PAPR Reduction of OFDM System using LBC

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ABSTRACT
In this paper, we propose an efficient scheme to reduce the peak-to-average power ratio (PAPR) in orthogonal frequency division multiplexing (OFDM) systems by using the standard arrays of linear block codes(LBC). Our scheme may be regarded as a modified version of the selective mapping (SLM), which is a probabilistic method to reduce the PAPR by selecting a signal with minimum PAPR from several candidates as the transmit signal. We choose lowest PAPR in each coset of a linear block codes as its coset leader from several transmitted signal. The paper also compared PAPR QPSK/DQPSK-OFDM with and without SLM.

General Terms
In wireless communication the orthogonal frequency division multiplexing is employed for efficient utilization of available bandwidth .

Keywords
OFDM, PAPR, QPSK, DQPSK, QAM, LBC, SLM.

1. INTRODUCTION
As a multi-carrier modulation technique, OFDM has been receiving much attention. Because of its robustness to muti-path fading and inter-symbol interference, the OFDM technique has been adopted in many wireless standards, such as wireless local area network, wireless metropolitan area network, digital audio broadcasting and digital video broadcasting.[1][2]. But OFDM is having major drawback of a high Peak-to-Average Power ratio(PAPR)[3][4].This causes clipping of the OFDM signal by the High power amplifier(HPA) and in the HPA output producing nonlinearity. This non-linearity distortion will result in-band distortion and out-of-band radiation. The in-band distortion causes system performance degradation and the out-of-band radiation causes adjacent channel interference (ACI) that affects systems working in neighbour band. Hence the OFDM signal may have In-band and Out-of-band distortion which degradation of Bit-error-rate (BER) performance. One solution is to use a linear power amplifier with large dynamic range. However, it has poor efficiency as well as it is expensive.

2. REDUCTION TECHNIQUES
At present, there are many PAPR reduction techniques of OFDM. The first is distortion technique, such as clipping, companding and so on. This technique is simple, but it is inevitable to cause some performance degradation. The second is coding technique [5]. It is an efficient method to reduce the PAPR for a small number of subcarriers, but it is inefficient transmission rate significantly for a large number of subcarriers. The third kind is probabilistic technique or the redundancy technique which is including selective mapping (SLM) and the Partial transmit sequence (PTS).[6-7] we used SLM Technique to reduce PAPR which give better performance as compare to PTS. Selective mapping technique is main focus of this paper. Combination of DQPSK with SLM not only reduces the complexity at receiver but also it reduces PAPR of OFDM signal

3. THE PAPR OF OFDM SYSTEM
The PAPR of OFDM is defined as the ratio between the maximum power and the average power, The PAPR of the OFDM signal X(t) is defined as

$$PAPR = \frac{P_{peak}}{P_{average}} = \frac{\max[|x_n|^2]}{E[|x_n|^2]} \qquad ....(1)$$

Where x_n = An OFDM signal after IFFT (Inverse Fast Fourier transform)

E[.] = Expectation operator, it is an average power. The complex baseband OFDM signal for N subcarriers represented as

$$X(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X_n e^{j2\pi n \Delta f t}, \qquad 0 \le t \le NT ...(2)$$

4. SLM TECHNIQUE
In selective mapping (SLM) technique [8-10] the actual transmit signal lowest PAPR is selected from a set of sufficiently different signals which all represents the same information. SLM Technique are very flexible as they do not impose any restriction on modulation applied in the subcarriers or on their number. Block diagram of SLM Technique is shown in Fig.1 Let's define data stream after serial to parallel conversion as $X=[X_0, X_1\text{--------},X_{N-1}]^T$. Initially each input $X_n^{(u)}$ can be defined as equation

$$x_n^{(u)} = x_n . b_n^{(u)} \qquad ...(3)$$

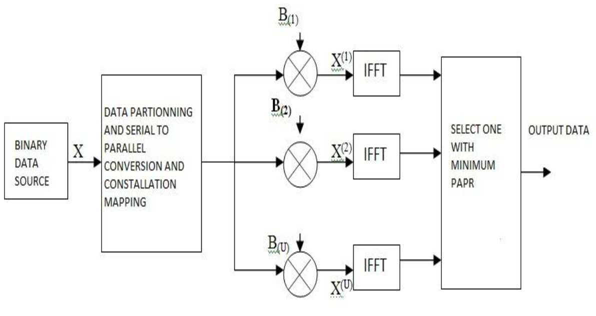

Fig 1 : Block Diagram of OFDM transmitter with the SLM Technique

$B^{(u)}$ can be written as a $x_n^{(u)}=[x_0^{(u)}, x_1^{(u)}, x_2^{(u)}\ldots\ldots, x_{N-2}^{(u)}]^T$

