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Performance Analysis of OFDM System Augmented with Hybrid Combination of Selective Mapping and Diverse Transforms

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Abstract

Orthogonal frequency division multiplexing (OFDM) is the most efficient technique found for correspondence system by having a having a marvellous immunity against multipath fading and between inter-symbol interference. One of the noteworthy disservices of OFDM system is their high peak to average power ratio (PAPR), which degrades system execution when nonlinear high power amplifiers (HPA) are used. Diverse PAPR reduction techniques are introduced in the literature. This paper exhibits a blend of PAPR reduction method selective mapping (SLM) with precoding procedures and also by replacing the conventional fast Fourier transform (FFT) with other diverse transforms. The hybrid combination of SLM and precoding/transforms results in a multicarrier modulation OFDM system that will bring down the high peak to average power ratio. Likewise, bit error rate investigation is accomplished for every one of these strategies. Simulation results demonstrate that the hybrid system has incredible PAPR reduction capabilities and bit error rate (BER) performance.

Keywords: *OFDM; PAPR; BER; SLM; DCT; DST*

1. Introduction

OFDM is a sensational modification of frequency division multiplexing (FDM) where all the subcarriers are orthogonal to each other. OFDM offers an enormous high spectral efficiency, multipath delay spread resistance, control efficiency and an exceptionally solid immunity to the frequency fading channels [1]. In any case, the high PAPR of OFDM signal is the essential issue for optical OFDM system. A massive PAPR offers ascend to signal disability through the nonlinearity of modulator, and fiber along these lines debases the transmission execution. For decreasing the PAPR of OFDM signal, different methodologies are proposed for the remote system and optical OFDM system, which can add reshaping to the signal, reduce the accessible data transmission and option the power [2]. The essential favoured perspective of precoded PAPR reduction strategies is that there is no defilement in BER of OFDM system [3]. PAPR can be portrayed as the relationship between the most outrageous compel of a case in a transmit OFDM picture and its ordinary power. At the point when a large number of subcarriers is out of stage, a huge PAPR can bring about the transmitter's power amplifier (PA) to keep running inside a non-saturation locale. This cause critical signal mutilation at the yield of the power amplifier [4]. Furthermore, the high PAPR can bring about immersion at the digital-to-analog converter (DAC), prompting to the immersion of the PA. PAPR additionally causes inter-modulation between the subcarriers and bends the transmit signal constellation. Along these lines, the PA must work with a substantial power back-off, estimated to that of the PAPR, which prompts to wasteful operation. Accordingly, it is important to diminish the PAPR of the transmit signal in OFDM system. In precoding, the

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balanced information of each OFDM piece expanded with by a duplicating with the precoding system before invert FFT (IFFT) square, and the inverse precoding system is associated after FFT square to recover the adjusted data. To reduce the PAPR, various techniques have been proposed in remote correspondence, for instance, clipping, coding, Partial transmit succession (PTS), SLM, interleaving, nonlinear companding and Hadamard transform, etc. The plans can prevalently be sorted into signal scrambling procedures, for instance, PTS, and SLM, for instance, clipping and companding strategies. Among those PAPR diminishment strategies, the minimum troublesome method is to use the clipping procedure. Regardless, using clipping strategy causes both in-band distortion and out-of-band distortion, and further causes a growing blunder bit rate of the system [4]. The SLM and PTS techniques upgrade PAPR measurements of OFDM signal essentially. In any case, they require the side data which is transmitted from the transmitter to the beneficiary to recover special data impede from the got signals, and the loss of the side data may realize the loss of the whole OFDM data block [5]. The organization of the paper is as follows: Section1 presents a brief introduction, whereas Section 2 presents a brief description of OFDM methodology. Section 3 describes the concept of SLM and Section 4 demonstrate the proposed methodology. The result discussion is presented in Section 5, followed by the conclusive remarks of the papers being presented in Section 6.

