High Performance PAPR Reduction Scheme with Digital Amplitude Pre distortion MIMO-OFDM Systems

T. Ganga Bhavani[1], U. Venu[2]
[1]*M.Tech Student, Vaagdevi College of Engineering, Warangal, Telangana, India*
[2]*Assistant Professor, Vaagdevi College of Engineering, Warangal, Telangana, India*

***Abstract-* The multiple-input multiple-output (MIMO) orthogonal frequency division multiplexing (OFDM) system, an attractive technique due to its robustness for time selective fading channels. The major drawback of orthogonal frequency division multiplexing (OFDM) systems is the high peak to average power ratio (PAPR), which results in signal distortion when the transmitter has nonlinear components. The MIMO-OFDM system also inherits from OFDM systems the drawback of high peak-to-average power ratio (PAPR) of the transmitted signal. The selected mapping (SLM) method is a major scheme for PAPR reduction. Unfortunately, computational complexity of the traditional SLM scheme is relatively high since it requires a number of inverse fast Fourier transforms (IFFTs). In this letter, a low-complexity PAPR reduction scheme is proposed for MIMO-OFDM systems, needing only one IFFT. The proposed scheme exploits the time-domain signal properties of MIMO-OFDM systems to achieve a low-complexity architecture for candidate signal generation. In such cases, PAPR reduction techniques may be resorted to help to improve the HPA efficiency.**

***Index Terms-* Multiple-input multiple-output (MIMO), orthogonal frequency division multiplexing (OFDM), peak-to-average power ratio (PAPR), Predistortion.**

I. INTRODUCTION

Recent trends in multiple-input multiple-output (MIMO) orthogonal frequency division multiplexing (OFDM) have attracted increasing attention because it is robust to time selective fading channels. However, MIMO-OFDM systems also inherit disadvantages from OFDM techniques, e.g., sensitivity to synchronization errors and high peak-to-average power ratio (PAPR). The literature presents a variety of PAPR reduction methods for OFDM systems, e.g., selected mapping (SLM)[1], [2], [3] and partial transmitted sequence (PTS) [4]. In addition, a joint PAPR reduction scheme is proposed in [5] for MIMO-OFDM systems. Unfortunately, the computational complexity of these schemes is extremely high. Existing PAPR reduction methods use clipping, coding or multiple signal representation [6-8]. Among of them, the clipping scheme is the simplest method to reduce the PAPR. However, the quality of its output signal is degraded by out-of band radiation and in-band distortion [9]. The out-of band spectral regrowth can be alleviated by time-domain filtering. Then, the ACE technique, allows the in-band fading to extend the signal constellation only into desired directions without sacrifice the subcarrier tones.

In [10], researchers propose a polyphase interleaving and inversion (PII) scheme for reducing PAPR in SFBC MIMO-OFDM systems. Although the PII scheme needs only two inverse fast Fourier transforms (IFFTs), its computational complexity is also high since it requires an exhaustive search of all possible parameter combinations to obtain a sequence set with the smallest maximum PAPR. The OFDM is an attractive technique for wireless multimedia communication by virtue of its excellent properties in frequency-selective fading environments. However, OFDM system exhibits large PAPR, which cause a loss in energy efficiency due to the need of power back-off at the HPA. Therefore, it is important to reduce PAPR of OFDM signal and to compensate for nonlinear distortion of the power amplifier. In this letter, low-complexity PAPR reduction architecture is proposed for SFBC MIMO-OFDM systems that employs the Alamouti scheme. As opposed to conventional schemes that require at least two IFFTs, the proposed scheme fully exploits the time-domain signal relationship between the two antennas and only needs one IFFT. The candidate signal pairs of the two antennas are generated in the time-domain, rather than the frequency domain, for complexity reduction by using a variety of time-domain signal properties inherent in SFBC MIMO-OFDM systems. Extending the proposed scheme to more than two transmit antennas is possible by applying appropriate time-domain signal properties. However, minor modifications should be made to the low-complexity architectures that adopt various encoding matrices.

