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Performance Improvement through PAPR Reduction in MIMO-OFDM systems using Selective Mapping (SLM) Technique

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ABSTRACT

To improve spectrum efficiency, 5G necessitates the use of highly sophisticated communication protocols. Because of their enhanced performance, Multiple Input Multiple Output (MIMO) along with Orthogonal Frequency Division Multiplexing (OFDM) have been used. To improve the system's performance, MIMO-OFDM techniques are applied. Because OFDM uses a large number of distinct subcarriers, the signal's amplitude can reach very high peak values. Multicarrier modulation in this form is spectrally efficient. However, the OFDM signal's strong power peaks result in a high PAPR. This high PAPR raises the BER and lowers system performance.

With varying route numbers, the Selective Mapping Technique (SLM) employing Complementary Cumulative Distribution Function (CCDF) is highlighted in this paper. When the number of subcarriers is large, SLM is effective. In MIMO-OFDM, the SLM technique can effectively minimise the peak to average power ratio. The fundamental issue with SLM is that it needs bits of side information to discover the actual data bits at the receiver. As SLM with no side information is offered for detection of signal. The simulation results clearly show that PAPR is inversely proportional to the route numbers.

KEYWORDS: MIMO-OFDM, PAPR, Complimentary Cumulative Distribution Function, Selected Mapping.

INTRODUCTION

Higher data speed is becoming a more common demand with each passing day. Enhanced communication transmission techniques have been used to provide high-speed connectivity. MIMO-OFDM is a high-speed communication transmission technology that provides immunity to frequency selective fading, great spectral efficiency and power efficiency for wireless wideband applications such as WLANs, 4G and 5G wideband wireless communications, MIMO-OFDM is primarily used as an air interface. MIMO is a system for enhancing the ability of a radio link with several transmitting and receiving antennas. It is used with OFDM to improve system efficiency. For wideband digital communication, OFDM has become a popular technology for transporting data over several simultaneous data streams and channels. At a low bit rate, each subcarrier is modulated using a typical modulation approach.

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1The transmitter input bits in MIMO-OFDM are separated into frames of bit. The OFDM signal has a enormous Peak to Average Power Ratio (PAPR), which is a major disadvantage of the MIMO-OFDM system (PAPR). Many strategies for determining the OFDM's PAPR problem can be divided into two categories: 1.Distortion-based techniques and 2.Redundancy-based techniques. By adding up some deformities to the subcarrier signal points, a distortion-based approach lowers PAPR of the OFDM symbol. Both out of band and PAPR can be suppressed with a recursive clipping and filtering procedure. Tone injection (TI), selective mapping (SLM), and partial transmit coding are illustrations of redundancy- based coding (PTS). Different alternatives for lowering the PAPR are there, however either the complexity or redundancy are considerable, or the PAPR improvements are minor. SLM outperforms PTS in terms of data vectors, despite the fact that their profits are equal. PTS complexity improves with number of sub-blocks. SLM is the most advantageous approach of all because it is easy to adopt, doesn't cause any abnormalities to the signal transmitted, and that reduces PAPR to a satisfactory level.

The serial data input is segmented as frames of a certain amount of bits in MIMO- OFDM and are divided into N different groups, with N being the subcarrier number in each group. The size of constellation a specific subcarrier is decided by the bits in each individual group. To get the vectors of the bits, Inverse Fast Fourier transform (IFFT) is availed. Create N symbols as a block, X= {Xk, k=0, 1, 2, 3. . . N−1} and each of the N subcarriers must be orthogonal. The N subcarriers must be orthogonal to each other. The OFDM signal xn with N subcarriers can be represented in the discrete time domain is as follows:

xn □
1 N□ 1
□ Xke
k□ 0
j2□ kn/ N ,
0 □ n □ N □ 1

Where Xk, k=0, 1, 2, 3….N-1 are the input symbols which are modulated by BPSK, QAM or QPSK. The discrete time index n is used here.

The OFDM signal's PAPR can be considered as the ratio of the signal's peak (maximum) to average power and it can be written as

PAPR □
Ppeak Paverage

PAPR can be evaluated in decibel (dB) and given as

max□ xn 2 □
PAPR □ 10 log10
E□ x 2 □
, 0 □ n □ N □ 1

Where E□ .□ represents the expected value and x □ □ x1, x 2 , x3. x N□ 1 □ T

To estimate the genuine PAPR by a factor of L, oversampling is used when symbol spaced sampling misses a few signal's peaks. The oversampled samples are achieved by performing an LN-point IFFT of the bit stream with (L-1) N zero padding. As a result, setting L= 4 is sufficient to hold the peaks.

2By modifying the transmit signal's constellation nature, a high PAPR lowers signal's quality. When MIMO-OFDM's signal with high PAPR is routed along power amplifier of non linear type, non linear distortion experiences by the signal. This leads system performance deterioration and adjacent channel interference (ACI) by causing band distortion and out band radiation. A linear power amplifier with a broad dynamic range is required to decrease this distortion. Several PAPR reduction strategies are assessed using the CCDF.

