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Performance Analysis of PAPR Reduction in LTE System

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Abstract

Peak to Average Power Ratio in Long Term Evolution (LTE) system is an challenging and a difficult issue. To avoid the insufficient cyclic prefix, proposed the block size to be minimized, so the bit error rate is decreased to improve the better performance of the system. PAPR reduction is also proposed with two modulation techniques such as Quadrature Amplitude Modulation and Quadrature Phase Shift Keying. In the receiver side, a Maximum Euclidian Distance decoder is introduced to minimize the distance in the Euclidian space to get the output signal. The proposed results of cyclic prefix and peak to average power ratio reduction can be plotted and simulated.

Keywords: Bit Error Rate (BER), Cyclic Prefix, MIMO-OFDM, PAPR, Pre-Coding

1. Introduction

The Orthogonal Frequency Division Modulation (OFDM) sends data at a higher bit rate and consequently, the need for more bandwidth due to the high resistance frequency selective channels[1]. The Orthogonal Frequency Division Multiplexing (OFDM) symbols sequenced alternately without any Cyclic Prefix (CP) before using each OFDM symbol[2,3] In the receiver side, the Space-Time Block Codes (STBC) is built with the CP free ***Multiple Input, Multiple Output*** (MIMO)-OFDM system through the time varying multipath channels. Moreover, the Inter Channel Interference (ICI) could not decreased effectively without CP in the OFDM system, instead the inter symbol interference has been placed. In wireless communication system, STBC can satisfy full diversity with a linear receiver and also having Multiple Input and Single Output (MISO) antennas[4]. The linear RF components and Peak-to-Average Power Ratio (PAPR)-reduction method are deployed to avoid unwanted out-of-band radiation and distortions in signal of the system[8]. Actually if the CP length is sufficient than the PAPR requirement does not reduced, then the spectral efficiency demanded. If the CP length is insufficient in the OFDM system, then the ICI can be introduced in the transmission block. In the LTE system, the OFDM signal faced critical problem in high PAPR and it leads to high effort in designing the Power Amplifier (PA) in preventing the signal clipping. When the PAPR provides high then the performance increases the hardware complexity and also increased power consumption[9]. The key design parameter can be implemented to minimize PAPR and also for obtaining the spatial multiplexing gain. The constant parameter 'a' is used to indicate the received Signal-to-Noise Ratio (SNR) loss at the reduction of PAPR. In some cases, the SNR loss provides the improved performance of PAPR reduction with the average transmission power at its required level[10,11.] Finally the simulation results provide a PAPR close to '1' with less SNR loss[12]. In OFDM system, when all subcarriers have the same phase, power of the moment the

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signal can be very large and thus the maximum of OFDM signal is much greater than the average signal. This phenomenon is called the PAPR problem.

2. Proposed System Model

The received signal is split into different frequencies and merged with their respective phase rotation sequences. These signals enter the Space Frequency Block Coding (SFBC) and each signal is split into two signals. The first signal of each output is X_1 and the second output is X_2. Each of these signals is then given to the Inverse Fast Fourier Transform (IFFT) filter and PAPR is also calculated before transmitting the data.

Also, a de-multiplexer selects the minimum PAPR signal from N number of data before transmitting. There are two transmitting antennas T_{x1} and T_{x2}. T_{x1} keeps the data unchanged, while the data at T_{x2} is multiplied by the phase offset $e^{j2\pi u/U}$. The receiving antenna Rx receives the signal and then performs FFT and the signals Y_e and Y_o are used in the below equations (1,2) to get X_e and X_o. It is then passed through MED (Minimum Euclidean Distance) decoder to minimize the distance in the Euclidian space to get the output signal D.

$$\bar{X}_e^u(l) = H_{1,e}^*(l)Y_e(l) + e^{\frac{j2\pi u}{U}} H_{2,o}(l)Y_o^*(l) \quad (1)$$

$$\bar{X}_o^u(l) = e^{\frac{-j2\pi u}{U}} H_{2,e}^*(l)Y_e(l) - H_{1,o}(l)Y_o^*(l) \quad (2)$$

3. Performance Analysis

3.1 BER Analysis

BER is an important parameter which is used to transmit the digital data from one form to another. During transmitting the information, the overall error can be detected and calculated the total number of bits in the system.

