A Novel PTS Architecture for PAPR Reduction of OFDM Signals and UF OFDM

Ankita Maheshwari[1] Pankaj Rathi[2]
[1]Research Scholar [2]Assistant Professor
[1,2]Department of (Digital Communication) Electronics and Communication
[1,2]SITE, Nathdwara, India

Abstract— In this proposed system a precoding-based PAPR reduction technique is proposed for both the UF-OFDM and the F-OFDM cases. In this system we are using the Zadoff Chu Transform for the precoding process. The input bit stream is first modulated by QAM modulation and then the precoding technique is performed. For UF-OFDM, after that the inverse discrete Fourier transform is performed on the data streams and then the filtering is applied. For the filtering operation Chebyshev filter is performed and then the data are send through the channel. Finally the performance of the proposed system is evaluated and compared with the existing system and it shows the better results Simulation results have shown that the decrement of PAPR. The out of band radiation of proposed scheme is less than original OFDM as shown in power spectral density (PSD) simulation result. All this simulation has been carried out in MATLAB simulation.

Keywords: UF-OFDM, F-OFDM, QAM, MATLAB

I. Introduction

The necessity of high data rate draws the great attention in multi-carrier system. It should be capable to operate smoothly in environment of high carrier frequency, high data transmission rate and mobility. The studied has shown that OFDM fulfil the multi-carrier system necessities. OFDM is a multi-carrier modulation (MCM) technique in which complex data symbols (i.e, BPSK, QPSK, QAM, MPSK etc.) are transmitted in parallel after modulating them over orthogonal sub-carrier. In single carrier (SC) system, one complex data is transmitted using one carrier and in this parallel transmission, complex data is transmitted over sub-carrier. Here the effective data rate of the system is same as of SC system. The parallel transmission increases the time period of symbol and the comparative amount of separation in time caused by multipath delay decreases. In OFDM system, the orthogonality among sub-carriers is maintained by using inverse Fast Fourier Transform (IFFT).A guard band is inserted between successive OFDM symbols. Insertion of guard band in OFDM symbols can be done by three methods-cyclic prefix, cyclic suffix and zero padding. By adding guard band in OFDM symbols, OFDM convert wideband frequency selective channel into collection of parallel narrowband flat fading channel, one channel across each subcarrier. Thus it removes Inter-Symbol Interference (ISI). Due to features like high immune to multipath fading, high data transmission rate and requirement of less complex equalizer, OFDM has been exploited by many high data rate broadband wireless communication systems of present generation [1], [2].

PAPR occurs due to large dynamic range of OFDM symbol waveforms. High PAPR in OFDM essentially arises because of IFFT pre-processing (i.e. OFDM signal consists of a number of independently modulated sub-carriers which can give a large peak when added up with same phases). Here, data symbols across sub-carriers add up to produce high Peak value signals [26-28].

As long as signal swing is limited to dynamic or linear range, input and output is linearly related as shown in figure 3.1. (i.e. around this mean, if the deviation of the voltage is small, then signal will still confined to linear amplification range.) But in OFDM system, swing of instantaneous power is very high compare to mean. So, it will cross over into the non-linear range where amplification is non-linear. As amplification is non-linear all the property of OFDM is lost (i.e. orthogonality is lost), then there will be extreme intercarrier interference. So, high PAPR in OFDM results in amplifier saturation, thus leading to ISI.

II. Methodologies

The mobile Worldwide Interoperability for Microwave Access (Mobile WiMAX) air interface adopts orthogonal frequency division multiple access (OFDMA) as multiple access technique for its uplink (UL) and downlink (DL) to improve the multipath performance. All OFDMA based networks including mobile WiMAX experience the problem of high peak-to-average power ratio (PAPR). The literature is replete with a large number of PAPR reduction techniques. Among them, schemes like constellation shaping, phase optimization, nonlinear companding transforms, tone reservation (TR) and tone injection (TI), clipping and filtering, partial transmit sequence (PTS), precoding based techniques, selective mapping (SLM), preceding based selective mapping (PSLM) and phase modulation transform are popular. The precoding based techniques, however, show great promise as they are simple linear techniques to implement without the need of any complex optimizations. This chapter reviews these PAPR reduction techniques and presents a Zadoff-Chu matrix transform (ZCMT) based precoding technique for PAPR reduction in mobile WiMAX systems. The mobile WiMAX systems employing random-interleaved OFDMA uplink system has been used for determining the improvement in PAPR performance of the technique. It has been further used in selective mapping (SLM) based ZCMT precoded random-interleaved OFDMA uplink system. PAPR of these systems are analyzed with the root-raised-cosine (RRC) pulse shaping to keep out-of-band radiation low and to meet the transmission spectrum mask requirement. Simulation results show that the proposed systems have low PAPR than the Walsh-Hadamard transform (WHT) precoded random-interleaved OFDMA uplink systems and the conventional random-interleaved OFDMA uplink systems.

