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A TECHNICAL REVIEW OF PEAK TO AVERAGE POWER RATIO REDUCTION IN MIMO-OFDM

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ABSTRACT

In this paper, detailed review of bit error rate (BER) and peak to average power ratio (PAPR) reduction in multiple input multiple output-orthogonal frequency division multiplexing (MIMO-OFDM) and performance analysis of OFDM in various channel is given. This paper will contribute in better choices of technical methods to reduce bit error rate and the peak to average power ratio in orthogonal frequency division multiplexing for high speed wireless communication. One major shortcoming of OFDM is the high peak-to average Power ratio (PAPR). Most investigated techniques modified are Selected Mapping (SLM) and Companding scheme (CS).These are PAPR reduction techniques for multiple input multiple output-orthogonal frequency division multiplexing (MIMO-OFDM) without affecting the Bandwidth proficiency of the system and the Bit Error Rate (BER) performance. This is one of the strongest candidates for Future 5-G LTE wireless communication.

KEYWORDS: OFDM, PAPR, AWGN (Additive white Gaussian noise), MIMO, BER, CS, LTE (Long term evolution) and SLM.

INTRODUCTION

Recently in high speed wireless communication, orthogonal frequency division multiplexing (OFDM) [1] has been regarded and used as one of the technologies, for the present communication systems. Wireless communication system is growing speedily in communication industry. Especially OFDM has been adopted for various mobile and wireless communication systems [3] such as wireless local area networks (WLAN), wireless metropolitan area networks (WMANs), digital audio broadcasting (DAB),digital video broadcasting (DVB), and mobile 4th-generation (4G) network. It has high data rate as well as high spectral efficiency. LTE [7] launched the latest step towards the 4th generation of radio technologies. OFDM is an attractive technique for completing high data rate (GHz) in the wireless communication systems [4] and it is robust to the frequency selective fading channel [5]. However, an MIMO-OFDM signal can have very high Peak-to Average Power Ratio (PAPR) [6,9] and bit error rate at the transmitter side which causes the high signal distortion such as the in-band distortion and the out-of-band radiation [9] due to the non-linearity of class-C high power amplifier (HPA) [8]. The result causes high power transmission from transmitter side. In this paper organized as follows- Section II explains PAPR reduction in OFDM system, Section III describes PAPR reduction techniques, the next Section IV describes overall examination of different techniques and Section V describes conclusion.

PAPR REDUCTION

MIMO-OFDM system suffers from the problem of high PAPR, which ascends as an end result of the coherent addition of multiple sub-carrier, amplitude and phase from the system. A high PAPR limits the range of linear process of power amplifier in transmitter. This reduces the transmission efficiency of the system which is serious problem in communication system. Let us consider the data block of length small n,(n) to be represented by direction over time interval [0,τ]. The OFDM symbol can be written as –

$$X(t) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} \mathrm{X_k} * e^{j2\pi kft} \qquad \text{.....(1)}$$

where f = 1/T,

PAPR { X(t)} = max. $|x(t)|^2$ / avg $[x(t)]^2$,

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where max. $[x(t)]^2$ = peak signal power,
avg. $[x(t)]^2$ = average signal power,
and e|.| = expectation operator.

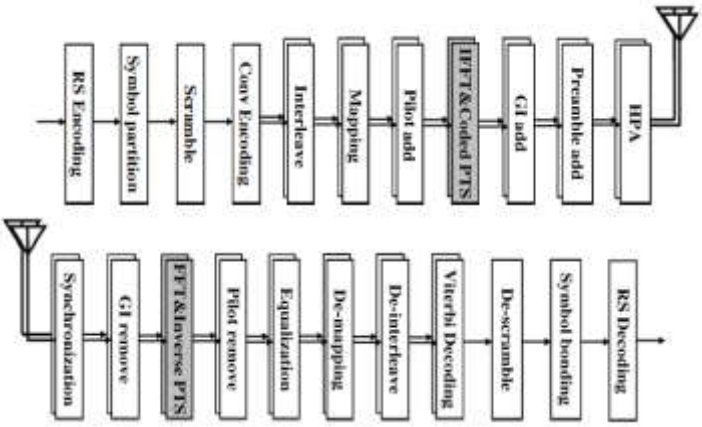

Figure 1- MIMO-OFDM System Model

Our goal is to reduhnice max.$|x(t)|^2$. This is the principle of PAPR**.** Figure-1 shows conventional MIMO-OFDM system [6].

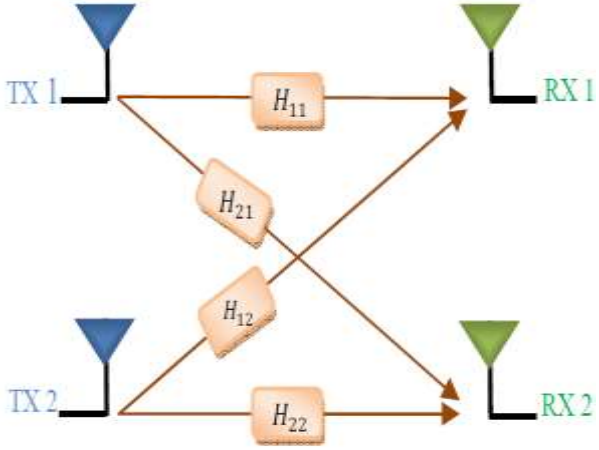

Figure 2- MIMO-OFDM Channel Model

The orthogonal transmitted pilot signals from the transmitter antenna Tx1 and Tx2 received pilot signals. Multiple signals are transmitted through H21 and H12 channels, on the receiver antenna Rx1 and Rx2 respectively [9] and hence receiving multiple signals simultaneously.

