INCREASING THE THROUGH PUT IN THE MIMO OFDM SYSTEMS BY USING PEAK CANCELLATION

Smt. A. RAJANI[1] , M . Sailaja Devi [2]
Assistant Professor[1], M.Tech Student[2]
Department Of ECE (Communications and Signal Processing)
Jawaharlal Nehru Technological University (Autonomous) , Kakinada.

ABSTRACT

In this paper the salient advantage of PC is its ease of hardware implementation, but it induces in-band distortion and out-of-band radiation. In order to restrict the amount of distortion within an acceptable level, it is critical to carefully design the cancelling pulses as well as the envelope threshold over which PC is applied. In most studies, however, they are determined empirically through computer simulations. This paper thus focuses on a rigorous theoretical analysis of PC applied to band-limited orthogonal frequency division multiplexing (OFDM) signals, and discusses its validity and limitation for practical applications. Based on the level-crossing rate approximation of the peak distribution, we derive a closed-form expression for the achievable signal-to-distortion power ratio (SDR). We also analyze the adjacent channel leakage ratio (ACLR) as well as error vector magnitude (EVM), with which the symbol error rate (SER) over an additive white Gaussian noise (AWGN) channel is obtained. All the theoretical results developed in this work are compared with those based on the corresponding computer simulations to justify our analytical approach. It thus serves as a useful and accurate tool for designing cancelling pulses as well as the threshold level, for given specific system requirements such as SDR (or EVM) and ACLR. Multiuser multiple-input multiple-output (MUMIMO) transmission techniques have been popularly used to improve the spectral efficiency and user experience. However, due to the coarse knowledge of channel state information at the transmitter (CSIT), the quality of transmit precoding to control multiuser interference is degraded and hence coscheduled user equipment (UE) may suffer from large residual multiuser interference

I. INTRODUCTION

In many wireless systems, multiuser multiple-input multiple-output (MIMO) techniques have been used to improve the spectral efficiency and user experience [3]. In contrast to the traditional single user MIMO (SU-MIMO) systems where the time-frequency resource element is dedicated to a single user, multiuser MIMO system allows multiple users to use the same time-frequency resources via a proper control of the interference among co-scheduled users at the base station. Control of this multiuser interference is achieved by applying a precoding to the symbol vectors of all users scheduled in the same time-frequency resources. Since the precoding matrix is generated using the downlink channel state information (CSI) which relies on the feedback information from the mobile users, inaccurate precoding operation from imperfect CSI causes a severe degradation in multiuser interference cancellation at the transmitter side and the channel estimation and detection at the receiver side, undermining the benefits of multiuser MIMO. In order to mitigate the degradation of channel estimation quality caused by multiuser interference, dedicated pilots (e.g., demodulation reference signal (DM-RS)) has been introduced in the Long Term Evolution Advanced (LTE-Advanced) standard [4].

While the purpose of common pilots is to serve all users in the cell, dedicated pilots are literally dedicated to a single or a group of users for better estimation of channels. The precoding matrix applied to the dedicated pilots is the same as that applied to the information vector. Thus, the estimates of the precoded channel (compound of the precoding matrix and the physical channels) can be used for the detection purpose. As the wireless cellular industry is moving fast towards the fifth generation (5G) communication systems, an attempt to use large number of antennas at the base station has received much attention in recent years. For example, LTE-AdvancedPro, the recent standard of 3rd Generation Partnership Project (3GPP) LTE, considers using up to 64 antennas at the base station [5].

IF cyclic prefix (CP) is not used in a traditional OFDM system, ISI/ICI will lead to a severely impaired bit error rate (BER) performance . Therefore, CP is a must for all current OFDM designs, which will become a big challenge to realize high-speed digital transmissions in the future. Two most important performance metrics in future wireless communications, such as 5G, are low latency and high spectrum efficiency. Low latency applications require to use short OFDM/OFDMA blocks, which is limited by CP length .Therefore, a CP-free OFDM/OFDMA system, which is the focus of this work, is believed to be more competitive than CP based OFDM/OFDMA in future wireless applications.

