TELKOMNIKA Indonesian Journal of Electrical Engineering
Vol. 12, No. 8, August 2014, pp. 6291 ~ 6296
DOI: 10.11591/telkomnika.v12i8.5549

Peak Power Reduction Using Improved Selective Mapping Technique for OFDM

M. R. Anjum*, Mussa A. Dida, M. A. Shaheen
School of Information & Electronics, Beijing Institute of Technology, Beijing, China, 100081
*Corresponding author, e-mail: engr.muhammadrizwan@gmail.com

Abstract

The concept of Orthogonal Frequency Division Multiplexing (OFDM) was initiated and well prominent since 1966 and gradually reached to its development into standard system form during 1990. Large amounts of digital data, with high data rate, reliable communication over fading channels can be transmit over radio waves that is why OFDM is known to be an attractive technique for multicarrier transmission scheme, it is an attractive technique for fourth generation wireless communication. The term OFDM is a special type of FDM which has very vast application in the field of wireless and wired communication systems. OFDM has Major disadvantage is that it leads to high Peak to Average Power Ratio (PAPR) which is consider to be as the main implementation drawback. This kind of system has the possibility of high PAPR. In this paper we are discussing about PAPR which affects the performance and efficiency of Power Amplifier (PA) and its influence by utilizing the Selective Mapping (SLM) technique in OFDM system for reduction of PAPR. Many kinds of techniques are available in OFDM system for reduction of PAPR, However the idea for improved SLM produces several independent signals based on converting the original data lock into many independent signal and then the signal has lowest PAPR that specific signal is transmitted. Also data rate trade-off exist at the receiver end when side information is detected for the recovery of data block which leads to the reduction of data rate. Improved SLM techniques for reducing the PAPR is the most promising reduction technique in its non-uniform phase factor for PAPR reduction in multicarrier OFDM system. Furthermore the estimate expression by using Complementary Cumulative Distribution Function (CCDF) for PAPR has been discussed. Simulated results demonstrate that OFDMA signals using improved SLM technique carried significant effects in reduction of PAPR in OFDM system.

Keywords: *FDM, OFDM, PAPR, SLM, QPSK*

1. Introduction

OFDM becomes prominent technology over the past decade due to its property of robustness against multipath fading, high speed transmission without utilizing the expensive equalizers that is why, it is form the basis of physical layer and for high data rate broadband technologies includes WiFi (IEEE802.11a/g), Digital Video Broadcasting (DVB), WiMAX (IEEE802.16a/e) and Digital Subscriber Line (XDSL). OFDM is like similar to Frequency Division Multiple Access (FDMA) where access of multiple users is achieved into multiple channels by sub-channel dividing the available bandwidth, which is then allocated the users. While OFDM spectrum efficiently utilizes by spacing the channel close to each other [1-5]. Major drawback in OFDM transmitted signal is PAPR and the characteristic of PAPR reduction including distribution needs to be considered. PAPR distribution follows the stochastic characteristics in OFDM system. It can be expressed in terms of Complementary Cumulative Distribution Function (CCDF), orthogonal subcarrier signal as shown in Figure 1.

High PAPR require linear amplifier and it is difficult to maintain linearity, the amplifier which produces non linear characteristic such that it play a great role of undesired distortion like out of band signal saturation. In order to overcome this problem several method can be employed such as clipping and filtering, Tone reservation (TR), Tone Injection (TI), Partial Transmit Sequence (PTS), Active Constellation Extension (ACE), Selective Mapping (SLM) also based on coding technique as well.

Received December 31, 2013; Revised February 18, 2014; Accepted March 6, 2014

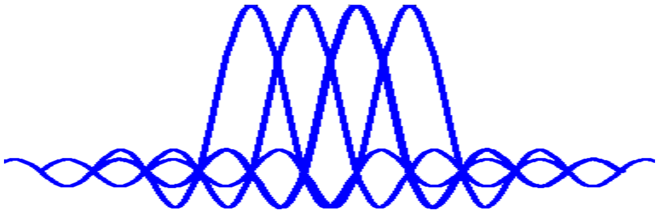

Figure 1. Orthogonal Subcarrier Signal

PAPR can be reduced in OFDM system using clipping and filtering but it generates in band clipping noise and filtering is known to be the phenomenon where side band is going to reduced or removed due to coz of clipping. Other methods like TR, ACE does not possess such kind of problem except the usage of high power to the transmitter. Phase rotation is also another technique for reduction of PAPR. Degradation occurs in (Bit Error Rate) BER and it is the drawback using this method. Due to out of band noise produces by using this method called clipping technique, high power consumption it utilize in constellation extension based method. Therefore recently work in progress to optimize the parameter for improving better PAPR reduction. In non linear region High Power Amplifier (HPA) produces signal distortion and PAPR of OFDM signal introduces degradation in BER. Further more in order to improve spectral efficiency of multicarrier among the inter modulation of subcarrier signal and out of band radiation noise.