A. *Selective Mapping (SLM)*

The SLM is one of the most popular PAPR reduction techniques in the literature (Lim et al., 2005). This technique is based on the phase rotations. In SLM based OFDM (SLM-

OFDM) systems, a set of V different data blocks are created at the transmitter representing the identical information and a data block with minimum PAPR is selected for the transmission. Fig.6 shows the general block diagram of the SLM-OFDM system. Every data block is multiplied with the V dissimilar phase sequences, each of length N, $B^{(v)} = [b_{v,0}, b_{v,1}, \ldots, b_{v,N-1}]^T$, $v= 1, 2\ldots V$, which results in the changed data blocks. Now suppose the altered data block for the v^{th} phase sequence is given by $X^{(v)} = [X_0 b_{v,0}, X_1 b_{v,1}, \ldots, X_{N-1} b_{v,N-1}]^T$, $v=1, 2\ldots V$. Each X_n^v can be defined as follows:-

$$X_n^v = X_n b_{v,n} \quad , \quad (1 \le v \le V)$$

After applying SLM to X, the OFDM signal becomes as follows:-

$$x_n^{(v)} = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k^v . e^{j2\pi \frac{n}{N} k} \text{ , n=0, 1, 2... N-1}$$

Where, $v = 1, 2\ldots V$. Amongst all the tailored data blocks: $x^{(v)}$, $v = 1, 2\ldots V$, the data block with minimum PAPR is selected for the transmission. Side information about the selected phase sequence must be communicated to the receiver which performs the reverse operation in order to recover the actual data block.

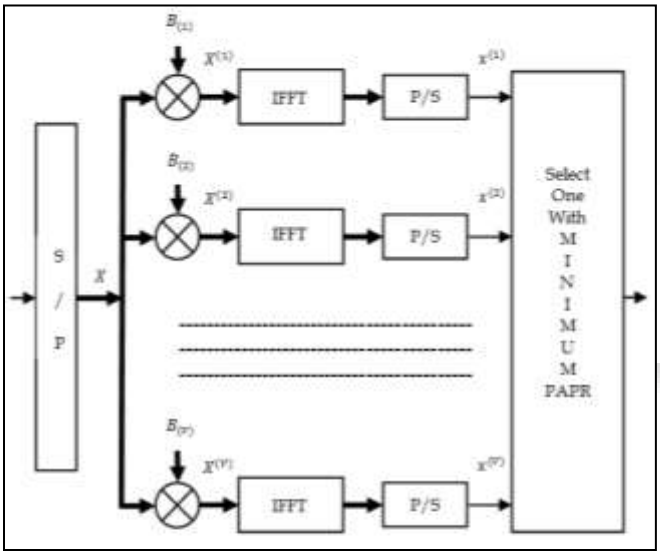

Fig. 1: Block diagram of OFDM system with Selective Mapping (Han & Lee, 2005)

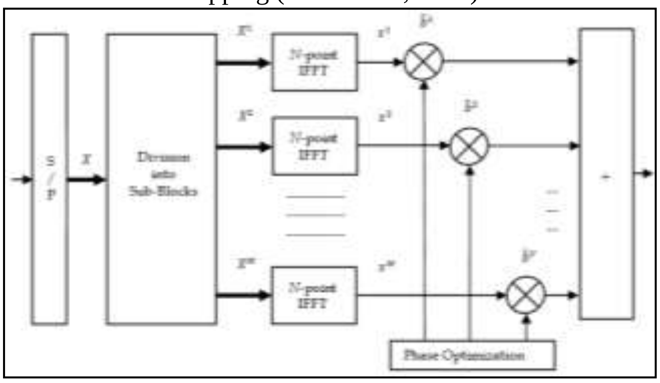

Fig. 2: Block diagram of OFDM system with Partial Transmit Sequence (Müller & Huber, 2019)