The length of CP is primarily decided by delay spread of a time-dispersive multipath channel, and it was shown in the literatures that CP should be made at least as long as 1/4 of an OFDM block in some scenarios. This is a heavy price a traditional OFDM system has to pay due to the waste of scarce spectral resources. Therefore, a lot of works were dedicated to investigate the effects of CP, and proposed various methods/algorithms to shorten CP length. The works were done based on single carrier block transmission, which has been applied to LTE in its uplink channels. In the authors modeled multipath interference as an additive colored noise, and tried to reduce the effects of insufficient CP length by adapting a modulation and coding scheme (MCS) to channel variation, as an effort to improve throughput. In a single carrier frequency division multiple access (SCFDMA) scheme was proposed, and it was proved that a shorter CP might be employed in scenarios with a relatively long channel delay spread using an adaptive algorithm.

presented a soft-decision-directed correction (SDDC) aided turbo frequency-domain equalization (FDE) scheme for insufficient CP length single carrier block transmission to achieve maximum power efficiency. suggested to use space-time and space-frequency block codes (STBC/SFBC) for single carrier (SC) FDE. The proposed algorithm can achieve spatial diversity in a distributed way over frequency-selective channels without CP, but the scheme is relatively complex. The maximum likelihood detection (MLD) employing QR decomposition and M-algorithm (QRM-MLBD) was suggested in to combat ISI for SC transmissions. In an overlap QRMMLBD system, the ISI is suppressed by picking up reliable symbols after QRM-MLBD, and therefore the overlap QRMMLBD achieves a higher throughput. An iterative algorithm was proposed in for an OFDM based HDTV broadcasting system to mitigate residual ISI, whose length exceeds the length of CP. It can offer a good performance only if CIR is moderate and interference power is much lower than signal power, and BER performance depends heavily on the number of iterations. However, more iterations will yield a longer detection delay, which may become an issue for its further improvement.

. To improve the transmission efficiency and shorten propagation delay, the works in proposed a fast OFDM (FOFDM) scheme. In FOFDM system, the amplitude shift keying (ASK) modulation was used, and hence only half of an OFDM block needs to be transmitted due to its complex conjugate property. Then, the receiver extends the received block according to the complex conjugate property. In this way, an OFDM block can be shortened . The difficulty in rigorous spectral analysis of PC stems from the fact that the PC event is a point process and thus it cannot be explicitly modeled by a stationary process. In this paper, we theoretically analyze the performance of an OFDM system operated with PC. Provided that the baseband OFDM signal is characterized as a band-limited complex Gaussian process, a closed-form expression of signalto-distortion power ratio (SDR) is firstly derived based on the level-crossing rate approximation of the peak distribution. Furthermore, by analyzing a cancelling pulse function, ACLR and EVM of the OFDM signal after PC are calculated. These results allow us to theoretically determine the threshold level that can meet the distortion requirement (in terms of SDR, EVM, and ACLR). The obtained results are then used for deriving the symbol error ratio (SER) of the OFDM system with M-ary quadrature amplitude modulation (M-QAM), transmitted over an additive white Gaussian noise (AWGN) channel in the presence of PC.

II. LITERATURE SURVEY

There have been some studies to improve the channel estimation quality of multiuser MIMO systems [6]–[13]. In [6], multiuser interferences are suppressed using the channel estimates predicted from adjacent symbols. Using the interference suppressed signals, tentative decisions are performed on data symbols. In [7], a joint detection algorithm for multiuser environment has been suggested. In this work, effect of the residual interference was considered to improve the performance of joint demodulation and decoding. Also, hannel estimation (CE) techniques accounting for the effect of multiuser interferences have been proposed. Notable examples include the maximum a posteriori (MAP)-based CE [8], [9], joint maximum likelihood CE and detection [10], Kalman filter-based soft decision CE [11], and CE combined with interference suppression [12], [13].

An aim of this paper is to propose an improved channel estimation technique for the multiuser MIMO systems. The proposed method exploits the channel information at the data tones to improve the channel estimation and subsequent detection quality. Towards this end, we pick a small number of reliable data tones and then use them for virtual pilots to generate the refined channel estimates. Our framework is based on the expectation maximization (EM) algorithm [14], where the channel estimation and data decoding are performed iteratively to generate the joint estimate of the channel and data symbols.