Where n = 0, 1, 2-------N-1, and u=0,1,2...U to make the U phase rotated OFDM data blocks. All U phase rotated OFDM data blocks represented the same information as the unmodified OFDM data block provided that the phase sequence is known. [9] After applying the SLM technique, the complex envelope of the transmitted OFDM signal becomes

$$x(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} x_n e^{j2\pi n\Delta ft}, \qquad 0 \le t \le NT \qquad (4)$$

Here Δf=1/NT , NT is the duration of an OFDM data block. Output data of the lowest PAPR is selected to transmit. PAPR reduction effect will be better as the copy block number U is increased. SLM method effectively reduces PAPR without any signal distortion. But it has higher system complexity and computational burden. This complexity can less by reducing the number of IFFT block [6, 8, 12].

5. MODIFIED SLM TECHNIQUE USING LBC

When the error control coding and OFDM modulation process work together such system is called COFDM. In a COFDM system to add redundancy and code the bits prior to IFFT. The purpose of this step of taking adjacent bits in the source data and spreading them out across multiple subcarriers. One or more subcarriers may be lost or impaired due to a frequency null and this loss would cause a continuous stream of bit error. Such an error is a burst of errors would typically be hard to correct.

The main purpose of the modified SLM technique is to reduce PAPR and IFFT block. There is only one IFFT block at transmitter if the sequence which is the lowest PAPR can be find out by a decision algorithm before IFFT [6].

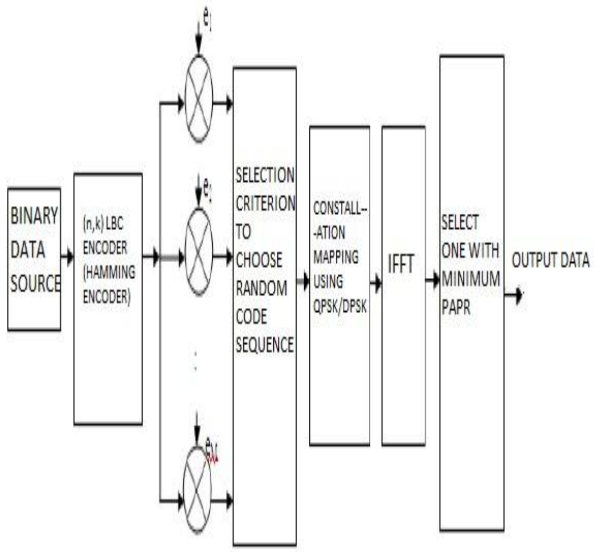

Fig 2: Block Diagram of an modified SLM Technique

5.1 Algorithm for modified SLM technique

Step 1: A binary information (bits) generated by data source is divided into blocks of 4 bits.

Step 2: Each information block is encoded into a code word c by a [7,4] hamming encoder.

Step 3: A control bit added to code word c to create an extended hamming code of 8 bits.

Step 4: Calculate the error table and coset leader,16 in number

Step 5:Sixteen vectors are constructed as c+e1, c+e2,c+ e3...........etc

Step 6: For each scrambled code word calculate the value of Z $= U^2 + V^2 + W^2$

Step 7: Scrambled code word with the minimum Z is selected and then Transformed to OFDM signal by constellation mapping and IFFT

5.2 Linear block code

Consider an [n, k] Linear code C with parity-check matrix H, where n is the length and k is the dimension of C. Since $Hc^t=0$ for any code word c ∈ C, any vector X ∈ e+c has the same syndrome as e, that is [2]

$$Hx^t = H(e+c)^t = He^t \qquad (5)$$

A binary information sequence is divided into blocks of 4 bits. Each message block is encoded into a code word C which is 7 bits by a [7, 4] hamming encoder. Hamming codes were designed for correction [11]. The parameters for the family of binary hamming codes are typically expressed as a function of a single integer m≥2 (for m=3, we have a (7,4) Hamming code) not necessarily prime, it is any positive integer. A hamming code on GF(2) has code length $n=2^m-1$, message length $k=2^m-1-m$, redundancy n-k=m and error connecting capability t=1bit.

