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Reduction Techniques of PAPR in VLC OFDM System

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***Abstract*: Wireless communication system is one of the important aspects in communication technology by using LED lights. Visible Light Communication OFDM system is a new way of data communications medium using visible light. Visible light frequency spectrum bandwidth ranges from 400 THz to 800 THz. Visible light communication technology enabling data transmission by using light emitting diode (LED). This device has attracted much attention in recent communication system. Orthogonal frequency division multiplexing modulation technique plays an important role in long distance communication system. The OFDM is a multi-carrier modulation scheme which enables transmission of multiple signals; simultaneously over a single transmission path. Orthogonal Frequency Division Multiplexing (OFDM) has been widely used in wireless communications technology due to its high data rate, frequency selective fading and immunity to delay spread and other advantages, but besides these benefits the main disadvantages is the high peak to average power ratio (PAPR). This peak to average power ratio is an important feature to analyze the system performances. PAPR will increase the system complexity and reduce the communication system performance. High PAPR limit the application of OFDM system. To reduce the OFDM signal peak to average power ratio (PAPR) in VLC system, the Selected Mapping (SLM), Partial Transmit Sequence (PTS) and Discrete Fourier transform spread (DFT-S) techniques are used. In this paper for PAPR reduction all above three techniques are used to further reduced PAPR at lower value. For statistical analysis of PAPR the Complementary Cumulative Distribution Function (CCDF) is used. Performance analysis in terms of CCDF plots will be shown.**

***Keywords*— Visible Light Communication; Light emitting diode; peak to average power ratio; Partial Transmit Sequence; Selected Mapping; Discrete Fourier transform spread.**

I. INTRODUCTION

Visible Light Communication uses the visible light spectrum bandwidth which ranges from 400 THz to 800 THz. This bandwidth is larger than the radio frequency (RF) bandwidth, which ranges from 3 kHz to 300 GHz. With a larger bandwidth it is possible to accommodate more Users and potentially achieve highest data transfer rates because each user can be given a larger portion of the bandwidth to transfer information. VLC addresses the issue of energy efficiency and requirement of wireless system capacity. Orthogonal Frequency Division Multiplexing (OFDM) is one of the Strong candidates for Transmission of high data rate due to Multicarrier Modulation, which provides high spectral efficiency, low implementation, low complexity and non linear distortion. Due to these advantages of the OFDM system, always used in various communication systems. But the major problem arrives while implementing this system is the high peak to average power ratio of this system. A high value of PAPR in system increases the complexity of the ADC and DAC converter and reduces the spectral efficiency of the radio frequency (RF) power amplifier.

VLC technology enabling data transmission by modulating light emitting diode devices has attracted much attention recently. Typical transmitters used for VLC are visible light LEDs and receivers are photodiodes and image sensors. With the rapid growth in light emitting diodes (LEDs) technology it is possible to implement this technology for commercially viable purposes. LEDs have a different advantage of being highly efficient at very low cost applications which enables them to be widely implement in various applications such as indoor and outdoor lighting, LEDs are now replacing by laser diodes which have less complex circuitry to operate them and no additional thermal and optical stabilization circuits are needed. White LED offers advantageous such as high brightness, reliability, and lower power consumption, maintenance-free and long lifetime. In visible light communication using LED lights, the large received power, which consists of the optical paths signal delay propagation, causes inter symbol interference. Visible light communication has properties that are having both advantageous and disadvantageous as compared to radio wave wireless communication. The main disadvantages of VLC are communication distance and data rate. There is one more disadvantage of visible light communication, which is data

rate. Its data rate is between kilobits per second to 10 megabits per second. The data communication range of visible light communication is typically between 1 to 90 meters. This distance is too short as compared to radio-wave communication, due to the fact that visible light communication is line-of-sight communication, which means that data communication is interrupted when there is an object present between a transmitter and a receiver.