III. IMPLEMENTATION HYBRID TECHNIQUE OFDM

A. *Spectrum Shaping Filtering*

The ideal raised cosine filter frequency response consists of unity gain at low frequencies, a raised cosine function in the middle, and total attenuation at thigh frequencies. The width of the middle frequencies are defined by the roll off factor constant Alpha, (0<Altpha<=1). In Filter Solutions, the pass band frequency is defined as the 50% signal attenuation point. The group delay must remain constant at least out to 15 to 20 dB of attenuation. When the pass band frequency of a raised cosine filter is set to half the data rate, then the impulse response Nyquist's first criteria is satisfied in that the impulse response is zero for T = NTs, where N is an integer, and T is the data period. Filter Solutions provides analog, IIR and FIR raised cosine filters. FIR are the most accurate and are best to use. However, if it is not possible to use an FIR filter, analog filters may approximate the raised cosine response. The higher the order of the filter, the greater the raised cosine approximation. High order raised cosine filters also produce longer time delays. The lower alpha values use less bandwidth, however, they also produce more ISI due to element value errors and design imperfections.

In this proposed system a precoding-based PAPR reduction technique is done by using the zadoffchu transform precoding method for both the UF-OFDM and the F-OFDM systems. The principle of this method is to transform the UF-OFDM signal to a lower order summation of single carrier signals and the F-OFDM signal to single carrier signal. The performance of the proposed PAPR reduction technique is evaluated by the simulation results

B. *OFDM Symbol Generation*

Using a large number of parallel narrow-band subcarriers instead of a single wide-band carrier to transport information. OFDM is a frequency-division multiplexing (FDM) scheme used as a digital multi-carrier modulation method and is essentially identical to coded OFDM (COFDM) and discrete multi-tone modulation (DMT). It is used in such diverse applications as digital television and audio broadcasting, wireless networking and broadband internet access. OFDM has also been adopted in some military communication systems. In an OFDM scheme, a large number of orthogonal, overlapping, narrow band sub-channels or subcarriers, transmitted in parallel, divide the available transmission bandwidth. The separation of the subcarriers is theoretically minimal such that there is a very compact spectral utilization. The attraction of OFDM is mainly due to how the system handles the multipath interference at the receiver. Multipath generates two effects: frequency selective fading and intersymbol interference (ISI). The "flatness" perceived by a narrow-band channel overcomes the former, and modulating at a very low symbol rate, which makes the symbols much longer than the channel impulse response, diminishes the latter. Using powerful error correcting codes together with time and frequency interleaving yields even more robustness against frequency selective fading, and the insertion of an extra guard interval between consecutive OFDM symbols can reduce the effects of ISI even more. Thus, an equalizer in the receiver is not necessary.

IV. CLASS DIAGRAM

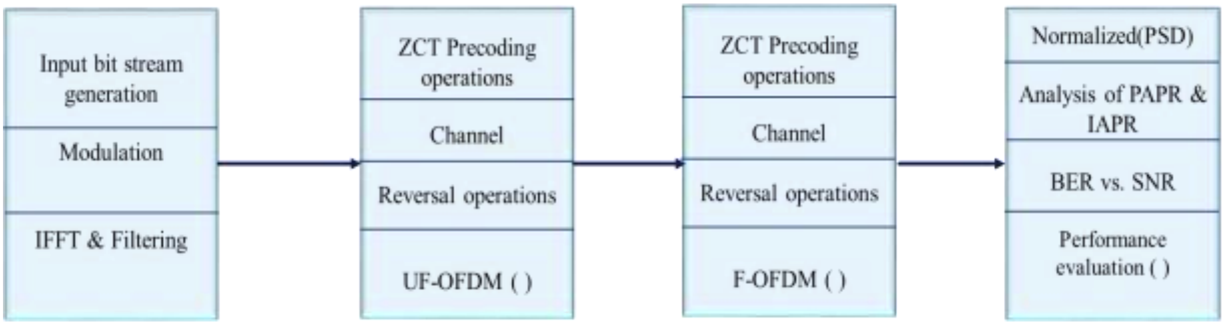

Fig. 3: Class Diagram

V. RESULTS AND DISCUSSION

The BER performance of the EX--UFOFDM and the ZCT-UF-OFDM are compared to the ZCT- UF-OFDMfor the 16-QAM and the 64-QAM constellations. As it is shown in this figure 5.2, the precoding has no effect on the BE performance in a AWGN channel. Hence, adding a precoding block to the modulation scheme improves the PAPR