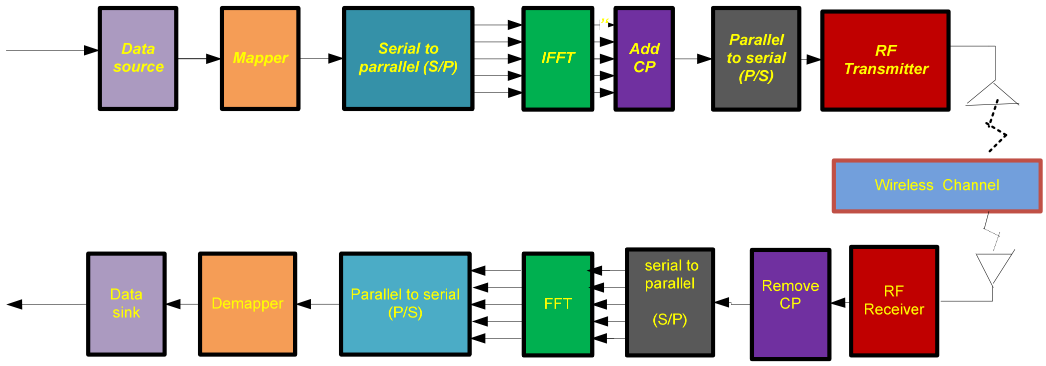

Figure 2. Process of a Typical OFDM System

The power amplifier of transmitter essentially requires operating in linear region. It is not possible to maintain specific limit to keep out of band power, if HPA do not operate in linear region with high back off. This condition is known to be not suitable for amplification also transmitter becomes expensive that is why work is to be needed to do more research further on characteristic of PAPR including distribution and reduction of OFDM system with technical features, process of typical OFDM system is shown in Figure 2. OFDM benefit contributes several aspects such that robustness to channel, high spectral efficiency immunity to impulse interference, less non linear distortion, uniform spectral efficiency, multipath delay spread to tolerance, immunity to frequency selective fading channel, capacity of handling strong multipath fading and immunity to inter symbol interference. However still the efficient design of OFDM system is considered to be the challenging issue and it is remain unresolved [6-8].

In this paper firstly the characteristic of OFDM PAPR distribution is analyzed and then determine system model for improved SLM technique in section 2 is discussed. Simulation results performance determine in section 3. Finally conclusion is drawn in section 4.

2. System Model

PAPR reduction in OFDM system carries many techniques or approaches such that clipping technique, adaptive pre distortion technique, coding technique and DFT spreading technique. Non linear saturation produces on the peaks to minimize the PAPR for that clipping method is employed. Clipping method is simple to implement, however it produces out of band and in band interfaces also it destroy the orthogonality among subcarriers. For this kind of specific approach includes clipping and filtering technique, block scaling technique, peak cancellation technique, and peak windowing technique. To select code words that reduce or minimize PAPR by coding technique, which creates no out of band radiation and it causes to produce no distortion but the bandwidth efficiency degraded and code rate is reduced with complexity. Reed Muller code, Golay complementary sequence can be used for large number of subcarriers. To transmit OFDM symbol with minimum PAPR probability existence can be produced by scrambling of input data block of OFDM symbol using probabilistic scrambling technique. This technique does not bear out of band power however as the number of subcarrier increases the complexity increases and spectral efficiency decreases. Furthermore to make PAPR below specified level techniques involves PTS, TR, SLM and TI. In OFDM system High Power Amplifier (HPA) can be used to compensate nonlinear effects using adaptive pre distortion technique. Where it can automatically modify the input constellation with least hardware requirement to overcome the time variation of non linear HPA [7].

For OFDM system with N subcarrier, for each OFDM subcarrier, there will be M independent data generated by multiplying each OFDM subcarrier with a phase offset P. The generated data are then compared to choose OFDM subcarrier with minimum PAPR. Figure 3 is showing an approach which used by SLM schemes for reducing PAPR for OFDM signal.