5.3 Hamming code

Hamming codes are only single error correcting. To improve the error detection and connection capability by adding parity check digit. The resulting code is called the extended binary hamming code. Suppose that c is a code over the alphabet {0,1}. Let ĉ. be the code obtain by adding a single character to the end of each word in c in such a way that every word in c. has even weight. The parity check matrix of [8,4] extended hamming code ĉ. is H :

$$\hat{H} = \begin{bmatrix} & & 0 \\ & & . \\ & & . \\ & H & 0 \\ 1 & 1 & 1 \end{bmatrix}$$

According to the formula S= e $H^{\wedge T}$, the syndromes which are corresponding to the non-error and one error patterns could be obtained. And other seven two errors patterns could be obtained from the other syndromes. So the standard array of *c*. is constructed. The standard array an [n, k] binary linear code C is a M×N array and for extended array an [8,4] for binary linear code *c*. is also M×N array. where $M=2^{m-K}$, $N=2^K$. At last sixteen vectors are constructed as ĉ +e1, ĉ +e2,.... as ĉ +e16 ,where e1 =0 and e1, e2 ,----- e16 are properly selected as the coset leaders of the standard array in terms of their PAPR. Then the Decision criterion is used to calculate the value of Z. Finally, the scrambled code word with the minimum Z is selected and then transformed to an OFDM signal by constellation mapping and IFFT.

Table1,Standard Array of an [n.k] Linear Block Code

$e_1 = c_1$	c_2	……..	c_N
e_2	$e_2 + c_2$	……..	$e_2 + c_N$
e_3	$e_3 + c_2$	……..	$e_3 + c_N$
.	.	.	.
.	.	.	.
.	.	.	.
e_M	$e_M + c_2$	……..	$e_M + c_N$

In this array there are M rows and each row is a coset c denotes the code word and e denotes the error in transmission.The $e_1, e_2, e_3, \ldots e_M$ are called as coset leaders and by using these error patterns the forbidden codewords has generated and the above mentioned criterion is used for each code word to calculate the value of Z. Finally the code word with the minimum value of Z is selected and then transformed to an OFDM signal by constellation mapping where the codewords mapped into signal constellation using QPSK or DQPSK modulation and IFFT. At the receiver, the received signal is converted into r by FFT and constellation de-mapping. The syndrome calculated from r is used for estimating the coset leader e chosen at the transmitter. The code word c is obtained by calculating c= e+r and then is converted into a message sequence of k bits.