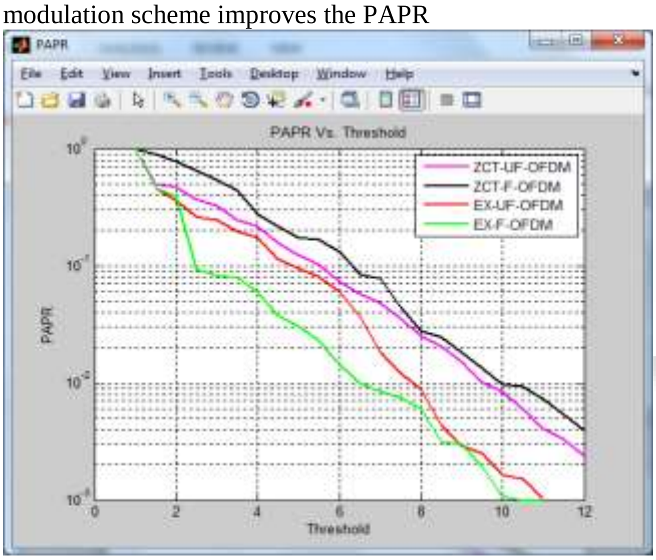

Fig. 4: PAPR Vs threshold

This graph illustrates that at lower number of subblocks least PAPR is achieved. So, the complexity issue on ZCT UF-OFDM, due to number of sub blocks is addressed by achieving minimum PAPR at minimum sub blocks. Not only that, proposed method have PAPR of 5.5dB which is minimum in comparison to EX-technique at same roll-off factor with 5.8dB peak value as well as PTS technique with sub blocks 16 UF OFDM,EX-F OFDM,

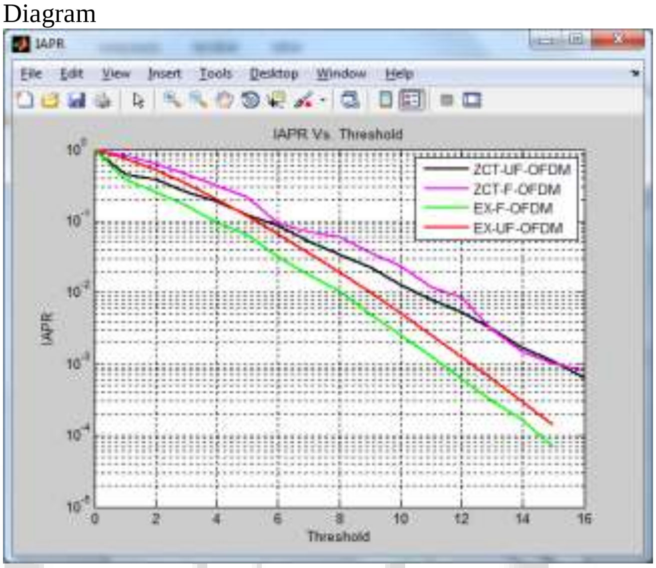

Fig. 5: IAPR Vs threshold

The main concept of the proposed method is to multiply encoded data with predefined ZCT-precoding matrix and applying these precoded data to ZCT-UF-OFDM,ZCT,F-OFDM,method where precoded data are partitioned into subblocks and choosing the optimized phase factor, the lowest IPAPR is obtained. From the result of the simulations, the proposed technique has low PAPR as compare to EX-F-OFDM,EX-UF-OFDM,. Using a few number of subblocks, a remarkable reduction in IPAPR is achieved. Therefore, complexity of more IFFT operations for Precoding method has been omitted because the proposed scheme achieves low PAPR by using few numbers of subblocks.

VI. CONCLUSION

A PAPR reduction technique for the UFOFDM and the F-OFDM modulation schemes was proposed .This technique has to keep the spectral efficiency and the BER performance of the system. For this reason, a precoding based PAPR reduction technique was proposed. This technique transforms the F-OFDM signal to a single carrier signal and the UF-OFDM to a multicarrier signal with smaller number of carriers. At the receiver, the received symbols can be decoded without the need of sending any “side information “and consequently without reducing the spectral efficiency. In addition to the PAPR and the PA output PSD tails reductions, this method conserves the BER in an AWGN channel. Further studies will be performed in the upcoming works about their BER performance in a frequency selective channel.