BER = (No. of errors) / (Total no. of bits sent) (3)

3.2 PAPR in Alamouti OFDM System

3.2.1 PAPR Definition

The transmitted OFDM signals are characterized with the peak-to-average (power) ratio (PAR)[6].

The Space-Frequency Block Coding (SFBC) is provides with two transmit antennas. Therefore, the transmitted input data are encoded with the two variables X1 and X_2.

$$X_1 = [X(0), X^*(1), \ldots, X(N-2), -X^*(N-1)] \quad (4)$$

$$X_2 = [X(1), X^*(0), \ldots, X(N-1), -X^*(N-2)] \quad (5)$$

Where X(K) is modulated input signal and N is the number of sub-carriers, and (.)* represent the complex conjugate operation. Then modulated signal is passed to the IFFT waveform and the time domain signal:

$$x_i(n) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_i(k) e^{\frac{j2\pi kn}{jN}} \quad (6)$$

where, I = 1, 2, and n = 0, 1. . . J(N-1) and J is an integer. The PAPR of OFDM signals is defined as

$$APR = \max_{i=1,2}\{PAPR_i\} \quad (7)$$

4. Existing Technique

To generate the transmission in the OFDM system successfully, it has to maintain the orthogonality of the carriers between all the carriers[5]. There are more number of multiple orthogonal subcarrier signals, that are overlapped together to join with the N-point IDFT of the transmitted symbols. IDFT is an important aspect in generating the OFDM symbol of the modulation symbol in every sub-channel. Selected Mapping (SLM) is a well-known technique of PAPR reduction and it provides the flexible performance to improve the diversity and providing a better spatial multiplexing[7]. Moreover, this system suffers from high PAPR and inter-symbol interference (ISI), which occurs due to loss of orthogonality due to channel effects. It also requires time and frequency synchronization to get a low bit error rate[6]. The Partial Transmit Sequence (PTS) is another method of the PAPR reductions; it's not only improves the BER but also the convergence speed in order to perform less decoding iterations and severely reduces the PAPR.

5. Proposed Technique

The pre-coding scheme can be inserted in the OFDM system to avoid the ISI in the communication channel and also this scheme to be used to destroy the spectral nulls between the two K consecutive information symbols[7]. The vector OFDM system can generated, if each K consecutive symbols are blocked together and no zero is assigned between each two sets of K consecutive symbols. Here proposed to reduce the cyclic prefix length instead of establishing K times as size K×1 vector OFDM system. This technique has shown significant improvements in BER performance. The spectral efficiency is increased by the use of OFDM and a reduced CP length is obtained. Also, the interference is less in low SNR region. The BER performance for IA based precoding, Single Carrier Frequency Domain Equalizer (SC-FDE), CP-OFDM; Zero-Padding (ZP) is analyzed.

6. Results and Discussion

Simulations results are obtained to evaluate the ability of the proposed scheme in the BER performance varies with SNR. Quadrature Phase Shift Keying (QPSK) and 16-QAM modulation techniques are employed to give

