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PAPR Reduction Using Modified Selective Mapping Technique

Ms. V. B. Malode[1], Dr. B. P. Patil[2]
[1]Department of Electronics, J.N.E.C., N-6 CIDCO, Aurangabad,
[2]Department of Electronics, M.A.E., Alandi, Pune,
[1]vandana_malode@yahoo.co.in
[2]bp_patil@rediffmail.com

ABSTRACT
Multi-carrier modulation is an attractive technique for fourth generation wireless communication. Orthogonal Frequency Division Multiplexing (OFDM) is multi-carrier transmission scheme. Its high Peak to Average Power Ratio (PAPR) of the transmitted signal is a major drawback. In this paper, we propose to reduce PAPR by probabilistic method Modified selective mapping technique using the standard arrays of linear block codes. We choose lowest PAPR in each coset of a linear block codes as its coset leader from several transmitted signal. Simulation results show that PAPR results are better as compared to earlier work done by Yang Jie ,Chen Lei et al**.** The paper also compared PAPR QPSK/DQPSK-OFDM with and without SLM.

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

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1.INTRODUCTION

OFDM is one of the multicarrier modulation (MCM) technique for 4th Generation (4G) wireless communication. This technique is very attractive technique for high-speed data transmission used in mobile communication, Digital terrestrial mobile communication, Digital Audio Broadcasting (DAB), Digital Video Broadcasting terrestrial(DVB-T), wireless asynchronous transfer mode (WATM), Modem/ADSL.[1] OFDM has many advantages such as robustness in frequency selective fading channels, High spectral efficiency , immunity to inter-symbol interference and capability of handling very strong multipath fading.[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 non-linearity. 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 neighbor 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 and is expensive too.

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.

The paper is organized as follows section II gives PAPR reduction techniques. An overview of the PAPR of OFDM System in section 3. Brief description of SLM technique in section 4. Modified SLM technique in section 5, Simulation results and a comparison of the QPSK/DQPSK with related work are presented in section 6. Finally conclusion are in section 7.

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

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

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

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

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 $X=[X_0, X_1$--------$,X_{N-1}]^T$. Initially each input $X_n^{(u)}$ can be defined as equation

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

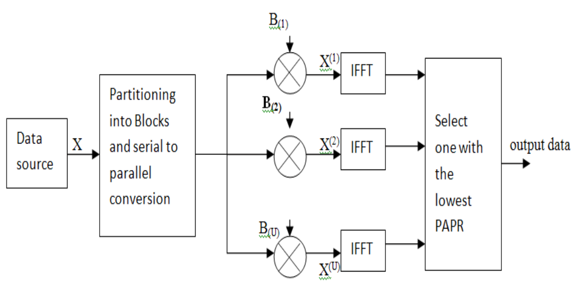

Fig. 1: Block Diagram of OFDM transmitter with the SLM Technique

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

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

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

Where $\Delta f = \frac{1}{NT}$, 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 reduce 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 LINEAR BLOCK CODES

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 a 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]

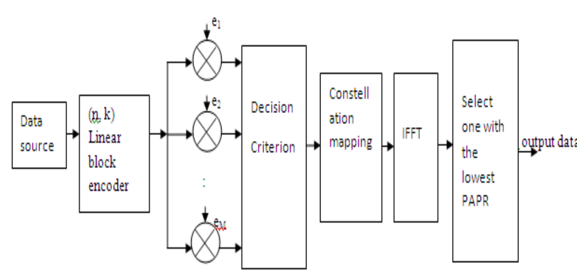

Fig. 2: Block Diagram of Modified SLM Technique

1.1 Algorithm for modified SLM Technique

Step 1: A binary information source is divided into blocks of 4 bits.

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

Step 3: A control bit added to codeword 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 codeword calculate the value of $Z = U^2 + V^2 + W^2$

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

1.2 LINEAR BLOCK CODES

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 codeword 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 codeword 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.

1.3 HAMMING CODES

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 $\hat{c}$ 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 $\hat{c}$ has even weight. The parity check matrix of [8, 4] extended hamming code $\hat{c}$ is $\hat{H}$:

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

According to the formula $S=e\hat{H}^T$, 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 $\hat{c}$ 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 $\hat{c}$ is also M×N array. where $M=2^{m-K}$, $N=2^{K}$.

At last sixteen vectors are constructed as $\hat{c}+e_1$, $\hat{c}+e_2$,……… $\hat{c}+e_{16}$,where $e_1=0$ and $e_1, e_2, \ldots e_{16}$ 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 codeword with the minimum Z is selected and then transformed to an OFDM signal by constellation mapping and IFFT.

Table 1: Standard array of an [n, k] linear block code

Zero Codeword → $e_1 = c_1$; coset leader → e_3; coset → row e_2

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

In this array there are M rows and each row is a coset c denotes the codeword and e denotes the error in transmission. This criterion is used for each codeword to calculate the value. Finally the codeword with the minimum value is selected and then transformed to an OFDM signal by constellation mapping 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 codeword c is obtained by calculating c= e+r and then is converted into a message sequence of k bits.