2. OFDM System Description

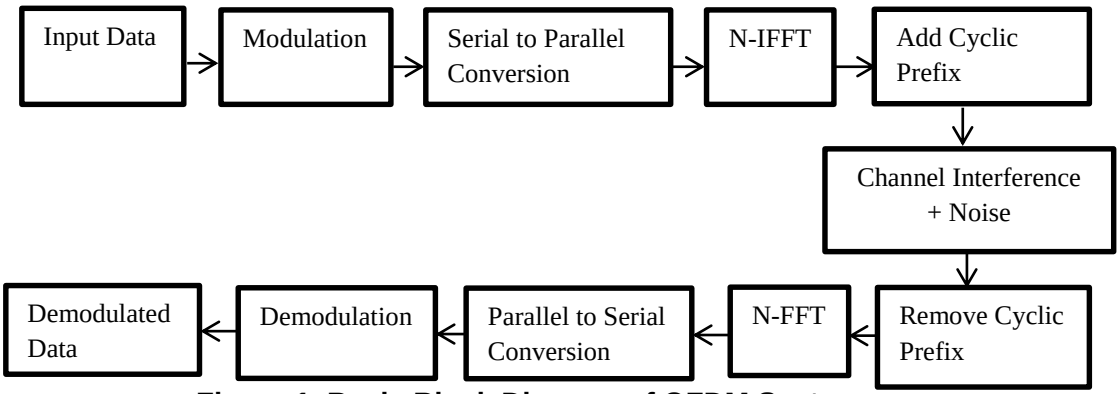

Figure 1. Basic Block Diagram of OFDM System

An OFDM symbol can be obtained simply by doing the IFFT operation on the input data and can be written as:

$$x(n) = \frac{1}{\sqrt{N}} \sum_{K=0}^{N-1} X(k)\, e^{j2\pi kn/N}, \quad 0 \leq k \leq N\text{-}1 \tag{1}$$

Where, X (k) (k=0, 1 … N-1) is input symbols modulation data, n is the discrete time index, and N is the number of subcarriers. The main purpose of adding the cyclic prefix block is to eliminate the inter symbol interference. OFDM provide orthogonality which is very much helpful to achieve the high data rate better and spectral efficiency.

- PAPR

The PAPR of OFDM signs x(t) is portrayed as the proportion time frame between the most extreme instantaneous power and its average power amid an OFDM symbol, which can be defined as:

$$PAPR_{db} = 10log\left(\frac{max(x(t)x^*(t))}{E\,(x(t)x^*(t))}\right) \tag{2}$$

Reducing the maximum x(t) is the main purpose of reducing the PAPR reduction techniques. The utilization of a substantial number of subcarriers presents a high PAPR in OFDM.