The EM algorithm is computationally efficient means to solve the maximum likelihood (ML) and maximum a posteriori (MAP) estimation problems [15]. There have been some studies using the EM technique for the channel estimation purposes [16]–[18]. In [16], EM-based channel estimation has been proposed for the frequency-selective channel environment with inter-symbol interference. In [17], an iterative receiver technique using the EM algorithm was proposed for the single user MIMO system. In [18], EM-based channel estimator performing the interference suppression using the sample covariance of the received signal has been proposed. Our proposed method is distinct from previous efforts in the following two aspects. First, we modify the original EM algorithm such that the soft information delivered from the channel decoder is incorporated into the cost metric in the Estep. Since the soft information generated from the channel decoder is more accurate than the output of the MIMO detector, we employ the feedback from the channel decoder as a prior information of the data symbols. We observe from numerical evaluations that use of feedback from the channel decoder improves both the convergence speed and the quality of channel estimation. Second, in order to reduce the computational complexity associated with the virtual pilot selection, we choose a small group of reliable data tones making a dominant contribution to the channel estimation quality. To do so, we design a mean square error (MSE) based data tone selection strategy. We show from numerical sim ulations in LTE-Advanced and LTE-Advanced-Pro scenarios that the proposed channel estimator outperforms conventional minimum mean square error (MMSE) scheme, which is most popular and has been used as a baseline in many real systems, and also existing EM-based channel estimation technique, especially in the scenario where the present multiuser MIMO systems fails to operate due to the insufficient pilot resources and the inaccurate precoding operation.

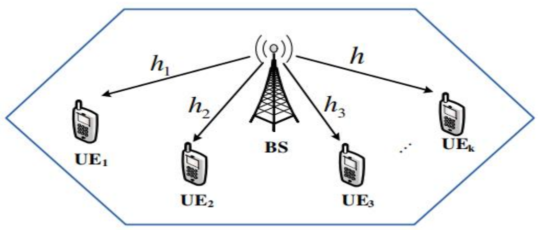

Fig. 1. Illustration of multiuser MIMO-OFDM system

III. PROPOSED METHOD

ORTHOGONAL frequency division multiplexing (OFDM) is commonly adopted in wireless communication systems due to its key advantages such as flexibility in resource allocation and high spectrum utilization [1]. As OFDM signal is essentially a sum of multiple signals aligned in frequency domain, its probability density function (pdf) in time domain resembles Gaussian distribution, and thus its amplitude has high peak-to-average power ratio (PAPR) [2]. This poses strict demands on the dynamic range of data converters and especially limits efficient operation of power amplifiers (PAs).

Due to the nonlinear nature of many analog devices, the actual analog front-end that should operate with a large linear range entails significant cost and power loss. Therefore, extensive research has been conducted focusing on achieving low PAPR in the digital front-end. The digital front-end is an intermediate between the physical layer and analog devices, and it primarily serves for frequency shifting, resampling, filtering, and impairment compensation for the analog front-end . The PAPR reduction carried out in the digital front-end gives no change to the physical layer and thus is commonly applied in practice. Provided that the resulting error vector magnitude (EVM) is tolerable, PAPR can be reduced to a certain level by introducing some degree of distortion. Meanwhile, the signal after PAPR reduction should conform to the spectral mask. More specifically, the adjacent channel leakage ratio (ACLR) should meet the system requirement. Among many PAPR reduction techniques, most of the socalled distortion-less approaches (such as selective mapping are not applicable to the standardized OFDM systems as they call for major modifications in the physical layer architecture. This paper thus focuses on the techniques that are standard-compliant, and such approaches include clipping and filtering (CAF) and peak cancellation (PC) . In principle, CAF induces peak regrowth due to the existence of the post-clipping filter to meet the spectral constraint, resulting in intractable PAPR regrowth. On the other hand, PC does not cause any PAPR regrowth but does exhibit out-of-band radiation caused by the cancelling pulse.