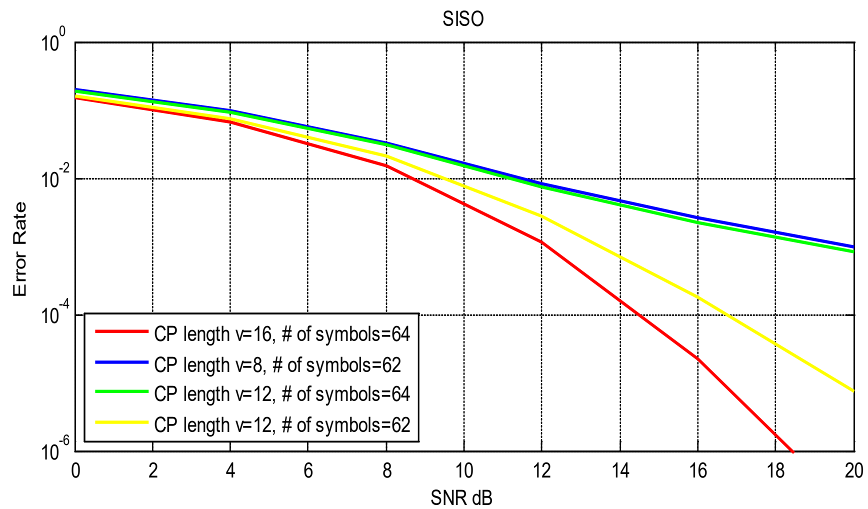

Figure 1. Block diagram of the proposed system.

Table 1. 16 QAM, block size N= 8, with varying CP length

	0dB	4dB	8dB	12dB	16dB	20dB
L=8	0.4	0.25	0.05	0.0008	0.000006	-
L=16	0.4	0.25	0.05	0.0008	0.000010	-
L=32	0.4	0.25	0.05	0.0009	0.000015	0.0000015
L=64	0.4	0.25	0.05	0.0008	0.000019	-

different CP lengths and different numbers of information symbols.

The simulations in Figure 1 shows proposed system of the PAPR reduction with MED decoder to select the minimum values of CIR as $L = 16$. The Zero Padding scheme could be used to achieve the full multipath diversity with the ZF receiver. The block size is kept constant for 16 QAM with varying CP length. Table 1, as CP length increases, BER also increases. BER is least when L=8 which states, the performance is better when CP length is minimum.

Now, the CP length is kept constant for 16 QAM with varying block size. Table 2, it states as block size increases, BER also increases. BER is least when N=8. So, the performance is better when block size also is minimum. In Table 3, the block size is kept constant for 64 QAM with varying CP length. From the observed data, it states that the CP length improves by increasing the BER. The system performs better when the BER is less (L=8) and also the CP length is minimized. The CP length is kept constant for 64 QAM with varying block size. As for the analysis Table 4, with the increase in the block size, BER also increases. At 12dB, BER is least for N=8. So, the overall performance is better when block size is minimum.

In Figure 2, the error rate versus SNR is plotted for different CP length and different symbols with v = 8 and 12 respectively. The number of transmitted in one block are 62 and 64, respectively. In Figure 3, the IA based pre-

Table 2. 16 QAM, CP length = 16 with varying block size

	0dB	4dB	8dB	12dB	16dB	20dB
N=8	0.35	0.25	0.05	0.0008	0.00001	-
N=16	0.40	0.30	0.12	0.0045	0.000045	-
N=32	0.42	0.35	0.20	0.025	0.00007	-
N=64	0.45	0.40	0.30	0.08	0.0005	-

Table 3. 64 QAM, block size N= 8, with varying CP length

	0dB	4dB	8dB	12dB	16dB	20dB
L=8	0.35	0.12	0.05	0.0008	0.000010	-
L=16	0.35	0.12	0.05	0.0007	0.000015	-
L=32	0.35	0.12	0.05	0.0006	0.000010	-
L=64	0.35	0.12	0.05	0.0007	0.000015	-

Table 4. 64 QAM, CP length = 32 with varying block size

	0dB	4dB	8dB	12dB
N=8	0.35	0.22	0.05	0.0006
N=16	0.37	0.28	0.10	0.004
N=32	0.40	0.32	0.20	0.02
N=64	0.42	0.38	0.25	0.07