3. SLM Methodology

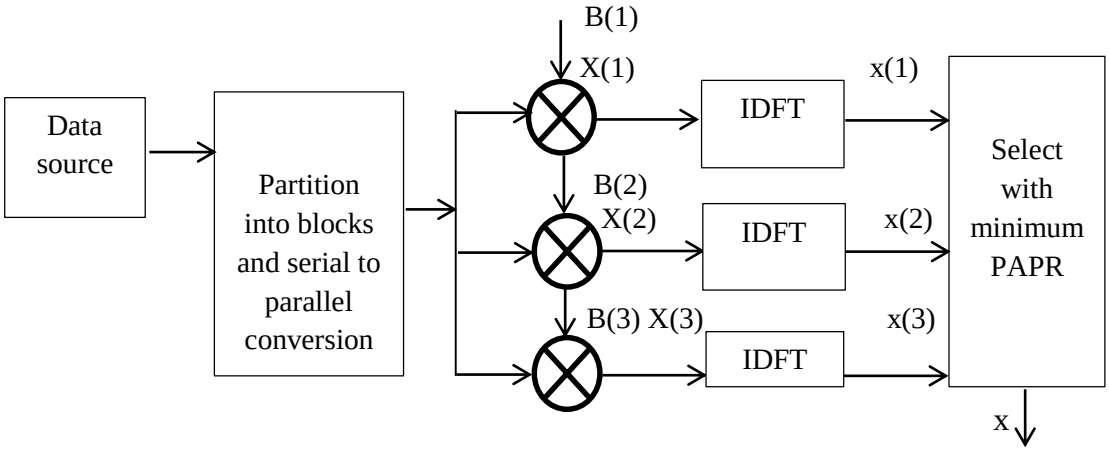

Figure 2. SLM Methodology

We have many techniques for reducing the PAPR, but in this paper, we are using selective mapping technique which comes under the signal scrambling technique [5]. The basic idea behind this technique is that it selects the sequence of signals with least PAPR value. The techniques come under this category are SLM, PTS and Interleaved OFDM. SLM is a promising technique which is helpful to reduce the PAPR in an OFDM system. The basic idea behind this technique is that it firstly divide the incoming or transmitted sequence into sub parts and check the PAPR of each sub sequence and transmit only that sequence which are having lower PAPR [6]. Thus it is helpful to overcome the major problem of OFDM system but on the other hand complexity increases as side band information is also required in this reduction technique. We can overcome this by using this technique with some other technique so that its disadvantages can be removed and make the system efficient [7]. The selected signals sent to the receiver along with selected signal as information (SSI) to decode information at the receiver. Even though SLM method uses codes, it's been limited to only PAPR reduction but not any error correction codes [8].

4. Proposed Methodology

(i) Hybrid SLM with Transform:

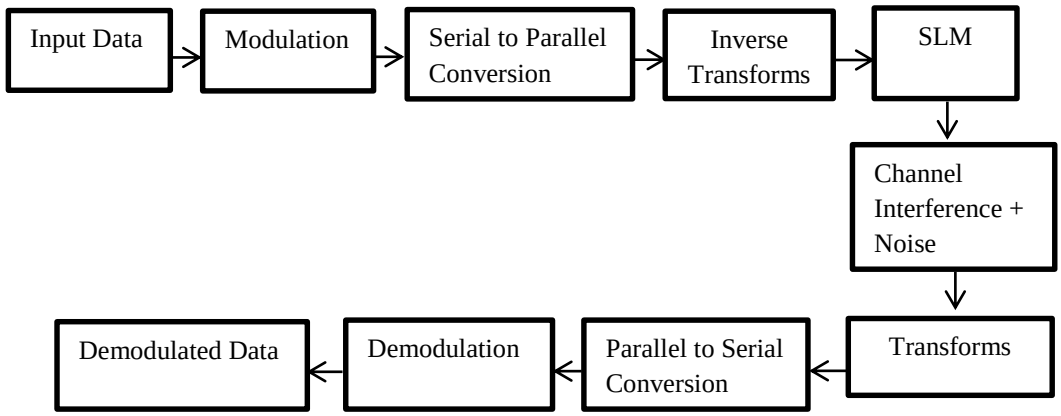

Figure 3: Hybrid Combination of SLM with Diverse Transforms in OFDM System

In this technique, we are using different transforms with SLM technique to reduce the PAPR of an OFDM system. In this system, we don't use IFFT block at the transmitter side and also FFT block at the receiver side. Reduction technique SLM is used after the transform block. In this paper we are using DCT, DST, Hadamard transforms and natural Hadamard transform.

- **DCT (Discrete Cosine Transform):** DCT expresses a limited succession of information focuses as far as an entirety of cosine capacities wavering at various frequencies [9].

$$\left[\frac{1}{\sqrt{M}}, \quad i=0,\ 0\leq j\leq M-1 \right. \tag{3}$$

$$\left|\sqrt{2}/\sqrt{\mathrm{M}}\cos\frac{(2\mathrm{j}+1)\mathrm{i}\pi}{2\mathrm{M}}\ 0\leq \mathrm{i},\mathrm{J}\leq \mathrm{M}-1, \right. \tag{4}$$

  Where i, j are row and columns respectively.

- **DST(Discrete Sine Transform):** It is proportionate to the fanciful parts of a DFT of generally double the length, working on genuine information with odd symmetry (since the Fourier change of a genuine and odd capacity is non-existent and odd), where in a few variations the information and additionally yield information are moved significantly a sample[8].

$$Y(k)=\sum_{n-1}^{N} x(n)\ sin\,\pi\frac{kn}{N+1}\ \ k=1,\ldots\ldots\ldots N \tag{5}$$

  x is input matrix, y is output.

- **Hadamard Transform:** Walsh-Hadamard change is utilized for direct change which could represent to a vector by the straight blend of the column vectors of a change matrix [10]. Its change system, W_N, is a square and symmetric matrix characterized as:

$$W_N=\begin{bmatrix} WN/2 & WN/2 \\ WN/2 & -WN/2 \end{bmatrix} \tag{6}$$

  Where W1 = 1. Particularly, if $N = 2^n$, n is a positive integer.

