$ where k is the number of data symbols being encoded, and n is the total number of code symbols in the encoded block. For the most conventional RS (n, k) code,

$$(n, k) = (2^m - 1, 2^m - 1 - 2t)$$

where t is the symbol-error correcting capability of the code, and $n - k = 2t$ is the number of parity symbols. An extended RS code can be made up with $n = 2^m$ or $n = 2^m + 1$. Reed-Solomon codes achieve the largest possible code minimum distance for any linear code with the same encoder input and output block lengths. RS codes are suitable for concatenation of codes. Good burst error correcting capability. It is possible to code and interleave data up to 4 code words. They are used when a code required has length less than the size of the field .The RS code is capable of correcting any combination of t or fewer errors, where t can be expressed as

$$t = (d_{min}-1) / 2 \qquad [3]$$

Where d_{min} is the minimum hamming distance of the code. The value 't' is the error correcting capability of RS code. RS codes are subset of BCH codes and can be designed to have any redundancy. However, the complexity of a high-speed implementation increases with redundancy. Therefore even most attractive RS codes have high code rates and low redundancy [8].

III. PROPOSED METHOD

The simulation model of the proposed system is shown in Fig.1 and Fig.2. At the transmitter random bits are generated and grouped into 45 bits. Each data block is coded through 2 different branches. The first data branch is encoded using BCH code and the second branch is with RS code. The redundant bits are added in order to lower the PAPR Ratio to both the branches and avoid burst errors during transmission. After encoding, each block is modulated using 64 PSK Modulation techniques to produce sequence of symbols $X0, X1, \ldots X_{N-1}$.Where N is the number of subcarriers used. Later to each block side information are suffixed which helps to identify whether the code employed is RS or BCH. After modulation each block is interleaved, using random interleaving technique. This helps in avoiding the burst errors distributed across the length of data. After interleaving each data block is converted in to a time domain signal using IFFT for transmission. In order to combat this large peak of sub carriers in addition to encoding Companding technique is employed. This technique do not impose any restrictions in selecting parameters such as number of sub carriers, frame format and constellation type [3]. In the proposed technique we have used μ law companding after taking the IFFT for each of the data block.

At the receiving end first, μ law expansion of received data is performed followed by N point FFT to get the data back to frequency domain. Based on side information used, receiver will identify the encoding method used at transmitter for each block of data it receives. Then resultant data is deinterleaved and subjected to PSK demodulation. Output from each block is compared with transmitted data and BER is computed. Finally decoding is done by removing the redundant bits to get back estimation of transmitted bits. This procedure is continued till entire data transmitted is decoded successfully. The primary advantage of proposed technique is, no signal distortion is introduced and BER performance is maintained. But the receiver needs to estimate sequences, the one which has been transmitted with least PAPR [1], which required additional side info to identify encoding used. Use of RS and BCH codes with good error correcting capability, along with interleaving reduces PAPR, overcome burst errors in multipath wireless applications. Entire algorithm is shown in flowcharts in Figure 3.

