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A Comparative Study of PAPR Reduction Technique & Performance Improvement Using A Novel PTS Technique In OFDM – MIMO System

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Abstract

Orthogonal Frequency Division Multiplexing (OFDM) is considered to be a promising technique against the multipath fading channel for 4G & 4.5G wireless communications. One of the major drawbacks of multicarrier transmission is the high peak-to-average power ratio (PAPR) of the transmit signal. If the peak transmit power is limited by either regulatory or application constraints, the effect is to reduce the average power allowed under multicarrier transmission relative to that under constant. This paper present different PAPR reduction techniques and conclude an overall comparison of these techniques. We also propose to simulate the (PTS) Partial Transmit Sequence method for PAPR reduction. The PAPR performance of the PTS technique is affected as the number of sub blocks increase.

Keywords: OFDM, MIMO, PAPR, PTS

I. Introduction

MIMO is an acronym that stands for Multiple Input Multiple Output. It is an antenna technology that is used both in transmission and receiver equipment for wireless radio communication. There can be various MIMO configurations. For example, a 2x2 MIMO configuration is 2 antennas to transmit signals (from base station) and 2 antennas to receive signals (mobile terminal). The growing demand of multimedia services and the growth of Internet related contents lead to increasing interest to high speed communications. In wireless environment the signal is propagating from the transmitter to the receiver along number of different paths, collectively referred as multipath. While propagating the signal power drops of due to the following effects: path loss, macroscopic fading and microscopic fading. Fading of the signal can be mitigated by different diversity techniques. In radio, multiple-input and multiple-output, or MIMO (commonly pronounced my-moh or me-moh), is the use of multiple antennas at both the transmitter and receiver to improve communication performance. It is one of several forms of smart antenna technology. Note that the terms input and output refer to the radio channel carrying the signal, not to the devices having antennas. MIMO technology has attracted attention in wireless communications, because it offers significant increases in data throughput and link range without additional bandwidth or increased transmit power. attracted attention in wireless communications, because it offers significant increases in data throughput and link range without additional bandwidth or increased transmit power.It achieves this goal by spreading the same total transmit power over the antennas to achieve an array gain that improves the spectral efficiency (more bits per second per hertz of bandwidth) or to achieve a diversity gain that improves the link reliability (reduced fading). Because of these properties, MIMO is an important part of modern wireless communication standards such as IEEE 802.11n (Wifi), 4G, 3GPP Long Term Evolution.

Multicarrier transmission, also known as orthogonal frequency-division multiplexing (OFDM) or discrete multi tone (DMT), is a technique with a long history that has recently seen rising popularity in wireless and wire line applications. The recent interest in this technique is mainly due to the recent advances in digital signal processing technology. International standards making use of OFDM for high-speed wireless communications are already established or being established by IEEE 802.11, IEEE 802.16, IEEE 802.20, and European Telecommunications Standards Institute (ETSI) Broadcast Radio Access Network (BRAN) committees. For wireless applications, an OFDM-based system can be of interest because it provides greater immunity to multipath fading and impulse noise, and eliminates the need for equalizers, while efficient hardware implementation can be realized using fast Fourier transform (FFT) techniques.

One of the major drawbacks of multicarrier transmission is the high peak-to-average power ratio (PAPR) of the transmit signal. If the peak transmit power is limited by either regulatory or application constraints, the effect is to reduce the average power allowed under multicarrier transmission relative to that under constant power modulation techniques. This in turnreduces the range of multicarrier transmission. Moreover, to prevent spectral growth of the multicarrier signal in the form of intermodulation among subcarriers and out-of-band radiation, the transmit power amplifier must be operated in its linear region (i.e., with a large input backoff), where the power conversion is inefficient. This may have a deleterious effect on battery lifetime in mobile applications. In many low-cost applications, the drawback of high PAPR may outweigh all the potential benefits of multicarrier transmission systems. A number of approaches have been proposed to deal with the PAPR problem. These techniques include amplitude clipping and filtering, coding, tone reservation (TR), tone injection (TI), active constellation extension (ACE), and multiple signal representation techniques such as partial transmit sequence (PTS), selected mapping (SLM), and interleaving. These techniques achieve PAPR reduction at the expense of transmit signal power increase, bit error rate (BER) increase, data rate loss, computational complexity increase, and so on. In this article we describe some PTS PAPR reduction techniques for multicarrier transmission.