(ii) Hybrid SLM with Precoding:

In Hybrid precoded technique, we used IFFT with transform block and that output is fed to the reduction technique SLM to get the better results of PAPR and BER because sometimes alone transform can't give the good BER [11]. So precoding is used in combination of SLM. Which on combine form hybrid technique. DCT, DST, Hadamard transform and natural Hadamard transform are used in combination of IFFT block [12]. Firstly transform is applied to the modulated data and that transformed data given to the IFFT block and further process to the SLM block. The same procedure is done at the receiver side.

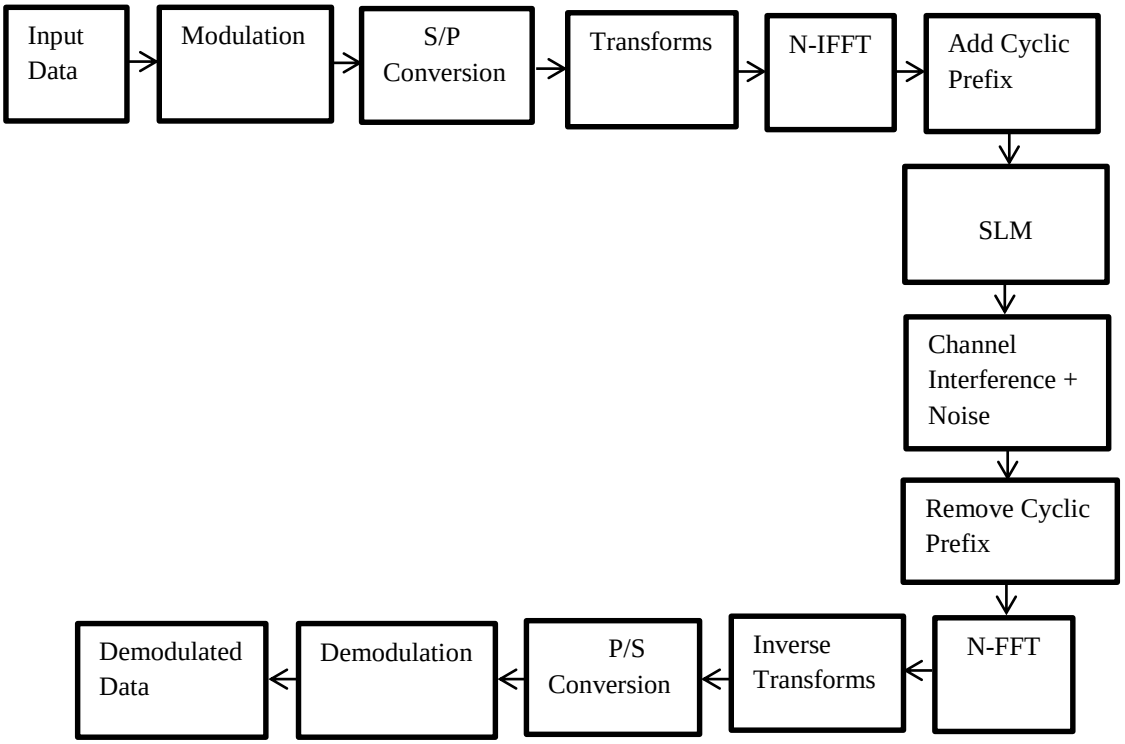

Figure 4. Hybrid Combination of SLM with Precoding Techniques in OFDM System

5. Result Discussion

PAPR and BER analysis are done for above defining techniques.

