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Performance Analysis of Different Selected Mapping Schemes for OFDM Systems

Ramanjeet Kaur *, Charanjit Singh**, Amandeep Singh***
*(Department of Electronics and Communication Engineering, Punjabi University Patiala, India
Email: ramanjeetkaur2628@gmail.com)
** (Department of Electronics and Communication Engineering, Punjabi University Patiala, India
Email: channisingh@yhaoo.com)
***(Department of Electronics and Communication Engineering, Punjabi University Patiala, India
Email: singh.amandeep183@gmail.com)

ABSTRACT
One of the well – known Peak to Average Power Ratio (PAPR) mitigation technique for orthogonal frequency division multiplexing (OFDM) is Selected Mapping (SLM). Up till now, many different low complexity SLM schemes have been proposed, but most of them reduce the computational intricacy at the cost of Bit Error Rate (BER) or Peak to Average Power Ratio (PAPR) mitigation performance degradation. Main aspect among the SLM schemes is the transmission of side information. In this paper performance of different SLM schemes is correlated to analyze the effect on PAPR, BER, computational intricacy and throughput.
Keywords – Complementary Cumulative Distribution Function (CCDF), OFDM, PAPR, Side Information (SI), SLM

I INTRODUCTION

OFDM is an enticing technique for wireless communication as it sustains sturdy reliability and high throughput in the frequency selective fading environments. It is a parallel transmission scheme where a high rate serial data stream is split into a set of low rate sub streams, each of which is modulated on a separate sub carrier. It bids elevated spectral efficiency, low complex receivers and simple digital realization by using the FFT operation. In spite of these rewards, one of the dominant drawbacks in OFDM is high Peak to Average Power Ratio (PAPR). High peak values are imported due to the addition of subcarrier components via an IFFT operation. The high PAPR brings the OFDM signal distortion in the non – linear region of high power amplifier and further leads to degradation of the performance of the system [1]. It enhances complication of converters and shrinks the effectiveness of radio frequency amplifier.

Multifarious methods are introduced to overcome the high PAPR [1]. Clipping technique [2] is used to reduce the peak power by clipping the signals to the threshold level. Partial Transmit Sequence (PTS) technique [3] generates alternative signal sequences representing the same OFDM signal and selects the one with minimum PAPR. Companding technique [4] [5] rates the signals non – linearly such that signals with large amplitude are suppressed and the signals with small amplitude are expanded. Many more PAPR reduction techniques are there in [1]. Among all the PAPR mitigation techniques, SLM scheme can effectively minimize the PAPR without signal distortion by using signal scrambling techniques. Main consideration of this technique is computational complexity and transmission of side information.

The organization of this paper is as follows. Selected Mapping is presented in section 2. CCDF and Performance analysis is discussed in 3. Conclusion is presented in section 4.

II SELECTED MAPPING

Using this method, parting all symbols to subsets containing the same information data and allow the sample with minimum PAPR to go down the line [1]. PAPR reduction is carried out by compounding autonomous phase sequences to the original samples and determining the PAPR of each phase sequence and sample combination. The combination with least PAPR is transmitted. SLM requires much system intricacy and computational strain because of many IFFT stages. We also need to calculate the PAPR for every autonomous sample.

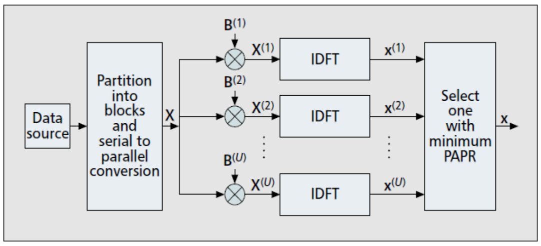

Fig 1: Block diagram of SLM technique [1]

As in the block diagram shown in Fig 1, each data block is compounded by U different phase sequences of length N, $B^{(u)} = [b_{u,0}, b_{u,1}, \ldots\ldots, b_{u,N-1}]^T$. This results in U different data blocks. Modified data block for u^{th} phase sequence is denoted as $X^{(u)} = [X_0 b_{u,0}, X_1 b_{u,1}, \ldots\ldots, X_{N-1} b_{u,N-1}]^T$.