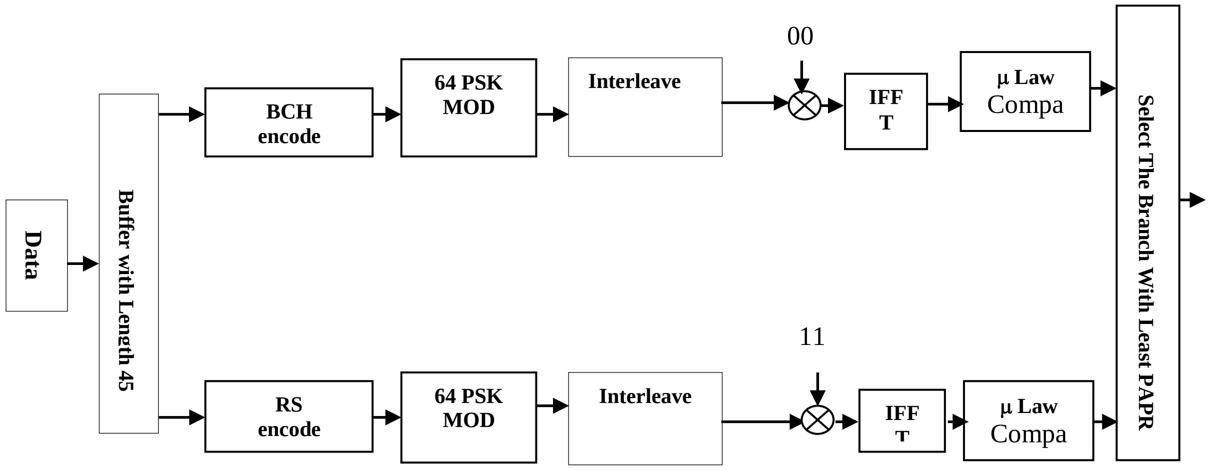

Fig.1 Block diagram of Transmitter for proposed scheme

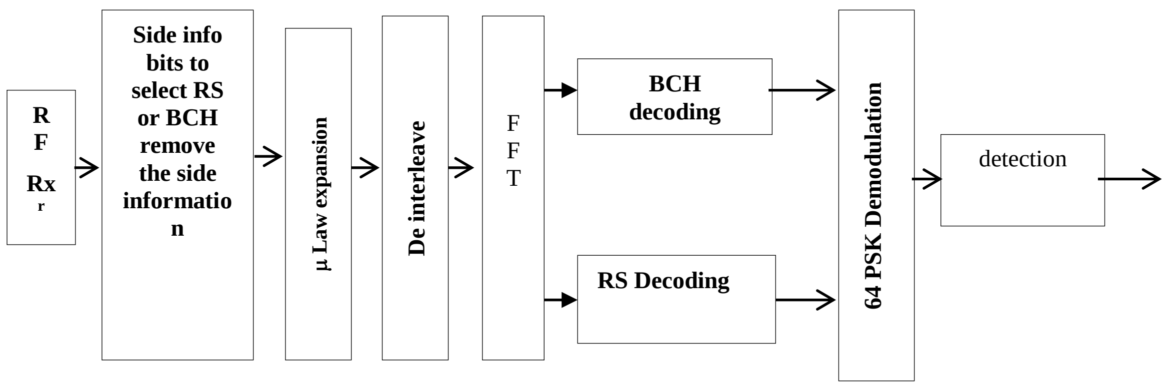

Fig.2 Block diagram of receiver for proposed scheme

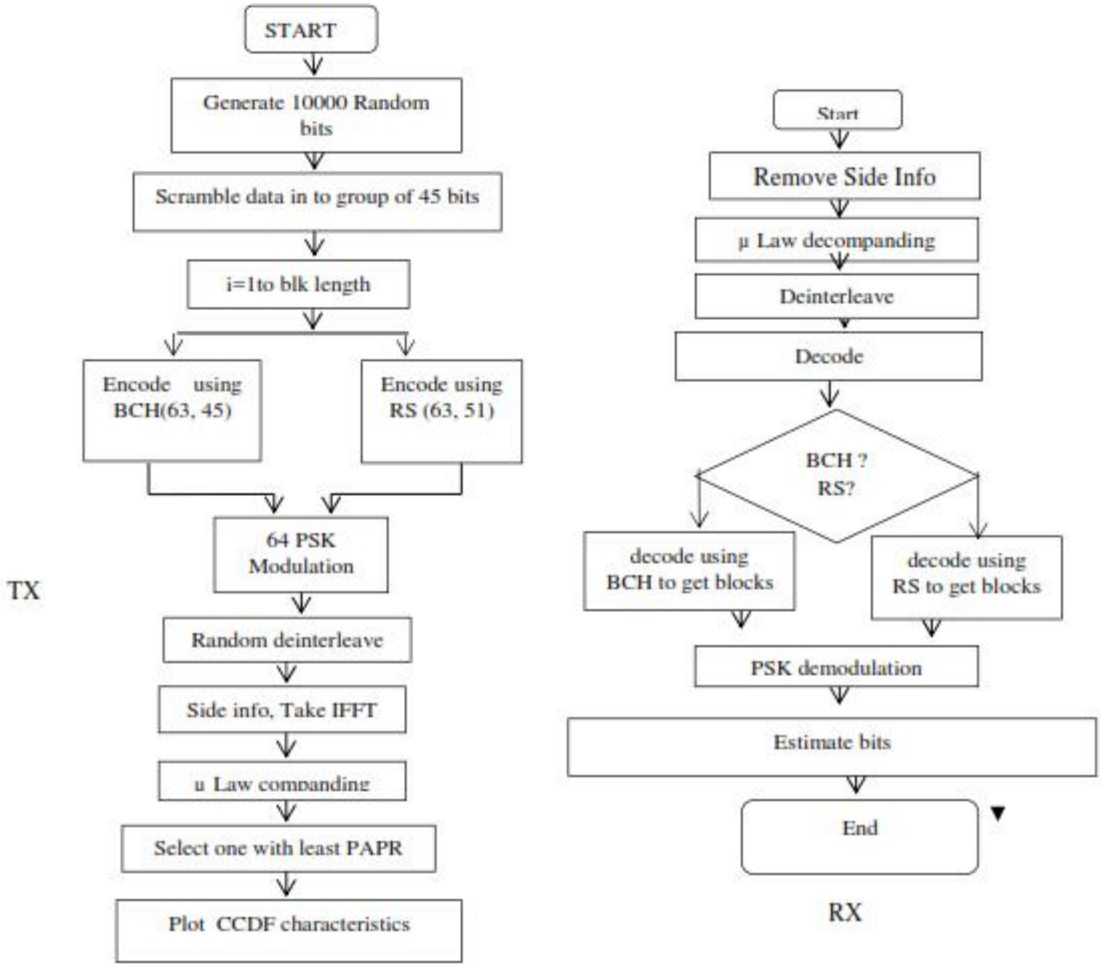

Fig.3 Flow chart for TX and RX operations

IV. SIMULATION AND RESULTS

In simulation channel is modelled as AWGN channel with 10000 bits and send as blocks on 64 subcarriers, 128 subcarriers. Each block encoded with BCH and RS is added with side information bits, n which help to identify encoding used. Simulation results have shown RS encoded block is selected more number of times than BCH code. PAPR for BCH and RS coded OFDM is shown in Table1 and CCDF plots as shown in Fig 4 and Fig 5.