(a) Analysis of OFDM System

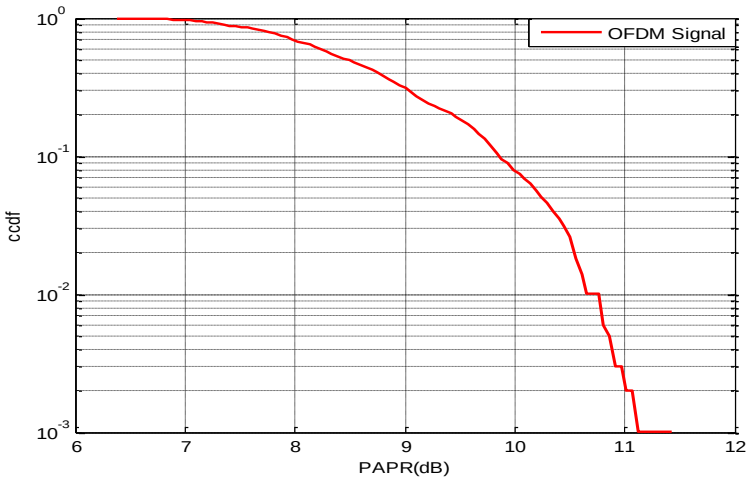

Figure 5(a). PAPR vs. CCDF of OFDM Signal

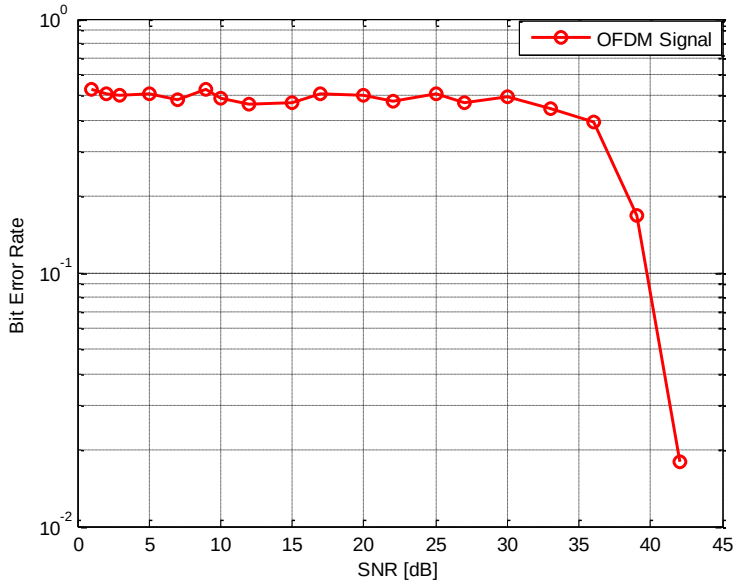

Figure 5(b). SNR vs. BER of OFDM Signal

Figure 5(a) and (b) shows the PAPR and BER analysis of OFDM signal which is 15dB and 45dB respectively which is quite increased. These results are for simple OFDM signal *i.e.*, without any reduction technique.