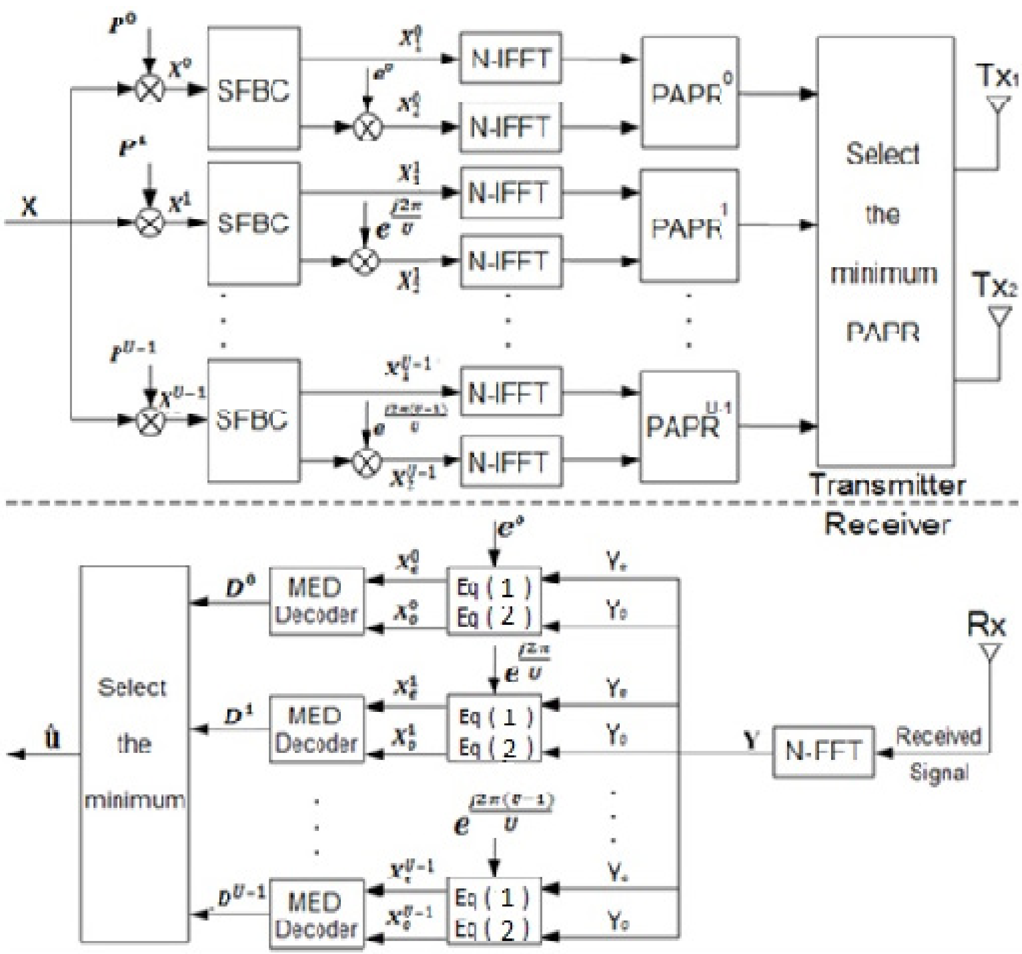

Figure 2. BER performances of the IA based pre-coding, SC-FDE, CP-OFDM, ZP-only.

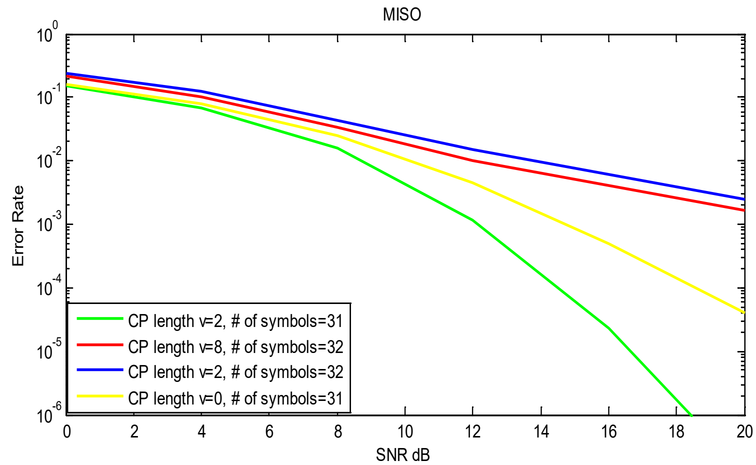

Figure 3. SISO case: BER performances of different CP lengths and different numbers of information symbols.

coding scheme with different CP lengths and different numbers of information symbols for the MISO configuration of $n_t = 2$ and $n_r = 1$ are shown. For different CP length and symbols, the simulation is performed. The graph states the error rate.