After passing the data blocks through the IDFT's the multicarrier signal becomes,

$$x^{(u)}(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X_n b_{u,n} e^{j2\pi n \Delta f t}, 0 \le t < NT \tag{1}$$

After this operation the one with lowest PAPR is selected to go down the line. The information about phase sequences is transmitted as side information at the receiver. By using this side information, reverse operation is performed to recover the original data block. The amount of PAPR reduction for SLM depends greatly on the number of and design of phase sequences. The concentration of this paper is especially upon the selected mapping technique.

Sending the extra side information (SI) index along with the transmitted signal is one of the disadvantages of the SLM technique. Here the two important analysis of this technique has been done. Out of them one is how to avoid the transmission of extra information along with the OFDM signal, means avoiding the SI index Transmission. Another one important analysis of this technique is how to reduce the computational complexity. Much work has been done on the SLM scheme [6] [7] [8]. Two different SLM schemes are described below:

2.1 Novel Semi – Blind SLM Technique

In an efficient semi – blind SLM technique proposed in [8] SI index is embedded in the transmitted symbols. This enclosure is accomplished by associating each SI index with a particular set of extended locations inside the data block. A suboptimal receiver is employed at the receiver side to recover the SI index.

But in a novel semi blind SLM technique [6], different set of extended locations associated with SI indices is there inside the data block. Hence no explicit SI index is sent along with the transmitted data which further increases the overall throughput. At the receiver side novel suboptimal receiver is driven based on maximum – likelihood (ML) detection algorithm. Further details of this proposed technique is in [6].

2.2 Modified SLM Scheme

To avoid the transmission of side information and reduce the computational intricacy, the conversion matrices are proposed in [9] to simplify the inverse Fast Fourier transform (IFFT) computations. By using only 2 CM's the computational complexity reduces to half that of the conventional SLM scheme. More CM's can be used to replace more IFFT's to further reduce the intricacy.

One disadvantage of using CM's is that it leads to degraded BER performance [7] as the elements of phase rotation vectors interrelated to CM's have variable magnitudes which further boost up the frequency selective fading.

A new modified SLM scheme [7] is proposed to avoid the SI transmission and reduce the intricacy. A peculiar set of CM's with large number of elements is designed to bring about the candidate signals. More detail about this scheme is given in [7]. This proposed technique can be directly pertinent to many practical OFDM systems.

III CCDF AND PERFORMANCE ANALYSIS

Cumulative distribution function (CDF) is one of the most regularly used criterions to measure the performance of PAPR technique. In [1] the CDF of the amplitude of a signal is given by

$$F(z) = 1 - \exp(z) \tag{2}$$

The complementary CDF (CCDF) is used instead of CDF, which helps us to examine the probability that the PAPR of a certain data block exceeds the given threshold

$$P(PAPR > z) = 1 - P(PAPR > z) = 1 - (1 - \exp(-z))^N \tag{3}$$

Performance Analysis

Fig 2 shows the performance of different SLM schemes on PAPR and BER.

In Fig 2, the proposed semi-blind scheme have lower PAPR than the SLM scheme in [6] because phases of the phase shift vectors are periodic while phases are random in proposed scheme. The proposed SLM scheme shows the same performance as classical SLM.

In Fig 3, both the schemes P – MSLM and MSLM [7] shows the almost same PAPR reduction performance. Since SI index is not needed in P-MSLM and more CM's can be used for PAPR reduction without loss in the useful data rate.

In Fig 4 the proposed SLM receiver [6] has improved BER performance for N = 64 and 128 and it becomes it comes closer to the perfect SI performance which is considered as lower bound.

In Fig 5 the BER performance of P – MSLM [7] remains same as M increases from 57 to 114. However there is small performance gap between P – MSLM and the original OFDM signal because the length of the equivalent channel is little larger than real channel which leads to little larger frequency selectivity for P – MSLM. There is minor performance gap between P – MSLM and MSLM with perfect SI because of the enhanced frequency selectivity due to proposed phase rotation vectors.