6. SIMULATION PARAMETER

No of subcarriers : 900

FFT Size : 64

Coding Technique : Linear block codes

Error correcting : Extended Hamming Code

Modulation : QPSK/DQPSK

Constellation Mapping : 256

Decision Criteria : $Z = U^2 + V^2 + W^2$

7. SIMULATION RESULT

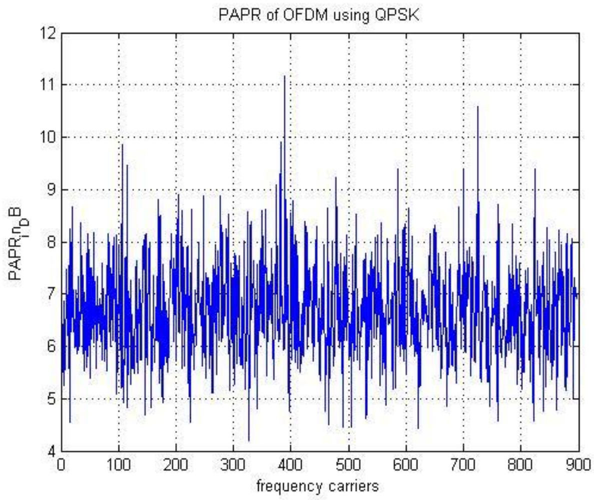

Fig 3: PAPR of QPSK -OFDM system

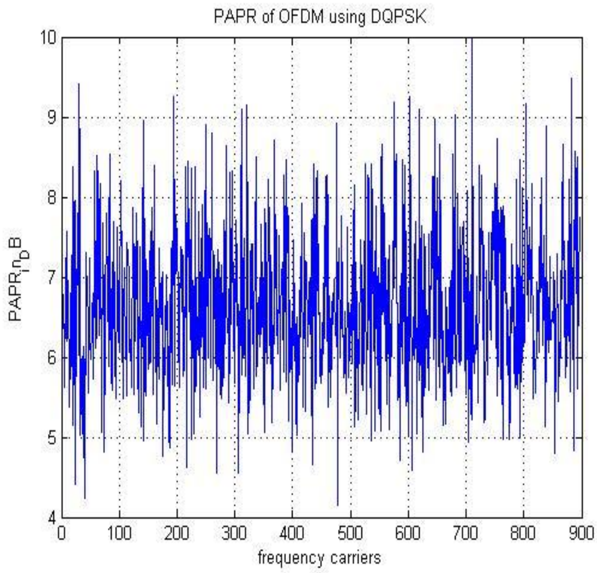

Fig 4: PAPR of DQPSK -OFDM system

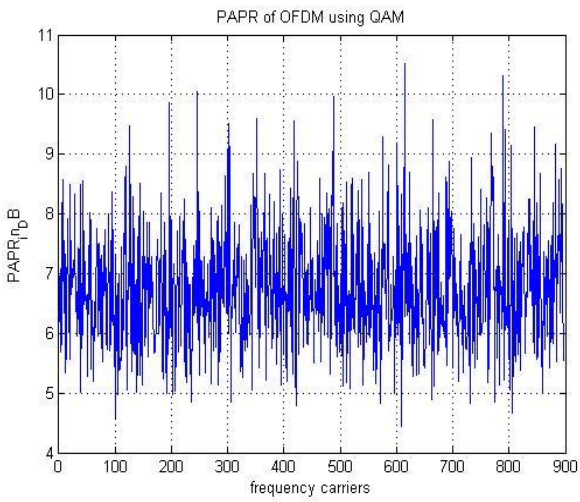

Fig 5: PAPR of QAM -OFDM system

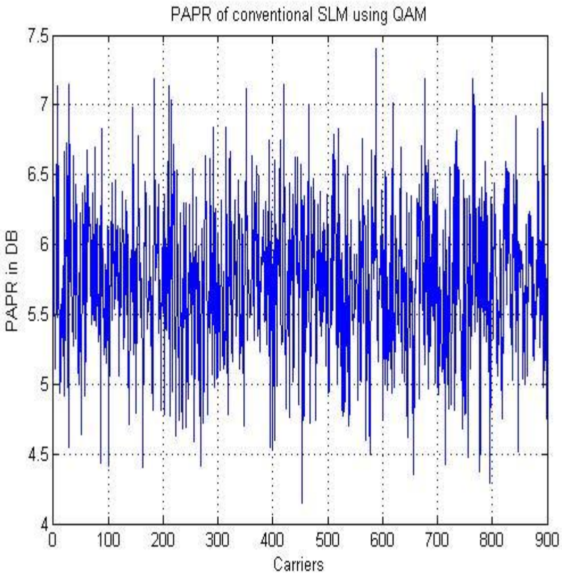

Fig 6: PAPR of DQPSK-OFDM system with Conventional SLM

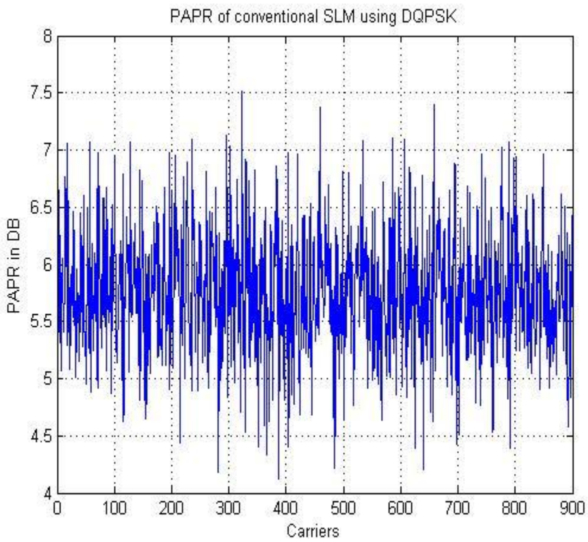

Fig 7: PAPR of DQPSK-OFDM system with Conventional SLM

In Fig 8 With reference [6] the Peak value for the modified SLM technique which is nearly equal to 5.5dB.So we concluded that PAPR of Modified SLM is better than conventional SLM.

8. CONCLUSION

A modified selective mapping technique is proposed in this paper to improve the performance of the OFDM system with respective PAPR. This scheme requires only one IFFT block at the transmitter and no side information needed to be transmitted. Hence results of simulation show that the modified SLM technique is simple and feasible scheme for PAPR reduction in OFDM system.

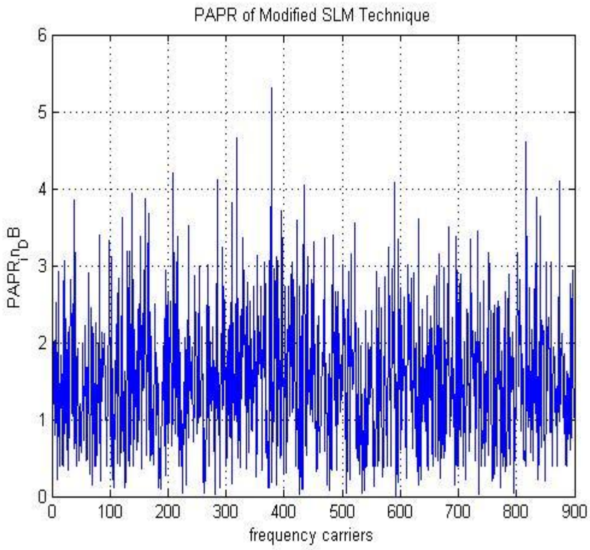

Fig 8: PAPR of the modified SLM Technique

9. ACKNOWLEDGEMENT

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