II. PAPR

The transmit signals in an OFDM system can have high peak values in the time domain since many subcarrier components are added via an IFFT operation. Therefore, OFDM systems are known to have a high PAPR (Peak-to-Average Power Ratio), compared with single-carrier systems. In fact, the high PAPR is one of the most detrimental aspects in the OFDM system, as it decreases the SQNR (Signal-to-Quantization Noise Ratio) of ADC (Analog-to-Digital Converter) and DAC (Digital-to-Analog Converter) while degrading the efficiency of the power amplifier in the transmitter. The PAPR problem is more important in the uplink since the efficiency of power amplifier is critical due to the limited battery power in a mobile terminal.PAPR is usually defined as :

$$\text{PAPR}= {Ppeak}/{Paverage} = 10 \log_{10}\frac{max[|x|2]}{E[|x|2]}$$

Where $Ppeak$ represents peak output power, $Paverage$ means average output power. E · denotes the expected value, xn represents the transmitted OFDM signals which are obtained by taking IFFT operation on modulated input symbols Xk. For an OFDM system with N sub-carriers, the peak power of received signals is N times the average power when phase values are the same. The PAPR of baseband signal will reach its theoretical maximum at (dB) =10log N.

III. PAPR Reduction Techniques

PAPR reduction techniques are classified into the different approaches: clipping technique, coding technique, probabilistic (scrambling) technique, adaptive pre distortion technique, and DFT-spreading technique.

3.1 Clipping Technique

The clipping technique employs clipping or nonlinear saturation around the peaks to reduce the PAPR[1]. It is simple to implement, but it may cause in-band and out-of-band interferences while destroying the orthogonality among the subcarriers. This particular approach includes block-scaling technique, clipping and filtering technique, peak windowing technique, peak cancellation technique[8], Fourier projection technique, and decision-aided reconstruction technique. Clipping causes in-band signal distortion, resulting in BER performance degradation. Clipping also causes out-of-band radiation, which imposes out-of-band interference signals to adjacent channels. Although the out-of-band signals caused by clipping can be reduced by filtering, it may affect high-frequency components of in-band signal (aliasing) when the clipping is performed with the Nyquist sampling rate in the discrete-time domain. However, if clipping is performed for the sufficiently-oversampled OFDM signals in the discrete-time domain before a low-pass filter (LPF) and the signal passes through a band-pass filter (BPF), the BER performance will be less degraded. Filtering the clipped signal can reduce out-of-band radiation at the cost of peak re growth. The signal after filtering operation may exceed the clipping level specified for the clipping operation.

3.2 Coding Technique

The coding technique is to select such codewords that minimize or reduce the PAPR. It causes no distortion and creates no out-of-band radiation, but it suffers from bandwidth efficiency as the code rate is reduced. It also suffers from complexity to find the best codes and to store large lookup tables for encoding and decoding, especially for a large number of subcarriers . Golay complementary sequence, Reed Muller code, M-sequence, or Hadamard code can be used in this approach. It was shown in that a PAPR of the maximum 3dB for the 8-carrier OFDM system can be achieved by 3/4-code rate block coding. Here, a 3-bit data word is mapped onto a 4-bit codeword. Then, the set of permissible code words with the lowest PAPRs in the time domain is chosen. The code rate must be reduced to decrease the desired level of PAPR. It was also stated in that the block codes found through an exhaustive search are mostly based on Golay complementary sequence. Golay complementary sequence is defined as a pair of two sequences whose a periodic autocorrelations sum to zero in all out-of-phase positions. It is stated in that Golay complementary sequences can be used for constructing OFDM signals with PAPR as low as 3dB.

3.3 Selective Mapping

In selective mapping (SLM) technique for PAPR the input data block X = [X[0], X[1]……X[N-1]] is multiplied with U different phase sequences $P^u = [P^u_0, P^u_1 \ldots\ldots P^u_{n-I}]^T$ where $P^u_v = e^{j\phi u}_v$ and φ^u_v€[0,2π] for v= 0,1,…..,N-1 & u

= 1,2,……U which produce a modified data block . IFFT of U independent sequences were taken to produce sequence among which the one with lowest PAPR was selected for transmission.