(b) Analysis of OFDM System with SLM Reduction Technique

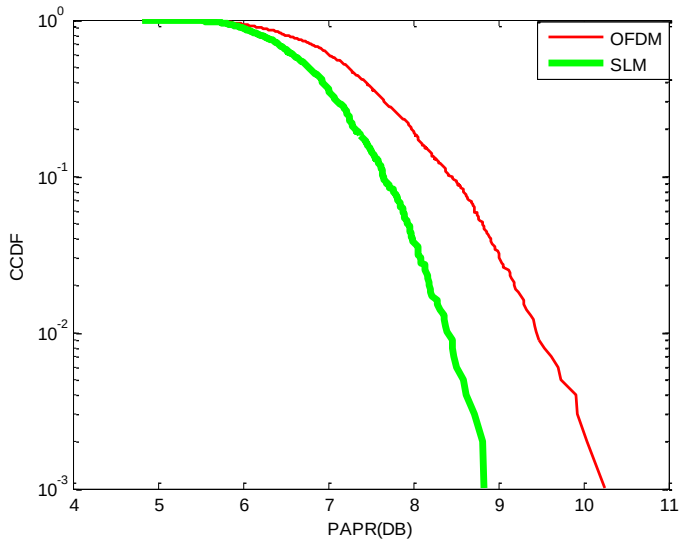

Figure 6(a). PAPR vs. CCDF of OFDM with SLM Signal

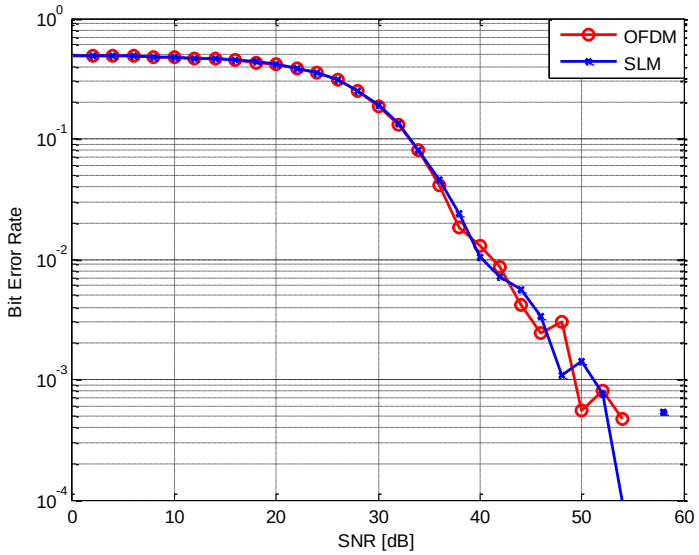

Figure 6(b). SNR vs. BER of OFDM with SLM Signal

In Figure 6(a) and (b) simulates the SLM technique for PAPR and BER. On comparison of OFDM signal with SLM signal PAPR is 10.3 dB and 8.7dB approximately which is lesser than the OFDM signal. So by applying the SLM reduction technique on the OFDM block, we get better performance of a signal by lowering down the PAPR of a transmitted signal and BER for SLM is 55dB approximately which is not quite useful for the system whether PAPR is good for SLM-based OFDM system.

(c) Analysis of OFDM with Hybrid Combination of SLM and Diverse Transforms

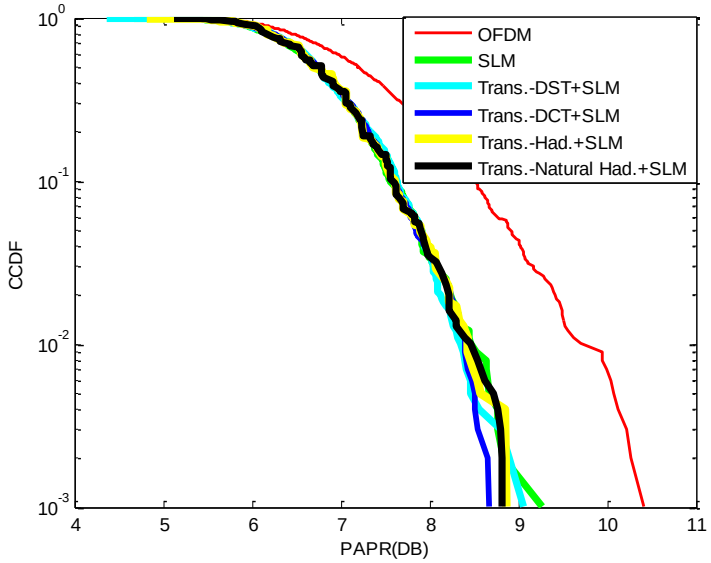

Figure 7(a). PAPR vs. CCDF Analysis of OFDM with the Hybrid Combination of SLM with Diverse Transforms

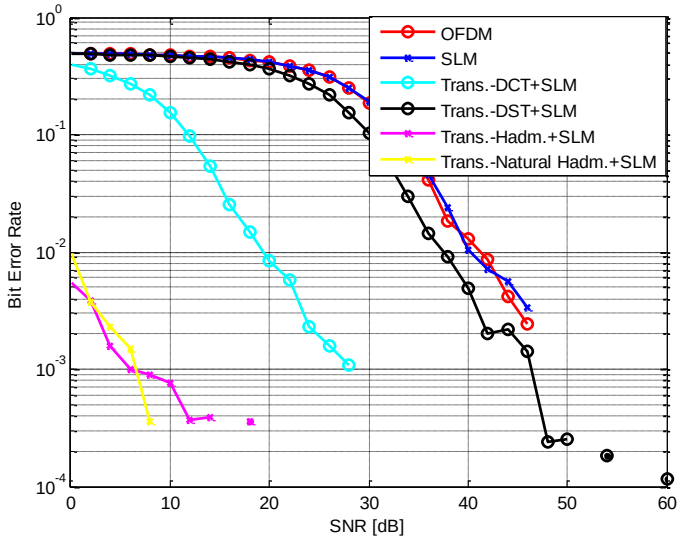

Figure 7(b). SNR vs. BER Analysis of OFDM with the Hybrid Combination of SLM with Diverse Transforms

Figure 7(a) and (b) simulates the proposed technique *i.e.*, Hybrid SLM with Transform (DCT, DST, Hadamard Transform, Natural Hadamard Transform) which represents the PAPR and BER analysis. In this technique different transforms are performed on the SLM data and the receiver data inverse operation of the transform is performed. No IFFT operation is performed here. PAPR for Hybrid SLM with DST, DCT, Hadamard and natural Hadamard are 9dB, 8.7dB, 8.9dB, 8.8dB respectively which is are approximately same and BER analysis for the same are 60dB, 20dB, 30dB, 9dB respectively.