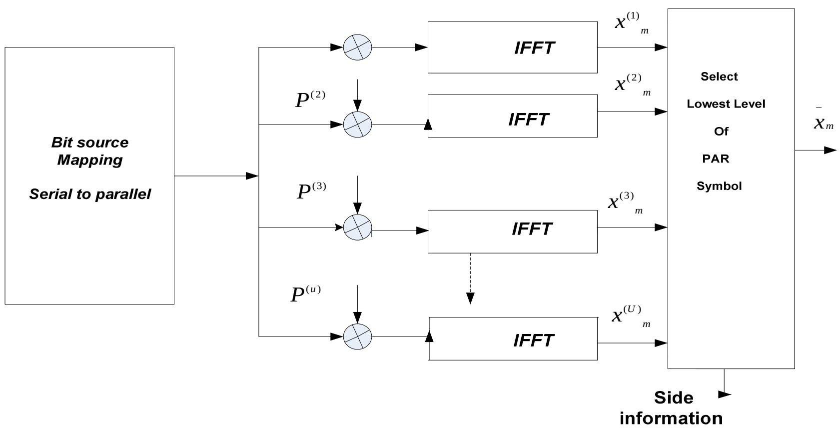

Figure 3. Block Diagram of SLM Approach

For proper reception of the transmitted OFDM subcarrier, the receiver must have information of which OFDM mappings was chosen i.e. The receiver can detect the correctly transmitted OFDM subcarrier, In this case extra information has to be transmitted along with the selected OFDM mappings. In this research an OFDM with subcarriers i.e. 128 bits is used and 4 bits are extra information is used. OFDM system modulation process used the binary bit stream change into complex data after a modulation keys such as QPSK data subcarrier X_T and after IFFT is to time domain x_k [9-15]. PAPR in OFDM system is the ratio of peak power to average power. In time domain x_k in baseband signal may determine as:

$$\text{PAPR (dB)} = 10\log_{10} \frac{\max\limits_{0 \le n \le N-1} \{|x_k|^2\}}{E\{|x_k|^2\}} \qquad 0 \le n \le N-1 \tag{1}$$

The OFDM symbol is complex value i-e, real part Xc and imaginary part xj of $x_m = x_c + jx_d$ and its Gaussian distribution becomes:

$$S(t) = \frac{1}{\sqrt{2\pi\delta}} e \frac{(t - m_t)}{2\delta^2} \tag{2}$$

According to probability theory the amplitude value for OFDM becomes

$$c = \sqrt{x_c^2 + x_d^2} \tag{3}$$

C is the Raleigh distribution, the pdf value may represent by:

$$P(c) = 2ce^{-c^2} \tag{4}$$

OFDM power symbol represent by $p\,|\,c\,|^2$, the pdf of Power .

$$\mathrm{P}_{\mathrm{power}}\ (\mathrm{y}) = e^{-y} \tag{5}$$

The Cumulative Distribution Function (CDF) of PAPR represent the probability distribution of the PAPR value below threshold value may defined as below:

$$P(PAPR \le Y) = (1 - e^{-1})N \tag{6}$$

The probability of PAPR value more than threshold value for the Complementary Cumulative Distribution Function probability (CCDF) represent by:

$$P(PAPR > Y) = 1 - P(PAPR \le Y) = 1 - (1 - e^{-y})^N \tag{7}$$

3. Simulation Result

Improved SLM technique carries computational complexity, however it has good PAPR reduction. Improved SLM technique are very flexible as they do not impose any restriction on modulation applied in subcarrier. In this technique input data block given by:

$$X = [X_0, X1, \ldots\ldots\ldots\ldots\ldots\ldots X_{N-1}]^T \tag{8}$$

This multiplied with U at different phase ϕ sequence.

$$P^U = [P_0^U, P_1^U, \ldots\ldots\ldots\ldots\ldots P_{N-1}^U] \tag{9}$$

After applying SLM technique the complex envelope of the transmitted OFDM signal becomes:

$$X_m = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X_n e^{j2\pi n\Delta ft} \qquad 0 \le t \le NT \tag{10}$$

NT represents the direction of OFDM data block. Output data of lowest PAPR is selected to transmitter PAPR reduction effect will be better as copy block number U is increased. Improved SLM based technique effectively reduces PAPR without any signal distortion. The higher computational complexity can reduce by reducing the IFFT block. The simulation result is done for point IFFT. Random signal 128 are generated and coded by different coding rates for the SLM technique. The coded signals are then QPSK modulated simply to ease the process CCDF of PAPR for 128 point IFFT. As shown in Figure 4 that the PAPR reduction using improved SLM technique provides better reduction in OFDM system than its conventional PAPR of OFDM system.