PAPR IN OFDM

A. Orthogonal Frequency Division Multiplexing:

Orthogonal frequency division multiplexing is a special case of frequency division multiplexing. OFDM is the combination of modulation and multiplexing .Is a multicarrier modulation scheme. Is the method of encoding digital data on multiple carrier frequencies. In modulations, information is mapped on to changes in frequency, phase or amplitude (or a combination of them) of a carrier signal. Multiplexing deals with allocation/accommodation of users in a given bandwidth (i.e. it deals with allocation of available resource). OFDM is a combination of modulation and multiplexing. In this technique, the given resource (bandwidth) is shared among individual modulated data sources. Normal modulation techniques (like AM, PM, FM, BPSK, QPSK, etc.) are single carrier modulation techniques, in which the incoming information is modulated over a single carrier. OFDM is a multicarrier modulation technique, which employs several carriers, within the allocated bandwidth, to convey the information from source to destination. Each carrier may employ one of the several available digital modulation techniques (BPSK, QPSK, QAM etc.).

B. Peak to Average Power Ratio: Presence of large number of independently modulated sub-carriers in an OFDM system the peak value of the system can be very high as compared to the average of the whole system. This ratio of the peak to average power value is termed as Peak-to-Average Power Ratio. Coherent addition of N signals of same phase produces a peak which is N times the average signal. The PAPR is the ratio of maximum power of a sample in a given OFDM transmit symbol to the average power of that OFDM symbol. When in a multicarrier system the different sub-carriers are out of phase with each other, then PAPR occurs. There are large number of independent modulated subcarriers in an OFDM system multicarrier concept, due to those subcarrier in an OFDM, the peak value of the OFDM system can be very high as compared to the average value of the whole system. This ratio of the peak to average power value is termed as peak to average power ratio PAPR=max |x(t)|2E[|x(t)|2] Where E [.] depicts Expectation operator.

In OFDM System Model, it can be noted that the input transmit signals are modulated first using either PSK or QAM i.e. Phase Shift Keying or Quadrature Amplitude Modulation and then undergo IFFT (Inverse Fast Fourier Transform) operation at the transmitter end. The orthogonal sub-carriers are produced at the transmitter side. These transmitted signals can have high peak values in time domain and these high peak values are referred to as high Peak to Average Power Ratio, in OFDM Systems as compared with Single carrier systems. The high PAPR is a result of summation of sine waves and non-constant envelope. The deleterious effect of High PAPR is that it decreases the Signal to Quantization Noise Ratio of ADC and DAC's, while lowering the performance of power amplifier. Therefore, RF power amplifiers needs to be operated in very large linear region, else ways the signal peaks will get entered into non-linear region and will cause distortion. So there are number of PAPR reduction techniques. The PAPR of OFDM signals x(t) is defined as the ratio between the maximum instantaneous power and its average power,

PAPR= PPEAKPAVERAGE=10log10 max |X(n)|2E|X(n)|2

Where Ppeak represents peak output power, 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 .

The instantaneous output of an OFDM system often has large fluctuations compared to traditional single carrier systems. This requires that system devices, such as power amplifiers, A/D converters and D/A converters, must have large linear dynamic ranges. If this is not satisfied, a series of undesirable interference is encountered when the peak signal goes into the non-linear region of devices at the transmitter, such as high out of band radiation and intermodulation distortion. PAPR reduction techniques are therefore of great importance for OFDM systems. Also due to the large fluctuations in power output the HPA (high power amplifier) should have large dynamic range.

PEAK CANCELLATION IN OFDM

For reducing PAPR, simple techniques are used such as clipping and filtering (CAF), and peak cancellation (PC), which have much lower complexity, can be considered as more realistic approaches from the viewpoint of practical implementation. These techniques essentially introduce nonlinear operations so that distortions are inevitable. Given that some degree of distortion is generally allowed for the transmitted signals, such techniques are very attractive. The major drawback of CAF is the peak regrowth caused by the filtering effect, and the amount of regrowth is generally intractable. Although PAPR regrowth can be somewhat alleviated by iterative use of CAF, the resulting complexity will be increased several fold because of the duplicated functional block [1].Peak cancellation is a class of peak-to-average power ratio (PAPR) reduction techniques for orthogonal frequency division multiplexing (OFDM). The above fig. shows the parallel data signal is then converted in IFFT first then add cyclic prefix of given input signal then this parallel signal get converted in serially and the extra peak is cancelled by peak cancellation method and finally get the better output signal. It can control the PAPR and out-of-band radiation simultaneously at the cost of additional interference. Orthogonal frequency division multiplexing (OFDM) is a robust transmission technique to combat the influence of wireless fading channels

However, OFDM suffers from high peak-to- average power ratio (PAPR) that significantly reduces the efficiency of the high power amplifier (HPA). To alleviate this, many approaches have been proposed to reduce the PAPR, among which the pre-distortion approach such as clipping, is an efficient one. Clipping cancels the signal peak by adding a scaled pulse function, at the cost of out-of-band radiation due to the infinite frequency response of the pulse function. Therefore, filtering should be combined at the cost of peak regrowth.