II. SYSTEM DESIGN MODEL

A. OFDM System Architecture

OFDM is multicarrier modulation technique known for its capability to mitigate multipath. In OFDM, a high speed data stream is divided into "N" narrowband data streams and is modulated using subcarriers which are orthogonal to each other and the information is transmitted on each sub carrier. OFDM is well suited for transmission of high data rate applications in fading channels due to its robustness to inter symbol interference. IFFT is performed at the transmitter and FFT at the receiver, resulting in conversion of wideband signal affected by frequency selective fading, into "N" narrowband flat fading signals. Therefore, simpler equalizer is required at the receiver. OFDM is used for dedicated short-range communications (DSRC) for road side to vehicle communications and as a backbone for fourth generation (4G) mobile wireless systems. In the traditional frequency division multiplexing (FDM) system, signals are transmitted in different channels. Guard intervals are required for channel isolation and filtering to prevent interference and guarantee effective wireless communication. However, at receiving end a series of band-pass filters are required to separate and extract information which results in less frequency spectrum utilization. Figure.1 and 2 depict the frequency spectrum utilization efficiency in FDM and OFDM system, respectively. Each subcarrier in OFDM system signal has a very narrow bandwidth with low symbol rate. The signal therefore, has immunity on multipath delay spread. At the receiving end transmitted in low-speed parallel subcarriers, it has increased symbol period which help to reduce the time dispersion and ISI of the system.

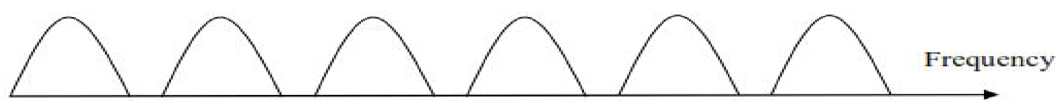


Figure 1 Spectrum of traditional FDM modulation scheme

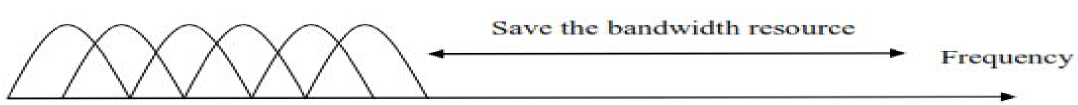


Figure 2 OFDM Spectrum.