II. OFDM AND PAPR OVERVIEW

The OFDM is a multi-carrier modulation scheme which enables transmission of multiple signals; simultaneously over a single transmission path. OFDM uses in wireless communications system because of its high data rate handling capacity. One of the main disadvantages of OFDM is the high PAPR. PAPR is an important criterion to measure the communication system performances. Presence of PAPR in VLC system will increase the system complexity and reduced performance. In VLC systems, intensity modulation is used at the transmitter. The forward signal drives the LEDs which in turn converts the magnitude of the electric signal into optical intensity. The human eye cannot see the fast-changing variations of the light intensity, and only responding to the average light intensity. A photodiode (PD) convert the received incoming optical power into the amplitude of an outgoing electrical signal. High PAPR value for the fixed number of data bits per sample introduces the serious quantization error. To minimize this quantization error, the accuracy should be increased. As a result the complexity of ADC and DAC will increase. To overcome this problem, linear amplifiers are needed

PAPR is given by:

$$PAPR = \frac{\max_{0<n<N} |x(n)|^2}{P_{average}}$$

The complementary cumulative distribution function of the PAPR of OFDM signals is used to evaluate the PAPR reduction performance accurately from the statistical analysis. CCDF plot helps us to measure the probability that the PAPR of a certain data block exceeds the given threshold value which is given as:

CCDF (PAPR(x(n))) = Pr(PAPR(x(n)) > PAPR0

III. PAPR REDUCTION TECHNIQUES

To reduce OFDM signal PAPR in VLC system, Partial Transmit Sequence (PTS), Discrete Fourier transform spread (DFTS), and selected mapping (SLM) techniques are used.

A. Partial Transmit Sequence

The PTS method is a typical algorithm of signal scrambling techniques. It was first introduced by S. H. Muller and J. B. Huber in 1997.The PTS method is adopted to carry out random phase weighting to the signal to reduce the OFDM signal peak value probability signal appears, thereby reducing the PAPR of OFDM signal. The PTS is effective distortion less PAPR reduction techniques. It provides PAPR reduction and good BER performance in VLC as compared with clipping and filtering.

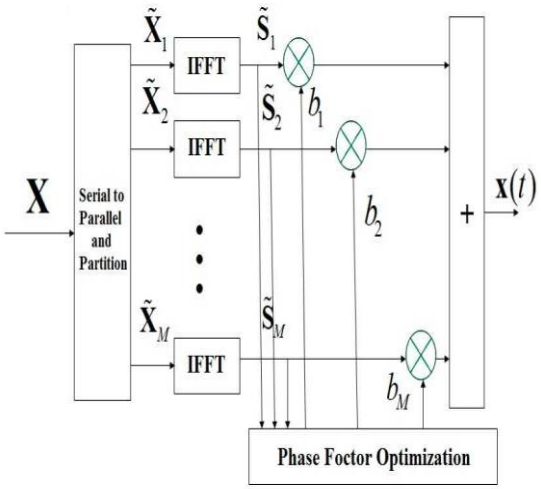

Figure 1.The block diagram of the PTS method in VLC system

PTS method used in VLC OFDM system block diagram is shown in figure1.In this PTS method the input data symbols in X are partitioned in to M disjoint sub blocks. The sub blocks $X^{(i)}$ are transformed in to M time-domain partial transmit sequences. These sequences are independently rotated by some phase factors (bi), These signals are then combined to produce the time domain OFDM signal packet back. PTS algorithm selects a vector (bi) such that the PAPR of the corresponding transmit sequence x(t) will be the lowest. However PTS is computationally complex and need to transmit appropriate side information. In PTS, many researchers are trying to reduce computational complexity in different ways because selection of optimized phase vector is tedious process. For reducing the OFDM signal PAPR value in VLC system, the Partial Transmit Sequence method is combined with Discrete Fourier transform spread are used.

B. Selected Mapping

SLM is the most popular PAPR reduction method in VLC. By choosing efficient phase rotation factors the PAPR performance of SLM-OFDM is improved. This will reduce the information data rate and increase the size of side information.

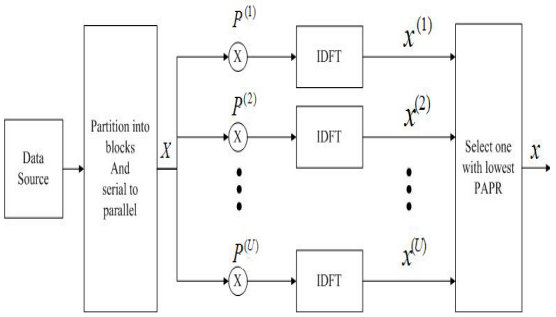

Figure 2.The block diagram of the SLM method in VLC system

SLM-OFDM system used with limited size of side information, the number of selected phase rotation factors is also being limited. Figure 2 shows the block diagram of SLM technique in VLC OFDM system. In SLM method input data symbols X are partitioned in to the blocks.The original input data X[X0,X1,….X(N-1)]T multiplied with independent phase sequences P(u) = [P(u)0,P(u)1,..P(u) (N-1)]T, u=(0,1,U-1), where U is the number of phase sequences. After multiplication, inverse discreet Fourier transform (IDFT) will be applied on each sequence to convert the signal from frequency domain to the time domain. The last step is comparing the PAPR among the independent data blocks and the candidate with the lowest PAPR will be selected for transmission.