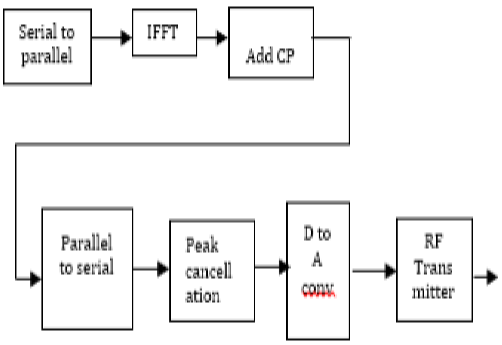

Fig.1: Peak Cancellation In OFDM

To control the PAPR and out-of-band radiation simultaneously, repeated clipping and filtering (RCF) is proposed in with a high complexity. To simultaneously make a better trade-off among PAPR, out-of-band radiation and computational complexity, peak cancellation is proposed as a candidate of clipping-based techniques. It introduces designed windowing function, with finite response in both time and frequency domains, to replace the original pulse function in clipping. In this case, peak cancellation will not cause severe out-of-band radiation, thus saving the complexity for RCF. Peak cancellation will introduce additional distortion to the transmitted signals, thus degrading the system performance.

IV. BLOCK DIAGRAM OF PC PROCESS

A basic diagram of the PC process considered in this work is sketched in Figure 1. Its principle is to generate cancelling pulses at the time instants where the peaks higher than the predetermined threshold are found. The generated pulses are linearly scaled and rotated with appropriate phase shift such that after their addition the original signals have the peaks reduced to the threshold [3], [5].The principle of PC is to generate cancelling pulses at the time instances where the peaks higher than the predetermined threshold γ are found and to subtract them from the original signal.

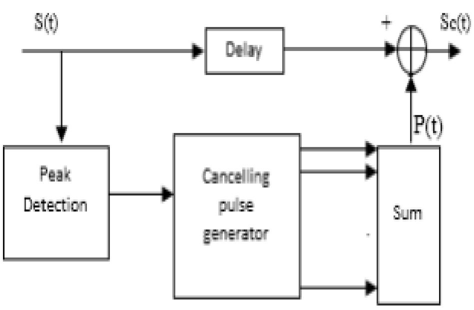

Fig. 2: Simplified block diagram of PC process

ERROR VECTOR MAGNITUDE

EVM is the ratio of the average of the error vector power (Perror) to the average ideal reference vector power (Pref). Error vector magnitude (EVM) is a measure of modulation quality and error performance in complex wireless systems. It provides a method to evaluate the performance of software-defined radios (SDRs), both transmitters and receivers. It also is widely used as an alternative to bit error rate (BER) measurements to determine impairments that affect signal reliability. (BER is the percentage of bit errors that occur for a given number of bits transmitted.) EVM provides an improved picture of the modulation quality as well. In wireless transceivers, EVM is a commonly adopted measure of the in-band distortion and out of band radiation.

V. CONCLUSION

In this paper, we proposed an EM-based joint pilot and data channel estimation algorithm for the multiuser MIMO systems. Our work is motivated by the observation that the inaccurate CSI caused by the insufficient pilot signals brings severe link performance degradation in multiuser MIMO systems. By using deliberately chosen data tones for the pilot purpose, the proposed method achieves better channel estimation and eventual link performance gain. Although our study focused on the state of the art cellular systems (LTE-Advanced and LTE-Advanced-Pro), we expect that the effectiveness of the proposed approach can be readily extended to future wireless systems such as machine-type communication with ultra-small packets for internet of things (IoT) network. In this scenario, often referred to as ultra reliability and low latency (uRLLC) and machine type massive communication (mMTC), devices exchange small amount of information with the base station to achieve the ultra low latency and energy efficiency so that the size of packet is much smaller than that of human-centric communications. Accordingly, the number of pilot tones in a packet is very small, and the proposed virtual pilot-based channel estimation strategy would be effective in improving the quality of service (QoS

REFERENCES

[1] H. Gazzah, "A Quadratic Complexity Subspace Algorithm for Blind Channel Shortening," Signal Processing, and their Applications (ICCSPA), 2013 1st International Conference on Communications, 2013, Conference Proceedings, pp. 1-6.