B. Transceiver OF OFDM

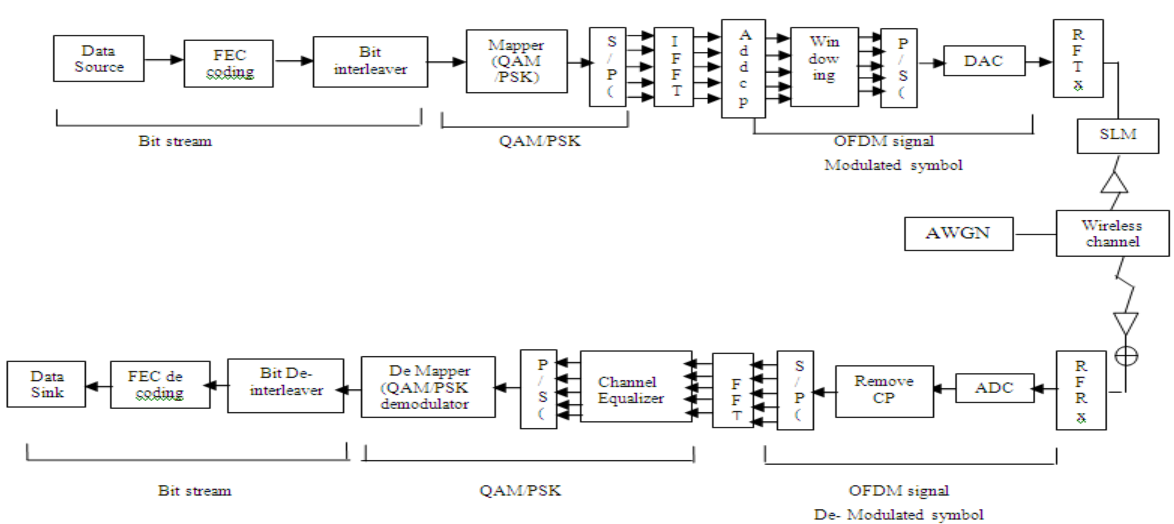


Figure 3 Transciever of OFDM

C. MIMO-OFDM Architecture

MIMO-OFDM [4], technique is used in wireless communication systems to achieve gigabit transmission. It enables high capacities suited for internet and multimedia services which increase the range and reliability. It also increases diversity gain and enhance system capacity of application services on a time-varying multipath fading channel improving power-spectral efficiency in wireless communication systems besides optimizing the power efficiency. The technology guarantees each user's quality of service (Qos) requirements that include low bit-error rate (BER) and high data rate and as a result ensures fairness to all the active users. It allows transmission over high frequency selective channels at a reduced Bit Error Rate with better quality signal. As MIMO can be combined with any modulation or multiple access technique, therefore the implementation of combination of MIMO and OFDM is more efficient. OFDM has the property of robustness against multipath delay spread. This is achieved by having a long symbol period, which minimizes the inter-symbol interference [5]. MIMO, can be used either for improving the SNR or data rate. Therefore both these techniques result in a new mechanism which is very helpful in aiming at the design of high-rate data carrying wireless mobile systems. One of the advantages of this system is to achieve reduced BER. The BER of this system is quite less as compared to an OFDM system. For a fixed value of SNR possible to achieve less bit error rate, so can say that have an improvement in SNR or can say that have less error probability of bits resulting in higher data rate. On increasing the number of antennas on transmitter and receiver side, the BER is further reduced because of diversity. In the current paper an 8x8 MIMO-OFDM system is discussed for reduction of PAPR using SLM technique and enhanced channel capacity.

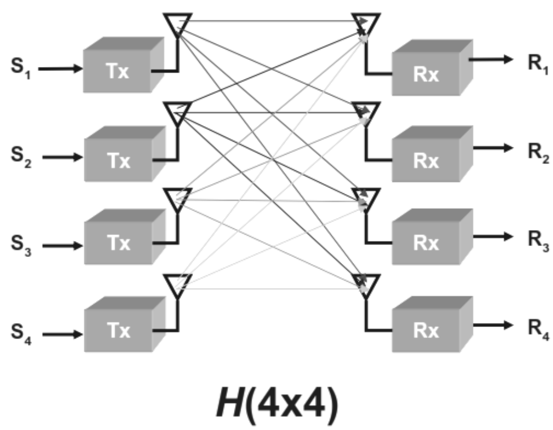


Figure 4 Block diagram of MIMO system (4 * 4)

Assume that MIMO system with transmit array of *NT* antennas and a receive array of *N*r antennas, the transmission is expressed as

$Y = Hx + n$ (1)

where, Y is *N*r × 1 receiving vector, x is *NT* × 1 transmitting vector and n is additive white Gaussian noise with autocorrelation matrix Rn = E {n nH} N0INT. INT is an Nt × Nt identity matrix, *N*0 is identical noise power of each receiving branch [14] - [15]. Figure 4 depicts 4 * 4 MIMO systems which comprises of 4 transmitter and 4 receivers.

D. Parameters of OFDM

(i) Peak to Average Power ratio (PAPR) : PAPR is defined as the ratio of the maximum peak power to that of average power of the complex pass band signal.

$$\mathrm{PAPR} = \frac{\mathrm{P_{peak}}}{\mathrm{P_{avg}}}$$

$$\mathrm{PAPR} = 10 \log \frac{\max\,[|s_n|^2]}{E[|s_n|^2]}$$

where, is the peak output power, is the average output power, E [.] denotes the expected value, represents the transmitted OFDM signals which are obtained by taking IFFT operation on modulated input symbols. PAPR is being very high can be reduced by using SLM probabilistic technique.

(ii) Polynomial Predistortion as Linearization Method: The HPA non-linearity introduces out-of-band and in-band distortion . Although PAPR reduction methods can reduce the peak power, it is not enough to suppress the distortion. Predistortion should be used to limit the spectral re-growth.

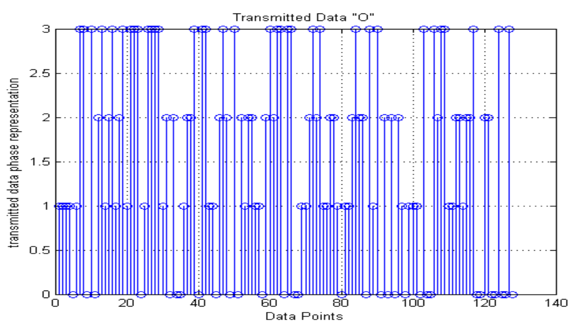
Rapp model is taken into consideration in this paper, which is widely used in most literatures for HPA performance analysis. The AM/AM transfer function of the HPA and the associated polynomial predistoter can be modeled as follows:

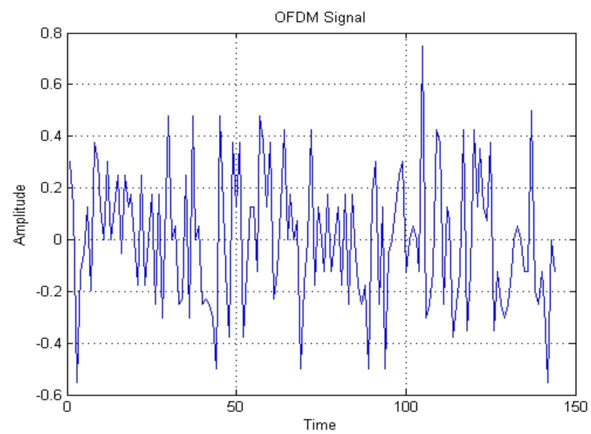
HPA AM/AM transfer characteristic:

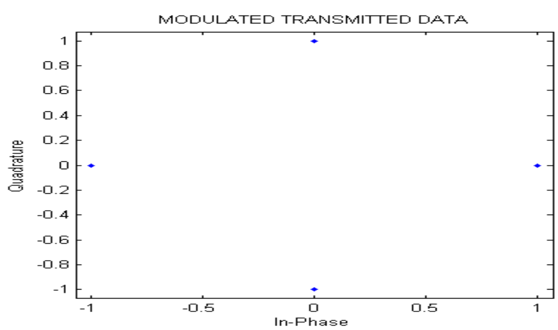
$$f_A(x) = \frac{x}{\left[1+(\frac{x}{A_{sat}})^{2p}\right]^{\frac{1}{2p}}}, x \in [0, +\infty]$$

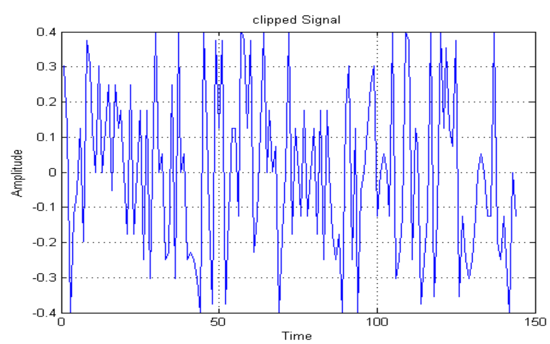
The predistortion is a linearization method in which the input signals are conversely predistorted before the HPA. HPA linearization system can be described as the cascade of the two function modules, the PAPR reduction module and predistortion module.