(d) Analysis of OFDM with Hybrid Combination of SLM and Precoding Techniques

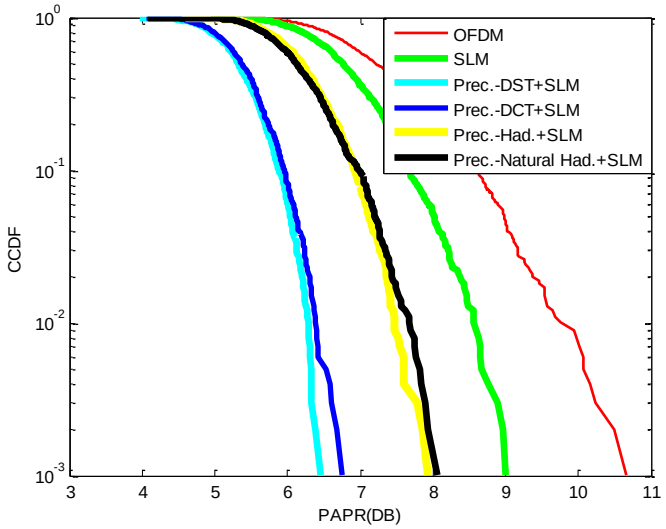

Figure 8(a). PAPR vs. CCDF Analysis of OFDM with Hybrid Combination of SLM and Precoding Techniques

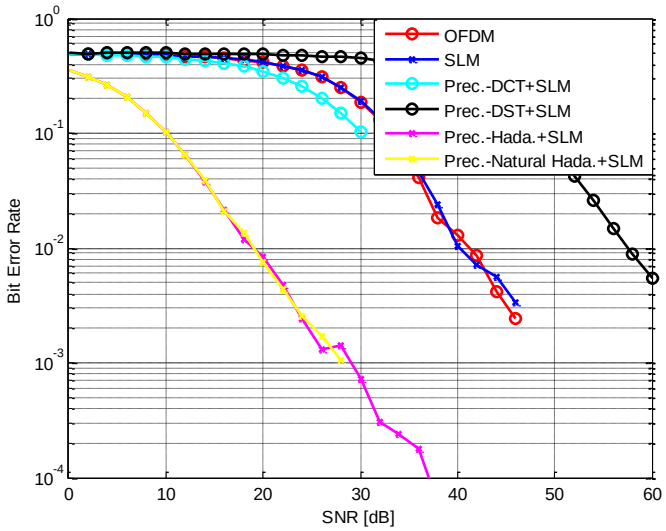

Figure 8(b). SNR vs. BER Analysis of OFDM with Hybrid Combination of SLM and Precoding Techniques

Figure 8(a) and (b) simulate the proposed technique for PAPR and BER analysis for the Hybrid technique which is the combination of reduction technique SLM with Precoded DCT, DST, Hadamard and natural Hadamard transforms. IFFT operation is performed here. PAPR for Hybrid SLM with DST, DCT, Hadamard and natural Hadamard are 6.5dB, 6.8dB, 8dB, 8dB respectively and BER analysis for the same are 60dB, 50dB, 38dB, 30dB respectively. By applying the precoding, PAPR gets lowered down if we compare these results with hybrid transform, but at the same time, poor BER results are there.

6. Conclusion

This paper evaluated the PAPR and BER performance for the OFDM system which includes the Hybrid combination of SLM with diverse transforms and precoding techniques. Complexity increases in SLM just because of the need of side band information, but at the same time, we get the better PAPR result as simulation results are given to support the statement. In hybrid techniques, we get the better results in the case of precoding with SLM but at the same time BER results are not up to the level, but with hybrid transform, with SLM good BER results are obtained in the case of natural Hadamard transform which is 9dB with 8.8dB value for PAPR. So proposed hybrid techniques simulation reduced the PAPR as compared to the conventional SLM, and better BER result gained as compared to conventional SLM.

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