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PAPR Reduction Using Extended BCH Code with Biasing Vector Technique in OFDM System

Shaik Riyaz[1], MVS Sairam[2]
[1]*System Engineer, TCS, Hyderabad, Telangana, India.*
[2]*Professor & HoD, Department of ECE, GVP College of Engineering (Autonomous), Visakhapatnam, AP, India.*
Corresponding Author: Shaik Riyaz

ABSTRACT:- Orthogonal Frequency Division Multiplexing (OFDM) is a distinct form of multicarrier modulation which is well suitable for high data-rate wireless and wired applications. Nevertheless, the foremost drawback of OFDM is that the time domain signal which is a sum of multiple sinusoids leads to high Peak to Average Power Ratio (PAPR). This paper aims to condense the PAPR using (8, 4) Extended BCH (E-BCH) code with biasing vector technique. (7, 4) BCH code is transformed in to (8, 4) E-BCH code by appending Redundant Bit (RB) intended for effective execution of Inverse Fast Fourier Transform (IFFT)/Fast Fourier Transform (FFT) in OFDM system. Then using biasing vector technique, favourable bias vector which contributes minimum PAPR is recognized. The codeword can be acquired at the receiver by XOR-ed with bias vector and removing RB. Results confirm that significant amount of PAPR is condensed in the proposed scheme.

Keywords:-OFDM, PAPR, BCH, E-BCH, RB, BV.

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I. INTRODUCTION

OFDM functions over large bandwidth and therefore naturally the data-rate is higher. Hence OFDM has become a significant Physical layer (PHY) transmission technique, which is employed in 4G wireless standards such as IEEE 802.11a/g [1], HIPERLAN2 [2], digital audio and video broadcast (DAB/DVB) [3, 4]. In OFDM, when all sub-carriers are added coherently, the peak power surges that origins the high PAPR. Therefore, the challenging issue in OFDM system is the high PAPR of the transmitted signal, which sources in-band distortion and out-of-band radiation when the signals are passed through a nonlinear power amplifier. Until now, various schemes for PAPR reduction have been suggested [7-9]. The techniques are classified as signal distortion and distortion less. In signal distortion techniques the original OFDM signal is distorted and hence error rate is increased. However distortion less techniques such as channel coding are most favoured since they can be used for both error controlling and PAPR reduction simultaneously. In this paper we proposed E-BCH code as channel coding and biasing technique is used to control the PAPR further.

The remainder of this paper is organized as follows. In section II, introduction to PAPR is discussed. E-BCH code is presented in section III. Section IV introduces proposed scheme. The results are discussed in section V. In section VI, conclusions are presented.

II. PEAK TO AVERAGE POWER RATIO

In OFDM system, N-point IFFT is employed for the data sequence, $X(k), 0 \leq k \leq N-1$, so as to produce $x(n), 0 \leq n \leq N-1$, the samples for the sum of N orthogonal sub-carrier signals. Therefore the discrete-time OFDM signal is expressed as [5]

$$x(n) = \frac{1}{N}\sum_{k=0}^{N-1} X(k)e^{j2\pi n\frac{k}{N}} \tag{1}$$

The PAPR of the discrete-time OFDM signal x(n) is defined as [6]

$$PAPR[x(n)] = \frac{\underset{0 \leq n \leq N-1}{\max}|x(n)|^2}{E\,|x(n)|^2} \tag{2}$$

where E [·] denotes the expectation operator.If the average power of the OFDM signal is supposed to be 1, the PAPR of the signal is become N^2 and the PAPR in dB = 20 log N.