[2] F. Schaich, T. Wild and Y. Chen, "Waveform Contenders for 5G – Suitability for Short Packet and Low Latency Transmissions," 2014 IEEE 79th Vehicular Technology Conference (VTC Spring), Seoul, 2014, pp. 1-5.

[3] Lorca, J., "Cyclic Prefix Overhead Reduction for Low-Latency Wireless Communications in OFDM," in IEEE

Vehicular Technology Conference (VTC Spring), pp. 1-5, May 2015.

[4] J. Yuansheng and X. Xiang-Gen, “A Robust Precoder Design based on Channel Statistics for MIMO-OFDM Systems with Insufficient Cyclic Prefix,” IEEE Transactions on Communications, vol. 62, no. 4, pp. 1249-1257, 2014.

[5] M. Batariere, K. Baum, and T. P. Krauss, “Cyclic Prefix Length Analysis for 4G OFDM Systems,” Vehicular Technology Conference, 2004. VTC2004-Fall. 2004 IEEE 60th, vol. 1, 2004, pp. 543-547.

[6] C. Prieto del Amo and M. J. Fernandez-Getino Garcia, “Suppression of Cyclic Prefix in Downlink LTE like Systems to Increase Capacity,” Vehicular Technology Conference (VTC Spring), 2013 IEEE 77th, 2013, pp. 1-5.

[7] S. Viswasom and D. Murali, “Effect of Cyclic Prefix Reduction on OFDM-CDMA systems,” Emerging Research Areas and 2013 International Conference on Microelectronics, Communications and Renewable Energy (AICERA/ICMiCR), 2013 Annual International Conference on, 2013, pp. 1-4.

[8] Z. M. Elkwash, N. M. Shebani, M. A. Mjahed, A. M. Masoud, and R. M. Elmareymi, “Effect of Cyclic Prefix on Data Rates in Wimax System with Variation in Delay Vector, Gain Vector, Signal to Noise Ratio and Coding Rates for Different Modulation Techniques,” in Electronics and Computer Engineering (TAEECE), 2013 International Conference on Technological Advances in Electrical, 2013.

[9] L. Zhi Qiang and T. C. Yang, “On the Design of Cyclic Prefix Length for Time-Reversed OFDM,” IEEE Transactions on Wireless Communications, vol. 11, no. 10, pp. 3723-3733, 2012.

[10] C. Yu-Pin, P. Lemmens, T. Po-Ming, H. Chien-Chuan, and C. PeiYin, “Cyclic Prefix Optimization for OFDM Transmission over Fading Propagation with Bit Rate and BER Constraints,” in 2011 Second International Conference on Innovations in Bio-inspired Computing and Applications (IBICA), pp. 29-32. [11] S. Ghazi-Maghrebi, H. Motahayeri, K. D. Avanesian, and M. Lotfizad, “A New Mathematical Analysis of the Cyclic Prefix Effect on Removing ISI and ICI in DMT Systems,” in TENCON 2011 - 2011 IEEE Region 10 Conference, 2011, pp. 237-241.

[12] E. Z¨oechmann, S. Pratschner, S. Schwarz, and M. Rupp, “MIMO Transmission over High Delay Spread Channels with Reduced Cyclic Prefix Length,” in WSA 2015; 19th International ITG Workshop on Smart Antennas; Proceedings of, 2015, Conference Proceedings, pp. 1-8.

[13] E. Z¨ochmann, S. Pratschner, S. Schwarz, and M. Rupp, “Limited Feedback in OFDM Systems for Combating ISI/ICI Caused by Insufficient Cyclic Prefix Length,” in 48th Asilomar Conference on Signals, Systems and Computers, 2014.