V. CONCLUSION

In this paper PAPR Reduction based on coding, interleaving and companding technique is discussed. The advantage of this method is either BCH and RS codes will be selected depending on different input iteration for PAPR reduction. The simulated results showed that encoding provides PAPR Reduction and comparatively RS codes perform better with companding compared to BCH codes. In continuation of this work, further for frequency selective fading channel the method has to be tested.

TABLE I. Simulation results

ENCODING	Subcarriers	PAPR in dB
BCH	64	3.8
BCH	128	4.7
RS	64	3.2
RS	128	4.2

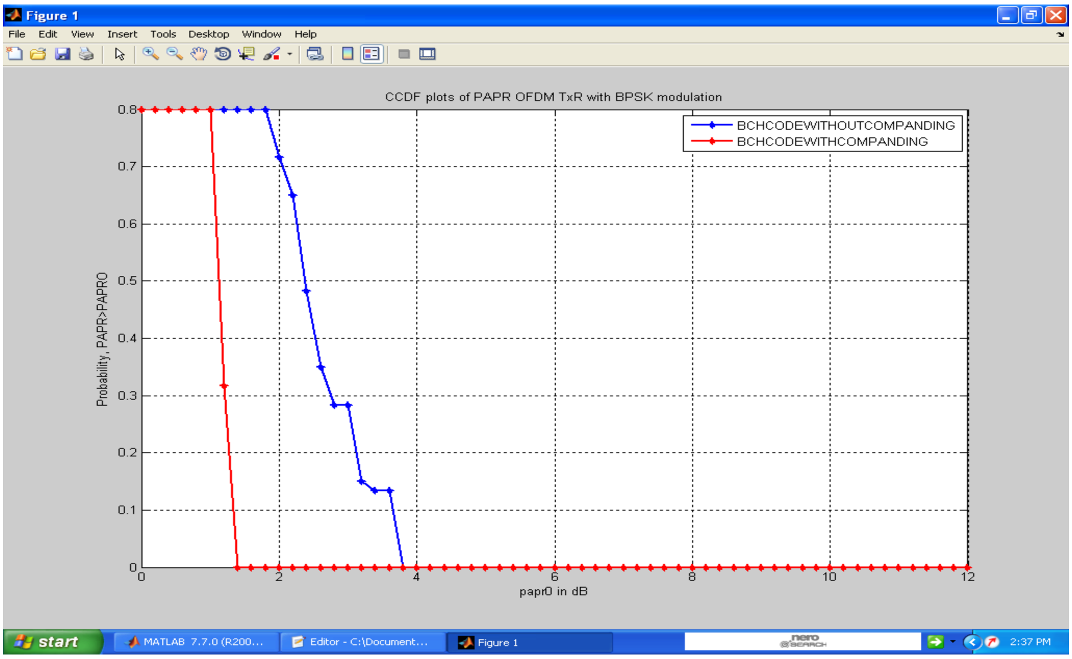

Fig. 4 CCDF plots for BCH codes with and without companding.

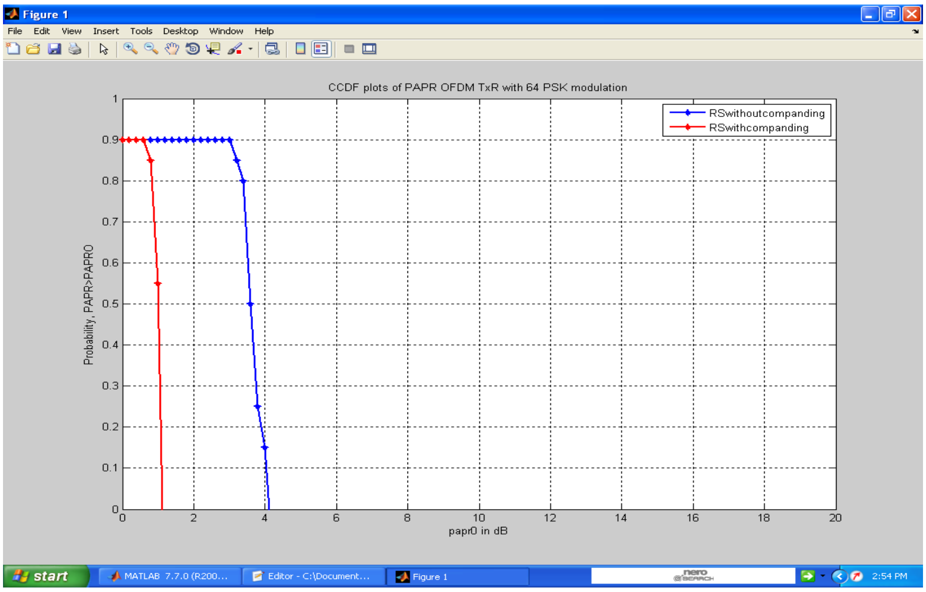

Fig. 5 CCDF plots for RS codes with and without companding.

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