In Figure 4, the IA based pre-coding scheme proposed for a MIMO-OFDM of four transmit and two receive antennas is simulated, i.e., $n_t = 4$ and $n_r = 2$. Both cases of satisfying (green and yellow) and not-satisfying (red and blue) are considered. Figure 5-7 plotted the comparison of PAPR reduction for 16-QAM and QPSK and its BER performance. It shows the Complementary Cumulative Distribution Functions (CCDF) of the PAPR for original signals. From that graph, it compares the P-SLM and

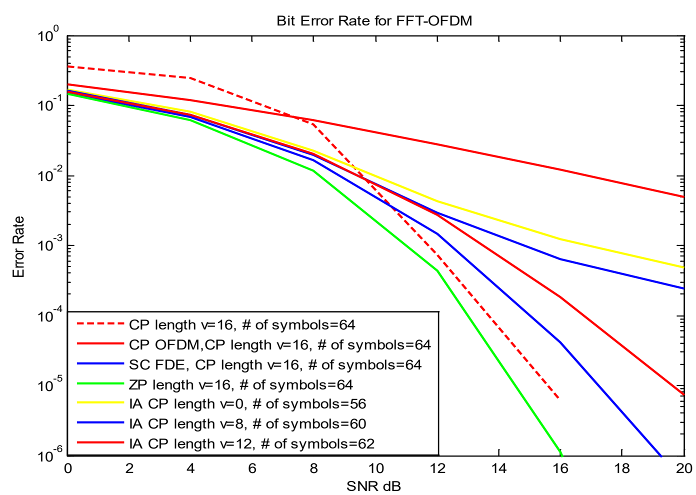

Figure 4. MISO case: BER performances of different CP length and different no's of information symbols.

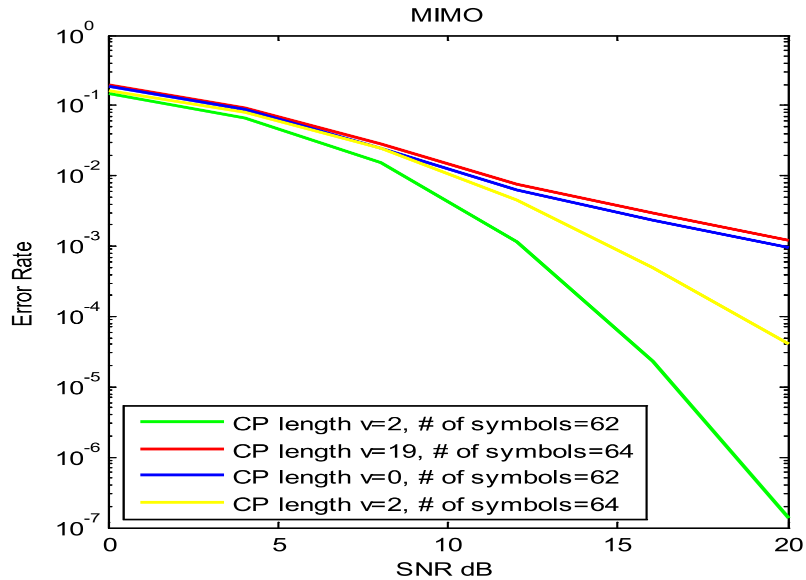

Figure 5. MIMO case: BER performances of different CP Lengths and different numbers of information symbols.