PAPR Calculation
Let us consider codeword be 0 0 0 0 0 0 0 0 and employ phase shift keying (PSK) modulation.
Then OFDM signal can be stated as

$$x(t) = -e^{j\omega t} - e^{j2\omega t} - e^{j3\omega t} - e^{j4\omega t} - e^{j5\omega t} - e^{j6\omega t} - e^{j7\omega t} - e^{j8\omega t}$$

Therefore, $|x(t)|^2 = x(t).x^*(t)$

$$= (-e^{j\omega t} - e^{j2\omega t} - e^{j3\omega t} - e^{j4\omega t} - e^{j5\omega t} - e^{j6\omega t} - e^{j7\omega t} - e^{j8\omega t})(-e^{-j\omega t} - e^{-j2\omega t} - e^{-j3\omega t} - e^{-j4\omega t} - e^{-j5\omega t} - e^{-j6\omega t} - e^{-j7\omega t} - e^{-j8\omega t})$$

$\max|x(t)|^2$occurs at $\frac{d}{d\omega t}|x(t)|^2 = 0$
or$\omega t = 0$
Substitute for ωt in equation (1), we obtain
$\max|x(t)|^2 = 64$ (assume the average signal power = 1)
Form equation (2) PAPR = 64 and PAPR in dB = 18.0 dB.

III. (8, 4) EXTENDED BCH CODE

Bose, Chaudhuri, and Hocquenghem (BCH) code is remarkable error correcting code [10]. For a BCH code (n, k), n = number of code words, k = number of message bits, any integer $m\geq3$ and for t error correction($t < 2^{m-1}$), there exists a primitive BCH code with the following factors:

Block length : $n= 2^m -1$
Parity check bits : $n- k\leq mt$
Minimum distance : $d\geq 2t+1$

Generator polynomial of BCH code can be expressed as

$g(x) = LCM[m_{t0}(x), m_{t0+1}(x),\ldots.., m_{t0+2t-1}(x)]$

where$m_{t0}(x)$ is the minimal polynomial of $\alpha^{t0}\epsilon$ GF(q^m).g(x) of BCH code is the lowest-degree polynomial over GF(2) which has $\alpha, \alpha^2, \ldots \alpha^{2t}$ among its roots. If α is a primitive element of GF(2^m), g(x) is the polynomial of lowest degree over GF(2) with $\alpha, \alpha^2, \alpha^3,\ldots,\alpha^{2t}$ as roots.

In our paper, we employed (7, 4) BCH code, which is single error correcting code. For single error correcting code, generator polynomial is only the primitive polynomial $m_1(x)$, therefore $g(x) = x^3+x+1$.

Algorithm for (7, 4) BCH codeword generation
Step-1: Select 4 bit length message
Step-2: Fix $g(x) =x^3+x+1$
Step-3: Pad the zero bits to message bits equal to the highest degree of g(x)\
Step-4: Obtain the parity bits by dividing the modified message polynomial by g(x)
Step-5: Append the remainder to the message bits for codeword generation
Step-6: Repeat the above steps for all combination of message bits.

Example:
Let message be 0001
Pad 3 zeroes (highest degree of g(x)) to the message, which makes 0001000
Convert the g(x) into binary form, i.e. g(x) = 1011
Divide the modified message bit by g(x) as given below:

1011)**0001**000
1011

1010
1011
1000
1011
011

Here the remainder is 011. Hence, the code word becomes 1001110.

Algorithm for Error Correction
Step-1: Received codeword is divided by $g(x) = x^3+x+1$, to get remainder polynomial, $r(\alpha)$
Step-2: Error correction can be done using the lookup table as shown below:

Table I Lookup table for (7, 4) BCH

Remainder polynomial $r(\alpha)$	Error Position
α^0	1
α^1	2
α^2	3
$\alpha+1$	4
$\alpha^2+\alpha$	5
$\alpha^2+ \alpha+1$	6
α^2+1	7

Where α is the primitive root of unity and $\alpha^3= \alpha+1$, $\alpha^4=\alpha^2+\alpha$, $\alpha^5=\alpha^2+ \alpha+1$, $\alpha^6=\alpha^2+1$.

Example:
Let the transmitted codeword be 0001011 corresponding to message 0001.

Csase-1: Let the error be 1st position. Then the received codeword is 0001010.
Perform the division operation to get remainder

1011)0001010
1011
0001

$r(\alpha)$for 0001 is α^0, hence from lookup table error position is 1st position.

Case-2: Let the error be 2nd position. Then the received code word is 0001001.

1011)0001001
1011
0010

$r(\alpha)$is α^1 , hence from lookup table, error position is 2nd position.

Case-3: Let the error be 3rd position. Then the received code word is "0001111".