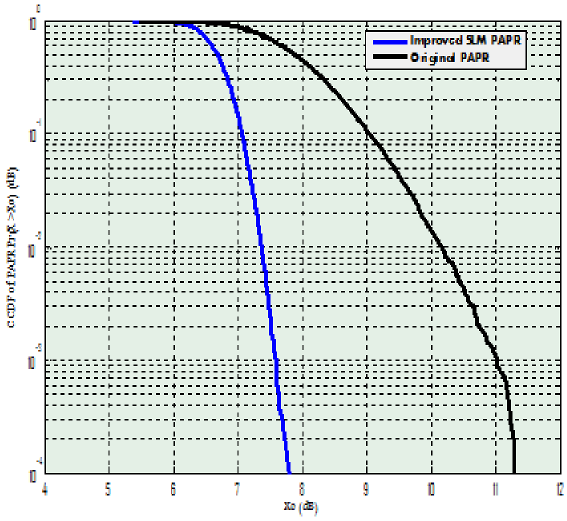

Figure 4. CCDF of PAPR for OFDM with SLM using 128 Carriers

4. Conclusion

OFDM provides spectrum efficiency and channel robustness due to this it becomes attractive technique for next generation communication system and for rapidly increasing the demand of frequency spectrum utilization. We have proposed an improved SLM technique by applying sets of pre-determined non-uniform phase in OFDM systems for the reduction of PAPR. Going for lower value of N (number of carriers) for OFDM signal is good practice for having a lower value of PAPR in multicarrier modulation. High PAPR produces the saturation in PA which tends to inter modulation mixing with next subcarriers. For reduction of PAPR several method are available such as windowing, coding, tone reservation, pulse shaping, clipping etc. However these methods are unable to get simultaneously large PAPR reduction with minimum complexity. In this paper, we have discusses many important aspects and also describe the mathematical analysis including PAPR characteristics in OFDM systems. An improved selective mapping technique improved the performance of the OFDM system with respective to PAPR with high spectral efficiency and low complexity. Simulation results shows that the PAPR reduction of OFDM system in Figure 4. The time domain selective mapping technique shows significant enhancements in the PAPR performance. However, the uplink transmitter's computational complexity is going up. Therefore, a compromise between the circuit's cost, complexity and the PAPR tradeoffs should be taken into consideration.

References

[1] Kargozar F, Nilashi M, Ibrahim O. SLM Technique Combined with a Random-Like Coding for Reducing PAPR in OFDM Systems with No Explicit Side Information. *International Journal of Information and Electronics Engineering*. 2013; 3(30).
[2] Tong, Yinghua, Shengling Geng. The Method of Signal Decomposition to Reduce the PAPR. *TELKOMNIKA Indonesian Journal of Electrical Engineering*. 2013; 11(10).
[3] Ahmad Mohammad, Fatama Newagy, Abd El-Haleem Zekry. Influence of Utilizing the Selective Mapping Technique for PAPR Reduction in SC-FDMA Systems. *International Journal of Computer Applications* (0975 – 8887). 2012; 48(25).

[4] Vijayarangan V, R Sukanesh. An overview of techniques for reducing peak to average power ratio and its selection criteria for orthogonal frequency division multiplexing radio systems. *Journal of theoretical and applied information technology*. 2009; 5(1): 25-36.
[5] Jiang, Tao, Yiyan Wu. An overview: peak-to-average power ratio reduction techniques for OFDM signals. *Broadcasting, IEEE Transactions on*. 2008; 54(2): 257-268.
[6] Muller, Stefan H, Johannes B Huber. *A comparison of peak power reduction schemes for OFDM.* Global Telecommunications Conference. GLOBECOM'97, IEEE. 1997; 1.
[7] Cho, Yong Soo, Jaekwon Kim, Won Young Yang, Chung G Kang. MIMO-OFDM wireless communications with MATLAB. Wiley. Com. 2010.
[8] Tao Jiang, Yiyan Wu. An overview. Peak-to-average power ratio reduction techniques for OFDM signals. *IEEE transactions on broadcasting*. 2008; 54(2): 1-5.
[9] Dae-Woon lim, Seok-Joong Heo, Jong-Seon. An overview of Peak-to-average power ratio reduction schemes for OFDM Signals. *Journal of communicaitons and networks.* 2009; 11(3): 257.
[10] Seung Hee Han, Jae Hong Lee. An overview of Peak-to-average power ratio reduction techniques for multicarrier transmission. *IEEE wireless communication*. 2005: 56-65.
[11] Moosa A Dida, MR Anjum, F Manzoor. Comparative Analysis of Orthogonal Frequency Division Multiplexing and Single Carrier Cyclic Prefix Modulation Schemes in Powerline Communication Systems. *IJERT Journal*. ISSN # 2278-0181. 2013; 2(12).
[12] Shi Pengfei, MR Anjum, Zhao Yue. Tone-Reservation based on fractional Fourier Transform for Chirp-based OFDM. *International Journal of Scientific & Engineering (IJSER) Journal.* ISSN # 2229-5518. 2013; 4(7).
[13] MR Anjum, yinbei Li, shifeng fei. Improved calibration method of amplitude and phase errors based on diagonal loading. *International journal of Advanced Materials Research*. Switzerland. 2013; 717: 359-364, ISSN: 1662-8985.
[14] Luqing wang, Chintha tellambura. A Simplified clipping and filtering technique for PAR reduction in OFDM systems. *IEEE signal processing letters*. 2005; 12(6): 453-456.
[15] Brian Scott Krongold, Douglas L Jones. PARP Reduction in OFDM via Active constellation extension. *IEEE Transactions on broadcasting.* 2003; 49(3): 258-268.