CCDF □ 1 □ □ 1 □ e□ PAPR0 □ N

PRINCIPLE OF SLM (SELECTED MAPPING)

S number statistically independent phase sequences, S(u) □ □ S(u) , S(u) ,.., S(u) □ T are

0 1 N□ 1

generated, In the SLM method, where

S(u) □ e j□ (u) , □ (u) □ 2□ 0, 1 , k □ 0, 1, 2, 3,. S.

k k

Following this, data block X ⍰ ⍰ X0 , X1, X2 , X3 ,......, XN⍰ 1,⍰ T is multiplied with each of S phase sequences component-by-component, that results in set of S different data blocks,

Xu ⍰ ⍰ X

S(u) , X S(u) , X

S(u) ,. , X

S(u)

⍰ T The time domain of all S alternative data

0 0 1 1 2 2

N⍰ 1

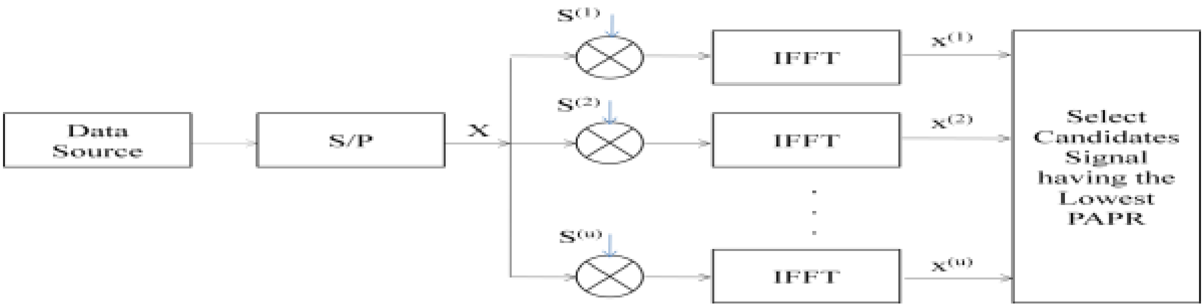
N⍰ 1, .

blocks is then obtained using IFFT, with xu expressing candidate signals. Finally, for transmission, the signal with the lowest PAPR is chosen, as shown in figure 1.

Figure 1: Block diagram of Selected Mapping (SLM) technique

The receiver needs side information in order to correctly recuperate the received signals. When binary bits are employed, ⍰ log 2 S⍰ bits are sufficient to describe this side information. With the sending signal, the side information is made available.

SLM can be applied to any signal constellation with any number of sub-carriers. With moderate complexity, it gives substantial improvement. To maintain side information, channel coding is required. After executing the dot product, it is important to determine 3which sequence is related to the shortest PAPR with M distinct candidates at the receiver in order to demodulate the incoming signal precisely. As a result, the information that must be learned by



receiver about the specified sequence of phase vector Pm and verify that it is accurately received.

An appealing technique is to send the branch number m's entire sequence to the receiving end as side information. In practise, however, the operation does not always necessitate the delivery of the complete vector sequence. It can be accomplished instead by providing the vector sequence's route number. This is only conceivable if the receiving end can use a look-up table or another way to re-establish the random phase sequence Pm. Channel coding is utilised to ensure a reliable communication because side information is critical in order to restore the signal at receiver's end. Once channel coding technique is offered, any additional side information is not essential, throughout the transmission process. All alternative paths are discovered in this way, and the most likely one is chosen as the best, at the receiving end.

SIMULATION OF SLM SCHEME

Using Matlab, an assessment of parameters that may influence PAPR reduction performance is carried out in this paper. According to the fundamentals of the SLM algorithm, the M, route number and N, subcarrier number has an impact on the effectiveness of SLM to reduce PAPR. As a result, simulations with various M and N values will be carried out, with the results revealing certain desirable features of signals expressing the same information.

Parameter	Value/Description
No. of random data bits	10000
Modulation Technique	QPSK
Over Sampling factor (Case 1)	8
Route Number (M) (Case 1)	4, 8, 16 & 32
Route Number (M) (Case 2)	8
Number of Subcarriers (N) (Case 2)	32, 64, 128 & 256

Table 1: Important Parameters used for the simulation of SLM scheme

Case 1: Analysis of PAPR reduction performance with various M values when N is kept constant at 128. Define

To begin, the rotation factor is described as Sm, n � � � 1, � j� from the standpoints of intricacy and practicability. When compared to conducting miscellaneous complex multiplication, this drastically reduces computation complexity. The process is repeated 10000 times, with an

4over-sampling factor of 8, and QPSK mapping as the modulation scheme for each sub-carrier. M=4, M=8, M=16, and M=32 are used as Route Numbers. As shown in figure 2, in terms of PAPR reduction, the recommended SLM technique outperforms the actual OFDM signal, which is unaffected by PAPR control strategy.