6. SIMULATION PERFORMANCE

Parameters used for simulation:

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

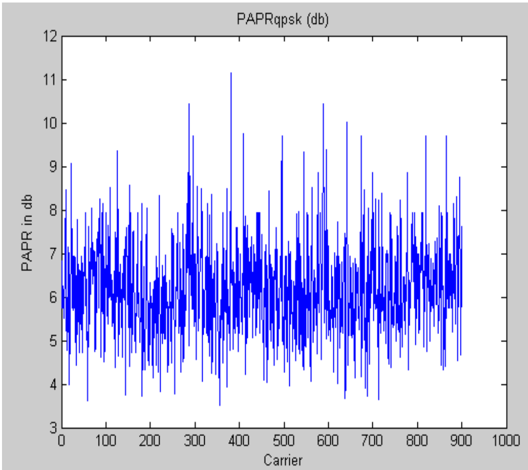

Fig.3a: PAPR of basic QPSK-OFDM system

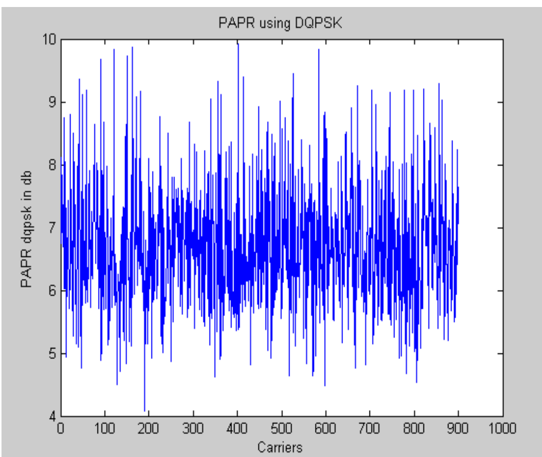

Fig.3b: PAPR of basic DQPSK-OFDM system

Simulation is carried out in MATLAB for QPSK-OFDM, DQPSK-OFDM with and without SLM & modified SLM technique.

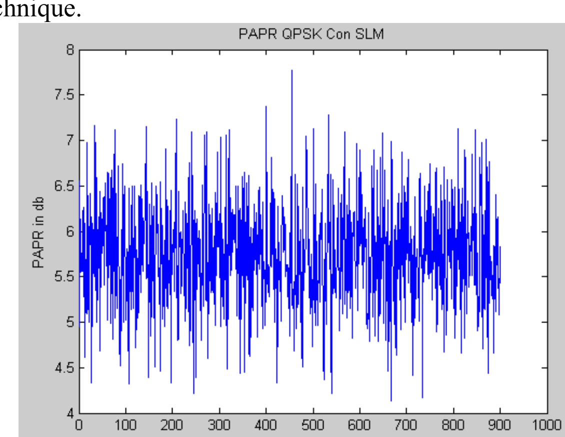

Fig. 4a: PAPR of QPSK-OFDM system with Conventional SLM.

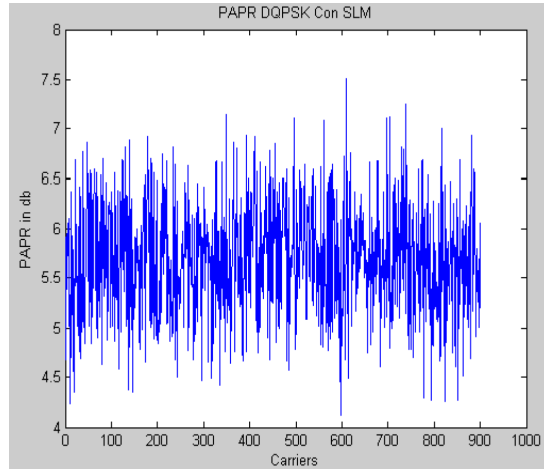

Fig. 4b: PAPR of DQPSK-OFDM system with Conventional SLM.

System	Maximum PAPR in dB	
	QPSK	DQPSK
Basic System (Without SLM)	11	10
Conventional SLM	7.8	7.5

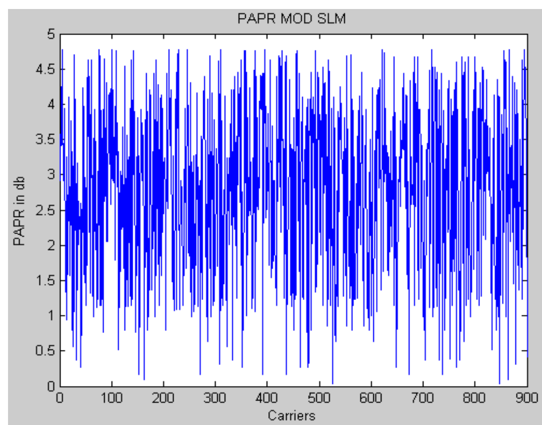

Fig.5: PAPR of the modified SLM technique

In Fig5 With reference [6] the Peak value for the modified SLM technique is 5.5 dB but in our case it is 4.77 db and average value PAPR is 2.8db. This result is better by 0.73 db. So we concluded that PAPR of Modified SLM is better than conventional SLM.

7. 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. Results of simulation of modified SLM technique show that the PAPR reduction of OFDM system, which further results in high performance of wireless communication. With the rising demand for efficient frequency spectrum utilization, OFDM proves invaluable to next-generation communication systems.

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Authors Biography

Ms. Vandana B. Malode is currently pursuing Ph.D. From Dr. BAMU Aurangabad, Maharashtra , India. She is currently working as Assistant Professor in Department of Electronics at Jawaharlal Nehru Engineering College, Aurangabad. She has published around 15 papers in International and National Conference. Her research interest is communication and OFDM technology.

Dr. B. P. Patil received his Ph.D. in 2000 and has more than 20 years of teaching and industrial experience. He has published 75 papers in International and National journals and Conferences. He also guided two Ph.D. students and guiding two students towards Ph.D. He is involved in three various research projects from Univ. of Pune. He is currently working as Professor and Head of Electronics Engineering Dept. at Maharashtra Academy of Engineering (MAE), Alandi, and Pune. His area of research includes sensor network and wireless communication.