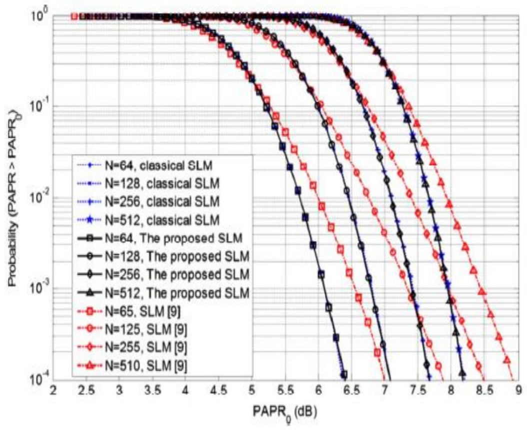

Fig 2: CCDF of the PAPR obtained with the proposed SLM technique, classical SLM and the SLM introduced in [6]

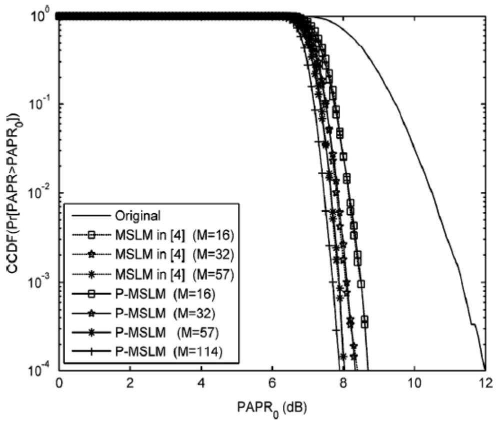

Fig 3: comparison of PAPR reduction performance between P – MSLM and MSLM [7]

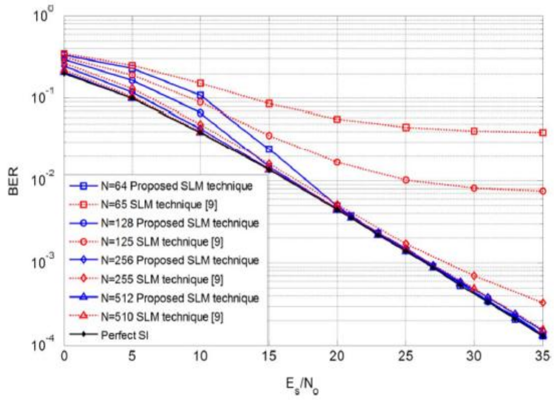

Fig 4: Comparison between BER performance of the proposed SLM and SLM technique introduced in [6]

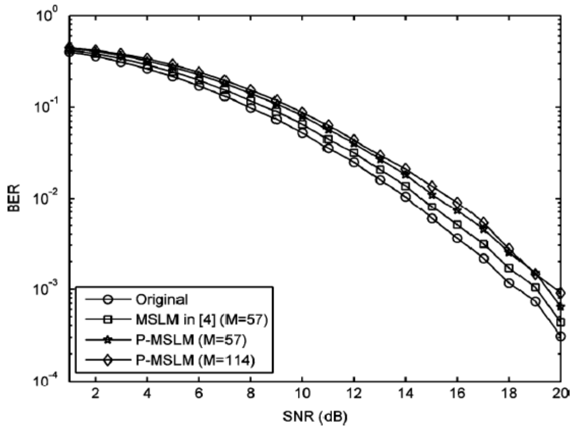

Fig 5: Comparison of BER performance between original OFDM signal, P – MSLM and MSLM in [7]

IV CONCLUSION

Using different SLM schemes, main consideration is on the transmission of SI information and computational intricacy along with the PAPR reduction and BER performance. The SLM scheme [6] increases the overall data rate by removing the SI index, while maintain the same PAPR performance to classical SLM. The SLM scheme in [7] leads to even lower computational complexity and proves to be a promising property for practical OFDM systems. Hence in further work more improvement can be done in these techniques for better results.

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