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

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ABSTRACT

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KEYWORDS: Selected Mapping, Complementary Cumulative Distribution Function, PAPR, and Multiple-Input Multiple-Output (MIMO-OFDM) are all terms associated with this technology.

INTRODUCTION

The need for faster data transfer rates increases daily. New methods of data transmission have allowed for lightning-fast connections. For wireless wideband applications like WLANs, 4G and 5G wideband wireless communications, MIMO-OFDM is predominantly employed as an air interface due to its high data transfer rate, excellent spectral efficiency, and low power consumption. Multiple-input, several-output, or MIMO, is a method of improving the performance of a radio connection by using multiple antennas. It complements OFDM by increasing the latter's effectiveness. Spreading information over several channels and data streams at once, as is done with OFDM, has made it a popular technique for wideband digital communication. Each subcarrier is modulated in the standard fashion at a low bit rate.

In MIMO-OFDM, the bits from the transmitter input are broken up into several frames. One significant drawback of the MIMO-OFDM setup is the very high Peak to Average Power Ratio (PAPR) of the OFDM signal (PAPR). There are a variety of methods for figuring out the PAPR issue in OFDM, however they may generally be broken down into two groups: Methods that rely on distortion and those that rely on redundancy. PAPR of the OFDM symbol may be reduced using a distortion-based technique by introducing a few distortions to the subcarrier signal points. Out-of-band and PAPR interference may be masked via a recursive clipping and filtering process. Examples of redundancy-based encoding include tone injection (TI), selective mapping (SLM), and partial transmit coding (PTS). There are a variety of approaches that may be taken to reduce the PAPR, but most of them are either too complicated, include unnecessary steps, or provide only marginal gains. SLM performs better than PTS in terms of data vectors, despite the fact that both companies earn the same amount of money. The greater the number of subblocks, the less complicated the PTS will be. Because of its simplicity, lack of impact on the transmitted signal, and effective PAPR reduction, SLM is the best method.

MIMO- OFDM divides the serial data input into N groups, where N is the number of subcarriers in each group. Each group receives a subset of the serial data input in the form of frames of a predetermined number of bits. A subcarrier's constellation size is determined by the number of bits that make up its constituent groups. Inverse Fast Fourier transform (IFFT) is used to get bit vectors. All N subcarriers must be orthogonal, thus make a block of N symbols using the notation X= Xk, k=0, 1, 2, 3,... N1. Orthogonality between the N subcarriers is required. When viewed in the discrete time domain, the OFDM signal xn with N subcarriers looks like this:

xn
1 N1
 Xke
k0
j2kn/ N ,
0 n N 1

Where Xk are the input symbols that are being BPSK, QAM, or QPSK modulated, and k=0, 1, 2, 3....N-1. Here, we make use of the n-based discrete time index.

Peak-to-average power ratio (PAPR) of an OFDM transmission is defined as

PAPR

Ppeak Paverage

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

max xn 2

PAPR 10 log10

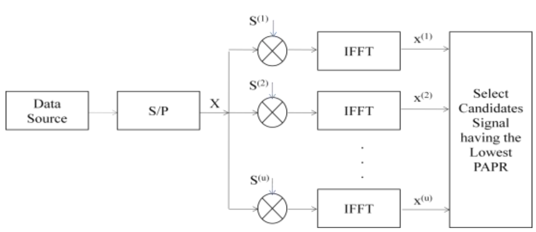
E x 2

, 0 n N 1

Where E.represents the expected value and

x x1, x 2 , x3 ,... x N1 T

If symbol spaced sampling misses some of the peaks in a signal, then oversampling may be used to estimate the true PAPR by a factor of L. The bit stream is IFFT at LN points with (L-1) N zero padding to produce the oversampled samples. Thus, the peaks may be securely



maintained by setting L= 4.A high PAPR degrades transmission quality by altering the constellation structure of the signal being sent out. Non linear distortion is introduced into a signal with high PAPR in MIMO-OFDM when the signal is sent via a non linear power amplifier. This results in band distortion and out-of-band radiation, which degrades system performance and may even cause adjacent channel interference (ACI). In order to lower this distortion, a linear power amplifier with a large dynamic range is needed. Several methods for decreasing PAPR are evaluated with the help of the CCDF.

CCDF 1 1 ePAPR0 N

PRINCIPLE OF SLM (SELECTED MAPPING)

S number statistically independent phase sequences, S(u) S(u) , S(u) ,.., S(u)

T are

0 1 N1

generated, In the SLM

method, where

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

S.

k k

Following this, data block X X0 , X1, X2 , X3 ,......, XN1,T is multiplied component-by-component by each of S phase sequences, yielding a collection of S distinct data blocks,

Xu X

Assume that S(u) and X are both true.

S(u) ,. , X

S(u)

Time-domain analysis of all possible variants of the data

0 0 1 1 2 2

N1

N1, .

xu represents potential signal candidates, and blocks are acquired through IFFT. Figure 1 depicts the process by which the signal with the lowest PAPR is selected for transmission.