The possibility of a large PAPR is greatly reduced. The performance of PAPR reduction improves as M is increased. CCDF curves with various M values can be compared when the probability is set to 1%. The PAPR value for instance M=4 is approximately 2dB lower than that of case M=1. The value of PAPR for case M=32 is around 3dB lower than that of case M=1 under the same conditions. However, the difference in performance between M=16 and M=32 would be less than 0.5dB, as shown by a comparison of the curves M=16 and M=32. This shows that increasing the value of M (such as M>=8) will not result in a linear improvement in performance in PAPR reduction, and OFDM signal PAPR reduction performance is not going to be much increased..

In addition, it can be seen that as M increases, execution time would lengthen. As a result, in practise, we frequently use M=8, which not only improves system speed but also avoids introducing quite so much computing complexity, allowing us to successfully conserve scarce resources.

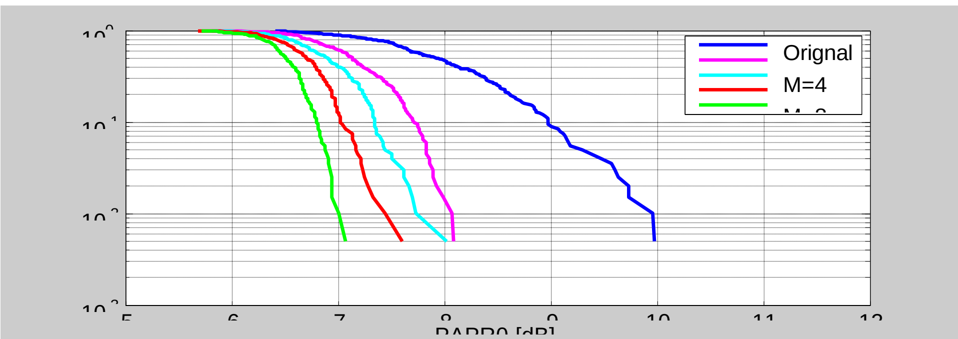


Figure 2: Comparison of PAPR reduction performances with different values of M.

Case 2: Analysis of PAPR reduction capability with various N values, while M is kept constant at 8. In this situation, the number of OFDM signal frames M is set to 8 and the number of sub-carriers N is set to 256, 128, 64, and 32, respectively. Figure 3 shows the CCDF curve of the original sequence's PAPR as a point of comparison to those who used the SLM technique.

Even though the number of carriers doubled after the adoption of the SLM method, the PAPR reduction performance of OFDM signal is not significantly reduced when the total number of sub-carriers exceeds 128, as shown in Figure 3.

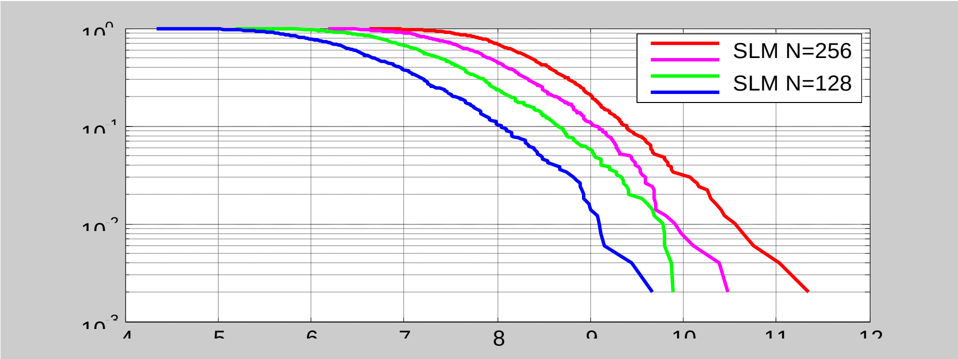


Figure 3: Comparison of PAPR reduction capability with various N values.

CONCLUSION

After analysing and comparing the above categories of simulation data, the following conclusions can be made:

1. The PAPR distribution of an OFDM system is greatly enhanced with SLM approach, lowering the possibility of a high peak power signal being presented. Increasing the amount of OFDM signal frames is a good idea. to massively increase complexity while just slightly improving PAPR reduction capacity.
2. Because FFT frames of any length can be used with the SLM approach., it can be employed in a variety of OFDM systems with varying carrier counts. It's ideal for OFDM systems with a lot of sub-carriers (greater than 128).
3. The performance of an OFDM system is increased considerably by SLM scheme by lowering the PAPR, but the cost, as well as the complexity of its design, is extremely evident. When using the SLM technique, the transmitter must calculate M group IFFTs every time, as opposed to only one in a typical OFDM system, and its M points out of N, the operation ofthe IFFT involves

n mul ⍰ M. N log 2 N2complex multiplication and nodd ⍰ M. N log 2 N 2addition, independently.

These issues impose a significant computational cost on real-world implementation of OFDM; the computational complexity must be lowered. As a result, in practise, we commonly use M=8 to compromise computer complexity while improving performance.

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