3.4 Tone Reservation

A tone reservation (TR) technique partitions the N subcarriers (tones) into data tones and peak reduction tones (PRTs). Symbols in PRTs are chosen such that OFDM signal in the time domain has a lower PAPR. The positions of PRTs are known to the receiver and transmitter. The main idea of this method is to keep a small set of tones for PAPR reduction. This can be originated as a convex problem and this problem can be solved accurately. Tone reservation method is based on adding a data block and time domain signal. A data block is dependent time domain signal to the original multicarrier signal to minimize the high peak. This time domain signal can be calculated simply at the transmitter of system and stripped off at the receiver. The amount of PAPR reduction depends on some factors such as number of reserved tones, location of the reserved tones, amount of complexity and allowed power on reserved tones This method explains an additive scheme for minimizing PAPR in the multicarrier communication system.

3.5 Tone Injection

Tone Injection (TI) method has been recommended by Muller, S.H., and Huber, J.B. This technique is based on general additive method for PAPR reduction. Using an additive method achieves PAPR reduction of multicarrier signal without any data rate loss. TI uses a set of equivalent constellation points for an original constellation points to reduce PAPR. The main idea behind this method is to increase the constellation size. Then, each point in the original basic constellation can be mapped into several equivalent points in the extended constellation, since all information elements can be mapped into several equivalent constellation points. These additional amounts of freedom can be utilized for PAPR reduction. The drawbacks of this method are; need to side information for decoding signal at the receiver side, and cause extra IFFT operation which is more complex.

IV. Proposed Approach

The partial transmit sequence (PTS) technique partitions an input data block of N symbols into V disjoint subblocks as follows:

$$X = [X^0, X^1, X^2 \ldots\ldots X^{v-1}]^T$$

where X^i are the subblocks that are consecutively located and also are of equal size. Unlike the SLM technique in which scrambling is applied to all subcarriers, scrambling (rotating its phase independently) is applied to each subblock in the PTS technique. Then each partitioned subblock is multiplied by a corresponding complex phase factor subsequently taking its IFFT. The PTS technique requires V IFFToperations for each data block and $[\log_2 W^v]$ bits of side information. The PAPR performance of the PTS technique is affected by not only the number of sub blocks, V, and the number of the allowed phase factors, W, but also the sub block partitioning. In fact, there are three different kinds of the sub block partitioning schemes: adjacent, interleaved, and pseudo-random. Among these, the pseudo-random one has been known to provide the best performance. In this paper we propose to partition the sub locks upto 64 to further reduce PAPR in comparison to 16[1][3].

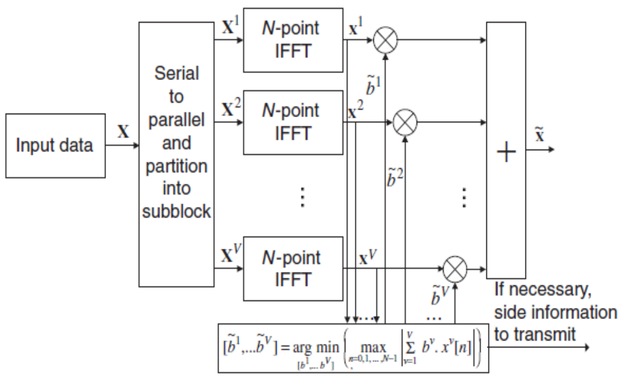

Fig1. Block Diagram of PTS technique

V. Analysis of PAPR Techniques.

The PAPR reduction technique should be chosen with awareness according to various system requirements.

Technique	Distortionless	PAPR Reduction	Data Rate loss
Clipping	No	Minimum PAPR reduction[1]	No
Coding	Yes	PAPR as low as 3db possible[1]	Yes
Selective Mapping	Yes	Data with minimum PAPR is transmitted	Yes
Tone Reservation	Yes	Peak reduction possible[1]	Yes
Tone Injection	Yes	PAPR reduction	Yes

		increases with the size of Constellation	
PTS (Conventional)	Yes	The PAPR varies as the block size varies.	Yes

VI. Conclusion

The description and study of several techniques of PAPR reduction was discussed and Proposed PTS technique which is the best solution for PAPR**.** The selected technique provides us with a good range in performance to reduce PAPR problem. PTS technique which is proposed will reduce the PAPR further more than 16 sub block division[4] & 8 sub block division[3] It is particularly suitable for the OFDM system with a large number of sub-carriers (more than 128). This research will continue in directions Firstly, PAPR reduction concepts will be expanded for distortion less transmission and identifying the best alternatives in terms of performance increase Secondly, PAPR reduction technique will be develop for low data rate loss and efficient use of channel. A study of the complexity issues of the PAPR reduction technique is required, especially looking at ways of further reducing the complexity of the sphere decoder.

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