REFERENCES

[1] Tanairat Mata ; Pisit Boonsrimuang ; Pitchaya Boontra A PAPR Reduction Scheme based on Improved PTS with ABC Algorithm for OFDM Signal 2018 15th International Conference on Electrical Engineering/ Electronics, Computer, Telecommunications and Information Technology (ECTI-CON) Year: 2018 | Conference Paper | Publisher: IEEE

[2] Azlina Idris ; Nur Lisa Mohd Sapari ; Mohd Syarhan Idris ; Suzie Seroja Sarnin ; Wan Norsyafizan Wan Mohamad ; Nani Fadzlina Naim Reduction of PAPR Using Block Coding Method and APSK Modulation Techniques for F-OFDM in 5G System TENCON 2018 - 2018 IEEE Region 10 Conference

[3] Yi-Hao Peng, Ying-Chih Kuo, Gwo-Ruey Lee, Jyh-Horng Wen, Nat.Chung Cheng Univ., Chia-Yi, ―Performance Analysis of a NewICI-Self-Cancellation-Scheme in OFDM Systems,‖ IEEE Trans 2017. vol. 53, pp.1333 – 1338.

[4] Thota Sravanti ; N Vasantha Precoding PTS scheme for PAPR reduction in OFDM 2017 International Conference on Innovations in Electrical, Electronics, Instrumentation and Media Technology (ICEEIMT) Year: 2017 | Conference Paper | Publisher: IEEE

[5] Necmi Taşpınar ; Mahmut Yıldırım A Novel Parallel Artificial Bee Colony Algorithm and Its PAPR Reduction Performance Using SLM Scheme in OFDM and MIMO-OFDM Systems IEEE Communications Letters Year: 2015 | Volume: 19, Issue: 10 | Journal Article | Publisher: IEEE

[6] Jun-Young Woo ; Hyun Seung Joo ; Kee-Hoon Kim; Jong-Seon No ; Dong-Joon Shin PAPR Analysis of Class-III SLM Scheme Based on Variance of Correlation of Alternative OFDM Signal Sequences IEEE Communications Letters Year: 2015 | Volume: 19, Issue: 6 | Journal Article |

[7] Cho, Y. S.; Kim, J.; Yang, W. Y. & Kang, C. G. (2011). MIMO-OFDM Wireless Communications with MATLAB. John Wiley & Sons, Inc. (Asia) Pte Ltd. ISBN:978-0-470-82561-7.Chu, D.C. (1972). Polyphase codes with good periodic correlation properties. IEEE Trans.Inform. Theory, vol. IT-18, pp. 531-532, 1972.

[8] Imran Baig ; Varun Jeoti A new ZCT precoded OFDM system with pulse shaping: PAPR analysis 2010 IEEE Asia Pacific Conference on Circuits and Systems Year: 2010 | Conference Paper | Publisher: IEEE

[9] Baig, I. & Jeoti, V. (2010). DCT Precoded SLM Technique for PAPR Reduction in OFDM Systems," The 3rd International Conference on Intelligent and Advanced Systems, Kuala Lumpur, Malaysia, 2010.

[10] Baig, I. & Jeoti, V. (2010). Novel Precoding Based PAPR Reduction Techniques for Localized-OFDMA Uplink System of LTE-Advanced. Journal of Telecommunication, Electronic and Computer Engineering (JTEC) Malaysia, vol.2 no.1, pp 49-58, 2010.

[11] Baig, I. & Jeoti, V. (2010). PAPR Analysis of DHT-Precoded OFDM System for M-QAM. The 3rd International Conference on Intelligent and Advanced Systems, Kuala Lumpur, Malaysia, 2010.

[12] Yuping Zhao and Sven-Gustav Häggman, ―Intercarrier Interference Self-Cancellation Scheme,‖ IEEE Trans. vol.49, JULY 2010. Adarsh,―OFDM system for wireless communications, 2010.

[13] Jeoti, V. & Baig, I. (2009). A Novel Zadoff-Chu Precoder Based SLM Technique for PAPR Reduction in OFDM Systems. invited paper, Proceedings of 2009 IEEE International Conference on Antennas, Propagation and Systems, Johor, Malaysia, 2009.

[14] Guel; Jacques Palicot Artificial signals addition for reducing PAPR of OFDM systems Desire 2008 IEEE International Symposium on Signal Processing and Information Technology Year: 2008 | Conference Paper |

[15] Thompson, S. C.; Ahmed, A. U.; Proakis, J. G.; Zeidler, J. R. & Geile, M. J. (2008).Constant envelope OFDM. IEEE Trans. Communications, vol. 56, pp. 1300-1312, 2008.