The PAPR performance was increase with more rotated groups present in SLM, but more data bits of side information are required also the data rate is lower.The OFDM signal with the lowest PAPR is selected for light transmission in the SLM method. Unlike the conventional PTS, SLM is not required to transmit and recover the side information about the phase rotation. SLM technique avoids the side information requirement at the receiver by cyclic shifting the pilot subcarriers for each of the independent mappings in pilot assisted SLM-OFDM systems. The effectiveness of the method is presented in presence of SSPA for marine channel.

C. DFT-Spread

DFT-S OFDM has been proven one of the most effective ways to reduce OFDM signal PAPR. On the basis of subcarrier allocation patterns, DFT-S OFDM system can be divided into interleaved DFT-Spread (IDFT-S) OFDM and localized DFT-Spread (LDFT-S) OFDM. In Visible Light Communication systems, the requirement of real signals, special circular conjugate symmetry constraints are imposed on to the OFDM subcarriers. It makes the DFT-Spread OFDM implementation in VLC quite different from the conventional DFT-Spread OFDM structure.

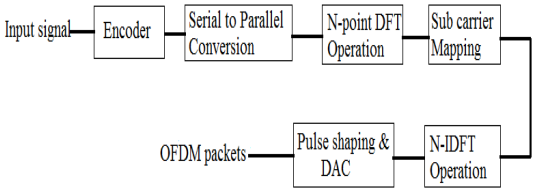

Figure 3.The block diagram of the DFT method in VLC system

With this DFTS technique, the theoretical analysis is firstly carried out to help characterize the OFDM system PAPR reduction value in VLC systems. In this method the data input symbols are first encoded and converted from serial to parallel before transforming the symbols to frequency domain by DFT operation are shown in figure3. After that the OFDMA modulation is then performed followed by pulse shaping filter that shape the signal to get the desired spectrum and then transmit the analogue signals through a channel after DAC conversion. Since different subcarriers in the frequency domain are occupied by every user like in OFDMA technique.

On the basis of this result detail comparisons of DFT-Spread OFDM with other techniques in terms of OFDM PAPR reduction are made for VLC systems. Simulation results analysis shows that the DFTS system reduced PAPR in OFDM system and also achieves a high performance gain in BER without any losses in the system transmission rate.

IV. SIMULATION ANALYSIS

The following simulation CCDF plot through MATLAB, PTS, SLM and DFTS verify the performance of PAPR under visible light communication in OFDM system.

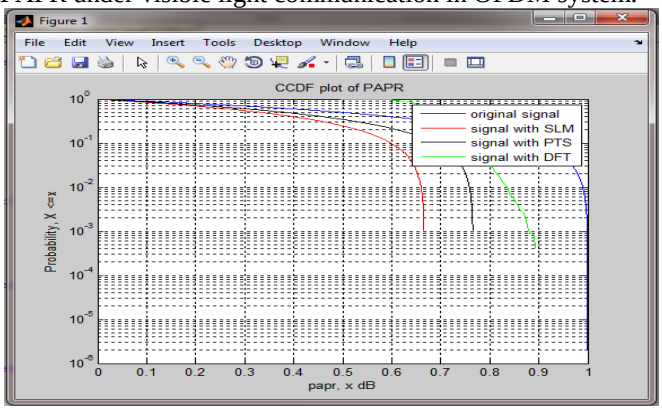

Figure4. Simulation of PAPR performance of the SLM, PTS and DFT algorithm

The above figure 4 shows the CCDF plot for the performance of different PAPR reduction techniques. The PTS method used in VLC OFDM system reduced PAPR

approximately by 2.2 dB. SLM method used in VLC OFDM system reduced PAPR approximately by 3.7 dB. DFT-S method used in VLC OFDM system reduced PAPR approximately by 1.33 dB.

V. CONCLUSION

In this paper, with the help of comparative study of PAPR reduction techniques, Partial Transmit Sequence (PTS), Selected Mapping (SLM) and Discrete Fourier transform spread (DFTS) have been analyzed. It is observe that SLM method for PAPR reduction has better PAPR reduction performance than the other PTS and DFT methods.

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