PAPR REDUCTION TECHNIQUES

PAPR reduction techniques differ according to the requirement of the system and are reliant on factors like spectral efficiency, failure in data rate, difficulty in calculation and increase in BER at receiver. Many techniques have been recommended for PAPR reduction, with different levels of success and complexity are described below as-

- Peak Windowing (PW)
- Partial Transmit Sequence (PTS)
- Tone Reservation (TR)
- Selected Mapping (SLM)
- Envelope Scaling (ES)
- Precoding Technique (PT)
- Companding Technique (CT)

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Peak Windowing (PW)
In this technique, it is possible to remove larger peak to average power, where large peaks arise infrequently, at the rate of a little amount of interference. It decreases PAPR at cost of increases BER and out of band radiation .It provides better PAPR passage with better spectral properties [9]. Large signal is multiplied with a specific window such as Gaussian shaped-window. The window type should be narrow, so that it affects the number of signal sample, which increases bit error rate. PAPR level will diminish to 6.8 dB with peak windowing technique.

Partial Transmit Sequence (PTS)
Partial Transmit Sequence (PTS) is one of the mainly resourceful techniques to diminish PAPR in OFDM. In this scheme, original signal is separated into number of sub-blocks and then phase rotation is added to develop number of candidate signal and choose the one with lowest PAPR [8] and then transmitted. A PTS scheme is used to reduce the computational complexity of the transmission scheme.

Tone Reservation (TR)
In this method, reserving a small segment of tones leads to large improvement of PAPR with simple operation at transmitter and no complexity at receiver.It is based on summing a data block and time domain signal. A data block is reliant on block signal to the original, multicarrier signal to decrease high peak. This time domain signal can be designed simply at the transmitter of system and stripped off at receiver [3]. This scheme takes an superiority as no necessitate of side information to send along with message, less complexity of the receiver. The advantages with this technique is reduction in complexity of the system.

Selected Mapping (SLM)
The main objective of this technique is to generate a sequence of data blocks at the transmitter end which represent the original information and then to choose the most favorable block among them for transmission. Selective Mapping is talented technique to diminish PAPR in MIMO-OFDM system [1]. Fundamental idea behind this scheme is phase rotation of signal and chooses minimum PAPR. In SLM, signal with low PAPR is selected from different self-governing phase sequences that have identical information at the transmitter [2].

Envelope Scaling (ES)
The main objective of this technique is to reduce PAPR by scaling. Input the packet for few sub carriers before IFFT operation. According to algorithm, input packet in some sub- carrier is scaled to attain the smallest amount of PAPR at IFFT output. So, there is no requirement of side information at receiver side for decoding resolution. PAPR reduces to 3 db with this method.

Precoding Technique (PT)
In Precoding technique, first the information source generates random data. The generated random data is modulated by modulation techniques such as BPSK, QPSK, QAM etc. This modulated data is passed through precoder. In PT, Unitary precoding matrix is taken for coding [5]. Modulated data is multiplied by Unitary precoding matrix, and thus the signal properties had changed, in accordance to the precoding matrix, then performs space time block code (STBC), and gained precoding output vector and at last performs IFFT operation. Finally, this processed signal is transmitted using transmitting antennas. This reduces the probability of occurrence of errors at receiver side, improves bit error rate (BER) performances and provide high data rate transmission[10].

Companding technique (CT)
Companding technique is used to decrease the dynamic range and high Peak-to-Average Power Ratio (PAPR) of the signal, in order to prevent it from distortion caused by channel. Mu-Law companding technique utilizes Mu-Law algorithm. Companding is a signal processing technique, it compresses the peak signals and expands the small signals, for reducing PAPR [11].This processed signal is transmitted using transmitting antennas.

CRITERIA FOR PAPR REDUCTION TECHNIQUE SELECTION

The criteria of the PAPR reduction technique is to know the approach that it can reduce PAPR mainly and at the same time other factors are not greatly affected. The following criteria should be considered while using the techniques**:-**
(i) The high ability of PAPR reduction is main issue to be taken in account for selecting the PAPR reduction technique, with as few damaging side effects such as in-band falsification and out-of- band radiation.
(ii) Low average power and BER**:-** Even though it can also diminish PAPR through average power of the original signals ,it requires a higher linear operation in HPA, which results in higher distortions .

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ANALYSIS OF DIFFERENT TECHNIQUES

Many techniques have been used to reduce the PAPR in MIMO-OFDM system. Now, as per the below table, we can analysis performances by different techniques-

Table 1- Comparison of PAPR Reduction Technique

Techniques of PAPR Reduction	PAPR reduction as compared to normal OFDM	BER as compared to normal OFDM
PW	6.8 dB	10.5 dB
PTS	5.7 dB	15.5 dB
TR	8.2 dB	14.0 dB
SLM	2.7 dB	7.5 dB
ES	3.0 dB	13.0 dB
PT	7.2 dB	6.0 dB
CT	2.0 dB	4.5 dB

Table 1 summarizes some PAPR reduction techniques and performance of PAPR and BER above. It can be clearly seen that no specific PAPR reduction technique achieves the best performance in all situations. Therefore, proper techniques should be selected based on practical systems.

CONCLUSION

This paper describes that the multicarrier systems are proving better transmission than single carrier systems. MIMO-OFDM is a digital multi-carrier modulation method in which great number of closely spread out orthogonal sub- carriers are used to carry data. One of the major weaknesses of MIMO-OFDM system is that the complex transmit signal can display a very high PAPR, when the input sequences are highly associated. This paper described various important characteristics related to the PAPR and BER with complete effect on the MIMO-OFDM system & provided several techniques adopted by the system according to the necessity. These techniques can be used to reduce the PAPR at the expenditure of loss in data rate, transmitted signal power increases, bit error rate performance degradation and computational complexity increases.

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