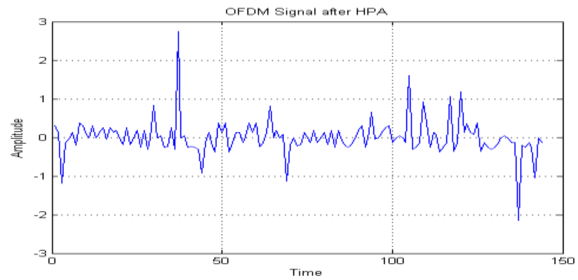
III. SIMULATION RESULTS

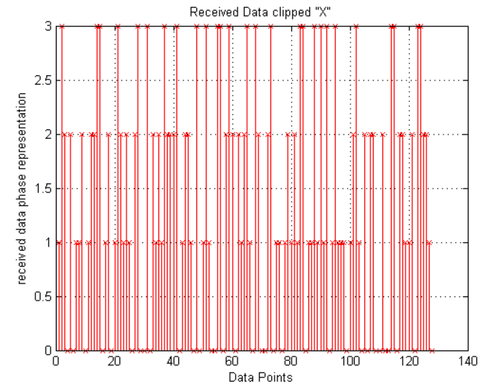


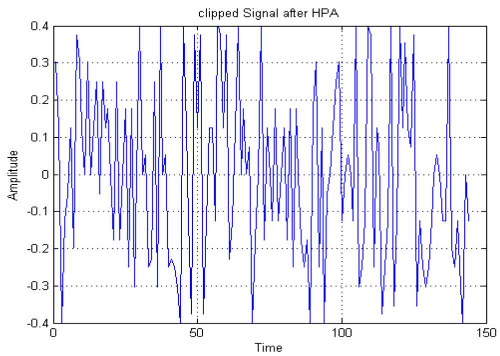


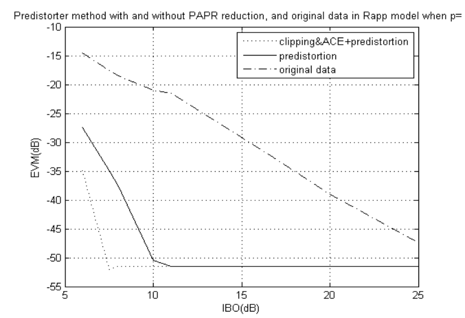


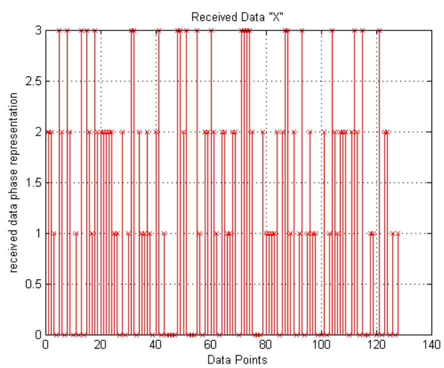


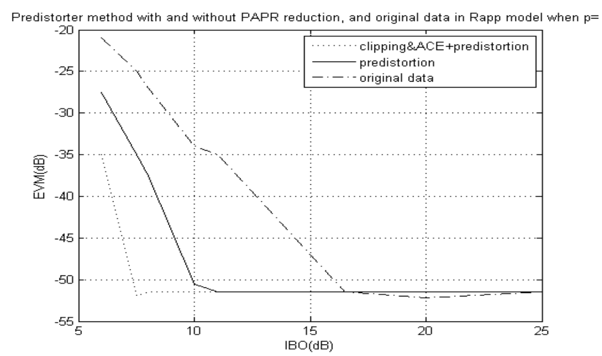

OFDM Signal after HPA
Amplitude
Time

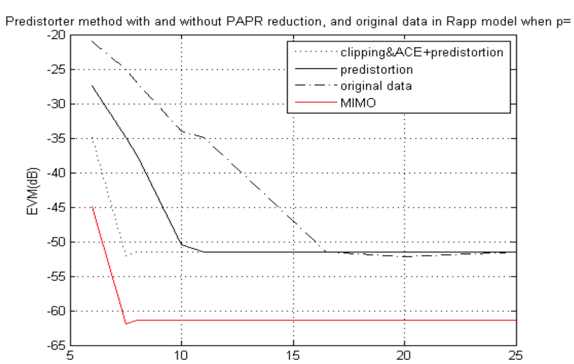

Received Data clipped "X"
received data phase representation
Data Points


clipped Signal after HPA
Amplitude
Time


Predistorter method with and without PAPR reduction, and original data in Rapp model when p=
clipping&ACE+predistortion
predistortion
original data
EVM(dB)
IBO(dB)


Received Data "X"
received data phase representation
Data Points


Predistorter method with and without PAPR reduction, and original data in Rapp model when p=
clipping&ACE+predistortion
predistortion
original data
EVM(dB)
IBO(dB)


Predistorter method with and without PAPR reduction, and original data in Rapp model when p=
clipping&ACE+predistortion
predistortion
original data
MIMO
EVM(dB)
IBO(dB)

This research performs a series of simulations to evaluate PAPR reduction performance of the proposed scheme. The simulations assume the data were 16-QAM modulated and the system contained sub-carriers N=256. To approximate the true PAPR, this study over-samples MIMO-OFDM signal by a factor of L=4.

The PAPR reduction and predistortion method suppresses the IBO better by about 14.55 dB than the original system. As seen in the Fig.3, when the smoothness factor p=2, the predistorter method plus PAPR reduction can achieve 1.85 dB and 5.75 dB IBO gain than predistorter method without PAPR reduction and original system, respectively. Consequently, it is clear that a good predistortion may be acquired but with low power efficiency. However, if the process PAPR reduction is utilized, we can improve the HPA power efficiency to a great extent with permitted average power increase.

IV. CONCLUSION

This paper provides an overview of Multiple-Input-Multiple-Output (MIMO) technology and Orthogonal-Frequency-Division-Multiplexing (OFDM). The focus of paper is that we investigate one of the bottleneck problems that exist in OFDM wireless communication system – high peak-average power ratio (PAPR) of OFDM signal, and discuss how to reduce it by different effective algorithms. In this case, PAPR reduction technique plays an important role in reducing the probability of signals falling into saturated area. Also, power efficiency of HPA can be increased. Overall, the tests of the proposed method show a good performance of linearity improvement at the cost of a slight increases in average power.

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