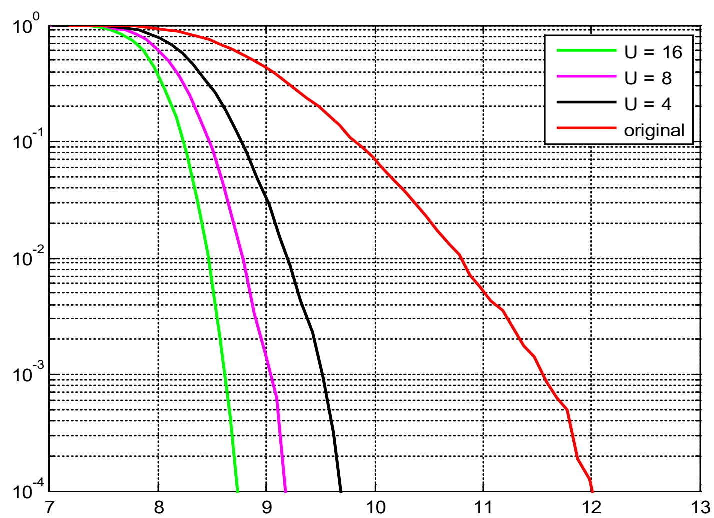

Figure 6. Comparison of the PAPR reduction with QPSK.

C-SLM scheme to give the same PAPR reduction performance and it offers better than B-SLM scheme. The simulation is carried out for different values of U, such as U=4, 8 and 16, with QPSK and 16 QAM modulation. For CCDF = 10^{-4}, the PAPR reduces at 2.6 dB, 3.1 dB and 3.6 dB respectively. Higher the value of independent codes, u,

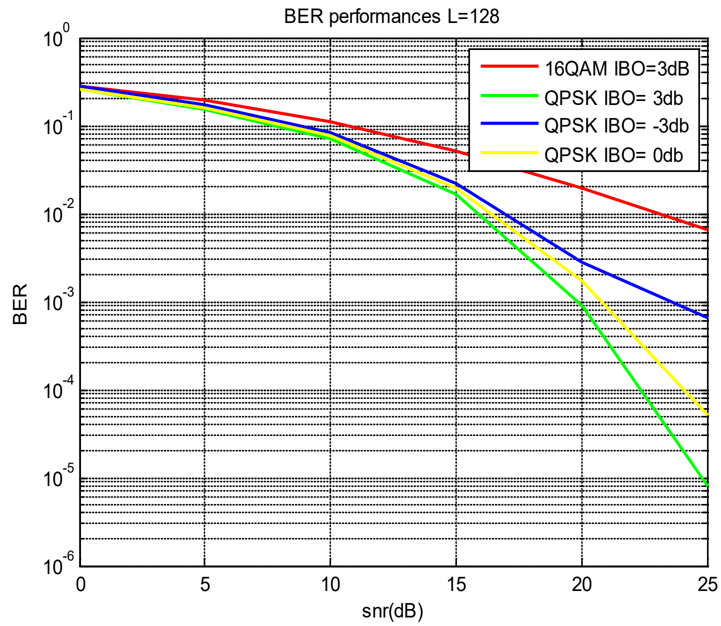

Figure 7. BER performance with QPSK and 16 QAM (L=128).

PAPR reduction is better. The BER less for QPSK modulation at 3db is minimum when the CP length is minimum with minimum symbols.

7. Conclusion

In MIMO-OFDM system, CP is used to avoid inter carrier interference and also to decrease the BER. But due to channel independent pre-coding the CP is insufficient. This insufficiency can be solved by using different block size for decreasing the BER as shown in Table 1-4. It is shown that the proposed pre-coding is more bandwidth efficient than the conventional ZP or CP added MIMO systems, if the number of receive antennas is not more than the number of transmit antennas. Also, a MED decoder is proposed to reduce the PAPR in Alamouti MIMO-OFDM systems without any disturbance and ICI information. Finally the PAPR reduction and BER yields better than the conventional technique.

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