1011)0001111
1011
0100

$r(\alpha)$is α^2, hence from lookup table, error position is 3rd position.

IV. PROPOSED SYSTEM FOR PAPR REDUCTION

The proposed encoder and decoder are depicted in Fig. 1 and 2, respectively. As illustrated in Fig. 1, a (7, 4) BCH encoder is used as channel encoder to convert a message of length 4 in to a code word of length 7.

For efficient IFFT/FFT implementation it is essential that the number of carriers to be in power of two. For this purpose, RB (bit 0 or 1) is appended as LSB.

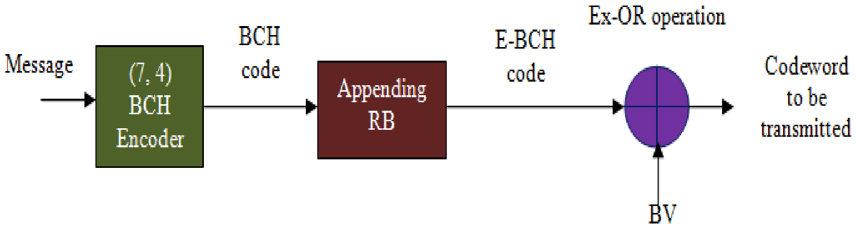


Fig. 1 Proposed Encoder

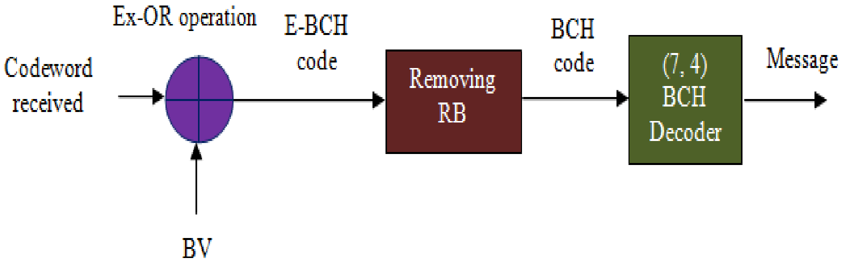


Fig. 2 Proposed Decoder

In our work, we consider 0 as RB. Then (7, 4) BCH code is transformed in (8, 4) E-EBC code. Then a BV of the same length is XOR-ed with code word. Any one of 2^8 probable BVs' is nominated and PAPR is computed for all possible (2^8) codes and maximum PAPR is identified from the computed values of PAPR. Similarly for all other possible BVs, maximum PAPR has been calculated. The BV, which has given the lowest of the maximum PAPRs is considered as the favourable BV.

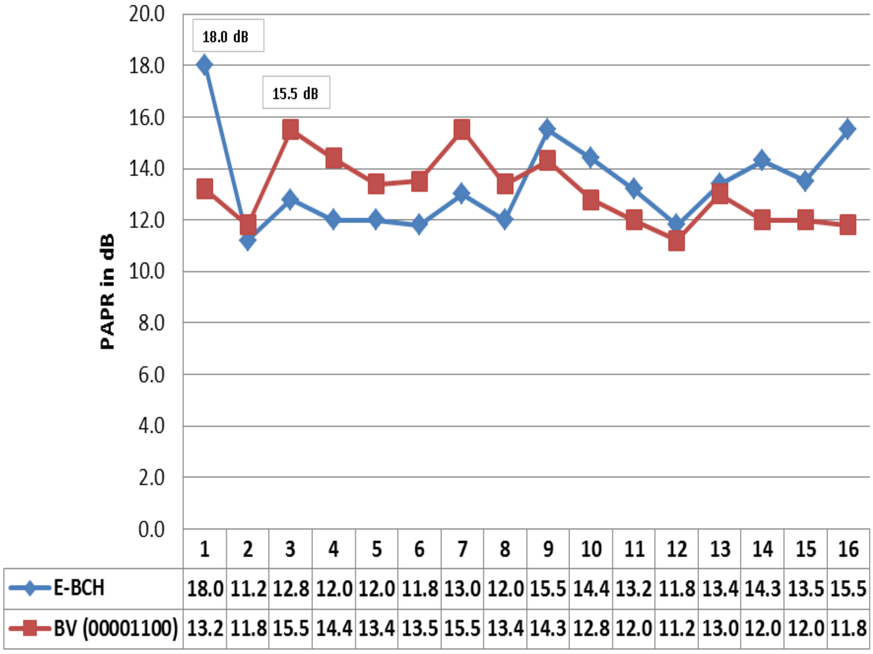
Reciprocal operation is performed at the receiver as shown in Fig. 2. The received code is XOR-ed with the same BV as used in encoder so that the original E-BCH code is generated at the receiver. Then RB is detached to get (7, 4) BCH code. The BCH decoder decodes message from the codeword.