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

The receiver cannot properly recover the sent signals without the assistance of auxiliary information. When dealing with binary bits, log 2 S bits are all that is needed to explain these supplementary pieces of data. The auxiliary data is sent together with the main signal.For signals with a varying number of sub-carriers, SLM may be used. Significant enhancement is achieved with just little difficulty. Channel

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encoding is essential to preserving contextual information. After carrying out the dot product, it is crucial to establishAt the receiver, in order to demodulate the incoming signal correctly, it must determine which of M possible sequences corresponds to the shortest PAPR. This means the receiver has to acquire knowledge about the prescribed phase vector Pm sequence and confirm proper reception.

Sending the whole sequence of the branch number m to the receiver as extra data is an attractive approach. However, in practice, it is not necessarily necessary to provide the whole vector sequence when performing the operation. Instead, the route number of the vector series will do the trick. Only if the receiver has some mechanism of re-establishing the random phase sequence Pm, such as a look-up table, is this even remotely possible. Because side information is essential for signal restoration at the receiver's end, channel coding is used to assure reliable transmission. Once a channel coding mechanism is made available, it is not necessary to send any supplementary data along with the main message. This method uncovers all possible outcomes and ultimately selects the one with the highest probability of success.

CASE STUDY: SLM PLAN SIMULATION

In this study, we use Matlab to evaluate a number of factors that may affect the effectiveness of PAPR reduction. The SLM algorithm's efficiency in lowering PAPR is influenced by two parameters: the M, route number, and the N, subcarrier number. Therefore, simulations will be run with different values of M and N, with the outcomes indicating certain desired characteristics shared by signals conveying the same meaning.

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

See Table 1 for a summary of key SLM simulation parameters.

Case 1: Examining the efficacy of M values between 1 and 128 in reducing PAPR. Define

First, from both theoretical and practical vantage points, the rotation factor is defined as Sm, n 1, j. The computational cost is much reduced as compared to doing random complex multiplication. It's done 10,000 times with an

Each subcarrier's modulation is a QPSK mapping with an oversampling ratio of 8. When referring to Route Numbers, the values M=4, M=8, M=16, and M=32 are often used. Figure 2 demonstrates that the suggested SLM approach provides superior performance in terms of PAPR reduction compared to the real OFDM signal, which is independent of PAPR management strategy.

Smaller PAPRs are far more likely to occur. As M is raised, PAPR performance improves. When the probability is lowered to 1%, it is possible to do a direct comparison between CCDF curves of varying M values. For example M=4, the PAPR value is around 2 dB less than in case M=1. The

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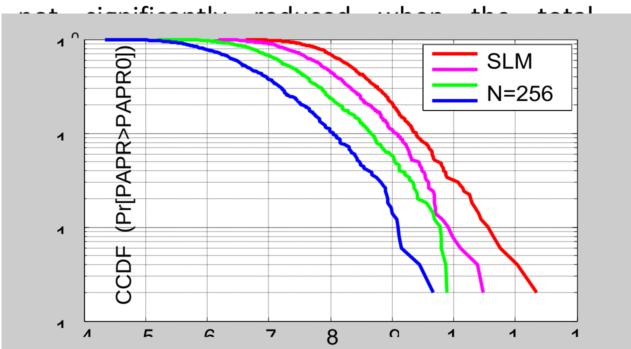
value of PAPR for case M=32 is roughly 3dB lower than that of case M=1 under the identical circumstances. It is clear by comparing the M=16 and M=32 curves that the performance gap between the two values is less than 0.5dB. This demonstrates that the performance of PAPR suppression for OFDM signals is not going to significantly improve when M is raised (for example, if M>=8).It is also obvious that the execution time would get longer as M grows. Therefore, in practice, we typically select M=8, which not only increases system performance but also reduces the amount of processing complexity introduced, therefore effectively conserving limited 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



reduction capability with various N values.

CONCLUSION

The following findings may be drawn from a comparison and analysis of the aforementioned types of simulation data:

First, the SLM method improves the PAPR distribution of an OFDM system, making it less likely that a signal with a very high peak power would be transmitted. Adding more OFDM signal frames is a useful strategy. substantially increasing complexity while just marginally enhancing PAPR reduction capabilities.

The SLM method is flexible in that it may be used to a wide range of OFDM systems, including those with different carrier counts and FFT frame lengths. It works wonderfully in high-subcarrier-count OFDM systems (greater than 128).

By reducing the PAPR, an SLM scheme improves the performance of an OFDM system, however this improvement comes at a high price and comes with a very complicated design. For an OFDM system to function normally, the transmitter only has to compute a single IFFT per group, however using the SLM method, M IFFTs must be calculated for each transmission.

The IFFT includes

n = mul(M)n = log(N)n

Calculating complicated numbers and independent addition

Real-world OFDM implementation is burdened by these difficulties, increasing the computational complexity, which must be reduced. Therefore, M=8 is typically used in practice to trade off computer complexity for improved performance.

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