V. RESULTS AND ANALYSIS

The simulation results are presentd to evaluate the performance of the proposed scheme. Table II presents PAPR values of E-BCH code and with BV = 00001100, 00001100, 00001100. In Fig. 3, the PAPR values of E-BCH code and with BV = 00001100 are presented.

Table II PAPR values with and without BV = 00001100, 00001100, 00001100

(7, 4) BCH code	PAPR in dB					
	E-BCH	BV = 00001100	E-BCH	BV = 00001100	E-BCH	BV = 00001100
0000000	18.0	13.2	18.0	13.7	18.0	15.5
0001011	11.2	11.8	11.2	14.3	11.2	12.0
0010110	12.8	15.5	12.8	12.7	12.8	14.8
0011101	12.0	14.4	12.0	12.8	12.0	15.5
0100111	12.0	13.4	12.0	15.5	12.0	13.2
0101100	11.8	13.5	11.8	14.2	11.8	12.0
0110001	13.0	15.5	13.0	14.4	13.0	12.0
0111010	12.0	13.4	12.0	13.2	12.0	14.6
1000101	15.5	14.3	15.5	12.0	15.5	13.2
1001110	14.4	12.8	14.4	14.9	14.4	14.6
1010011	13.2	12.0	13.2	15.5	13.2	14.9
1011000	11.8	11.2	11.8	12.0	11.8	12.7
1100011	13.4	13.0	13.4	12.0	13.4	12.8
1101000	14.3	12.0	14.3	13.4	14.3	11.2
1110010	13.5	12.0	13.5	13.6	13.5	15.0
1111001	15.5	11.8	15.5	15.3	15.5	12.7



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
E-BCH	18.0	11.2	12.8	12.0	12.0	11.8	13.0	12.0	15.5	14.4	13.2	11.8	13.4	14.3	13.5	15.5
BV (00001100)	13.2	11.8	15.5	14.4	13.4	13.5	15.5	13.4	14.3	12.8	12.0	11.2	13.0	12.0	12.0	11.8

Fig. 3 PAPR values for E-BCH code with BV = 00001100

From Fig. 3, it is perceived that the PAPR performance of the OFDM system is superior when biasing vector technique is employed. The amount of PAPR reduced can be expressed as

$$\begin{aligned}&(PAPR\ reduced\ in\ proposed\ system)_{dB}\\ &\qquad = (Max.PAPR\ using\ \mathrm{E-BCH\ code})_{\mathrm{dB}}\\ &\qquad - (\mathrm{Max.PAPR\ using\ E-BCH\ \ code\ with\ BV})_{\mathrm{dB}}\end{aligned} \tag{3}$$

For example, from figure 3, it is obsrved that the maximum PAPR without BV is 18.0 dB. However, it decreases to 15.5 dB when BV = 00001100 is used. Eventually, the proposed shcmee reduces PAPR of 2.5 dB.

VI. CONCLUSION

In this paper, we proposed (8, 4) E-BCH code with biasing vector technique to control the PAPR in OFDM system. (7, 4) BCH code is transferred into (8, 4) E-BCH code by appending RB. Then using biasing vector technique, the BV which condenses PAPR is identified. Reciprocal operation is used at the receiver to get the original message. The results show that the proposed scheme reduces the PAPR significantly and the performance of the proposed system is verified different combinations of BVs. For instance, with BV = 00001100, the maximum PAPR without and with BV is 8.0 dB and 5.5 dB, respectively. Eventually PAPR of 2.5 dB PAPR is reduced.

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