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Reduction of Peak to Average Power Ratio using Selective Mapping Technique of an OFDM Signal: An Analysis

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Abstract**—**Orthogonal Frequency Division Multiplexing (OFDM) is a optimistic and very popular modulation technique in multicarrier domain which is quite promising regarding the issues of interferences present in next generation mobile communication systems. It deployed in the area where high data rate and low latency required while efficiency will be as better as possible. The critical problem in OFDM system is maintaining low PAPR (peak to average power ratio) because it reduces the performance of system. There are several techniques which are used to overcome problem of high PAPR in OFDM modulation system. One of the techniques is Selective Mapping (SLM) which comes in distortion less criteria. In this paper analysis of PAPR reduction of an OFDM system for distortion less transmission criterion is shown. We have also used some mathematical equations to calculate and simulate its performance. It's also shown that SLM method grants the user a better PAPR reduction while having high complex circuitry.

Keywords: *OFDM, CCDF, PAPR, BPSK, SLM, PTS, QAM, QPSK.*

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I. INTRODUCTION

In recent year, demand of high speed internet increases rapidly. For performing video streaming, playing online games, video calling and voice over internet. A high data transfer rate is very essential for high speed data transfer this leads to a high speed internet operation. There are many technique used to provide high data rate for data transmission .Basically the multipath-communication play an important role for improvement of data rate .In multipath communication the main issue is bandwidth and inter symbol interference (ISI) [1] .To overcome this issue Orthogonal frequency division multiplexing (OFDM) play vital role, this increase data rate and also improves inter symbol interference (ISI). OFDM is a special case of frequency-division multiplexing (FDM) technique used as a digital multi-carrier modulation technique [2]. In this large number of orthogonal sub-carrier signals are used to carry data on many parallel data streams or channels. where each sub-carrier is modulated with general modulation methods (such as QAM or PSKs) at small symbol rate, maintaining total data rates equals to conventional single-carrier modulation method of the same bandwidth. OFDM is a multicarrier communication which provides high data rate for transmission of information over wireless channel. Due to high data rate OFDM is very promising techniques for next generation mobile communication namely long term evolution (LTE), 4th generation mobile communication (4G). OFDM has also numerous advantages which are used in many applications, such as digital video broadcasting (DVB), digital audio broadcasting (DAB), and wireless-Lan (IEEE802.11a/g), WiMAX [3].

High spectral efficiency, robust to channel fading, good immunity to inter-symbol interference (ISI), uniform spectral density, and less non-linear distortion are the advantages OFDM system. OFDM is the modulation technique used in several latest broadband wireless communication systems. Fundamental issue with OFDM is its high Peak to Average Power (PAP) ratio and inter-symbol interference (ISI).In OFDM system channel bandwidth is divided in N number of sub-band each called as subcarrier, individual subcarriers which are in-phase ware added results in large peak amplitude causes high PAPR at output. This large amplitude fluctuated signal requires a high power amplifier must be operated in linear region to amplify it. But in practical high PAPR forces the power amplifier to operate in non-linear region (saturation) which results in in-band distortion and out-band radiation. To make OFDM as an efficient transmission technique its PAPR must be reduced.

There are several mechanism to reduce the PAPR of an OFDM signal, namely Clipping and filtering, selective mapping (SLM), partial transmit sequence (PTS) and coding methods. Clipping and filtering method belongs to distortion, selective mapping and partial transit sequence fall in distortion-less methods. PAPR reduction using clipping and filtering technique is a distortion based technique [4].

Clipping is almost simplest PAPR reduction technique. In this reduction technique clipping is performed for oversampled signal where oversampling factor is greater than or equal to 4,

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i.e. L≥4.filtering is used to re- growth of peak of the signal. In clipping and filtering distortion present in the signal may affects the BER performance of the system [5].

Coding method is also a popular scheme to reduce PAPR without altering the main signal. Several coding schemes are there to reduce PAPR namely, Block-coding, Cyclic-coding, Shapiro- Rudin-coding, Golay-complementary coding, Reed-Muller Coding schemes. The most widely used coding method is Golay complementary sequence coding which ensures that the main signals may not exceed the PAPR value equals to 3 dB . The main advantage of using this coding is not only their small PAPR value but also their good error correction properties.

In Partial transmit sequences (PTS) method the original OFDM signal is first divided into a number of sub-blocks, and then adding the phase rotated sub-blocks to develop a number of candidate signals to pick the one with smallest PAPR for transmission.[6]

II. THE OFDM SYSTEM MODEL

OFDM is obtained by combining modulation and multiplexing. Generally multiplexing referred to independent signals, produced by different sources. In OFDM generally multiplexing is applied to independent signals, where independent signals are sub-set of main signal. The independent signals are nothing but sub-set of original signal, which are totally independent to each other due to orthogonality.

Two periodic signals is said to be orthogonal if and only if their integral product is zero in its fundamental interval $[T_1, T_2]$.

Assume $f(t)$ and $g(t)$ are two periodic and they are orthogonal if and only if

$$\int_{T_1}^{T_2} f(t)g(t)dt = 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

In terms of discrete time signal, let's assume $f(n)$ and $g(n)$ are periodic signal and they are orthogonal if

$$\sum f(n)g(n) = 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

In the OFDM system total channel bandwidth (W) which is divided into N sub-channel data stream and then transmit them simultaneously over number of sub-carriers. As the candidate bandwidth (W/N) of the subcarrier is smaller than that of coherence bandwidth (B_c), the channel is said to be a flat fading channel. The subcarriers in the OFDM system allowed to be overlapping because of the orthogonality present between the subcarriers which save bandwidth. The OFDM signal is an addition of individually modulated subcarriers which are transmitted simultaneously as data stream [7].

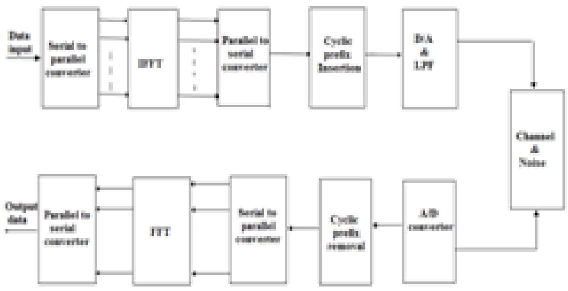

Figure 1: OFDM BLOCK DIAGRAM

Figure 1 shows the block diagram of OFDM system. A block of data stream are modulated using M-array modulation namely - MQAM, M-PSK technique and then passed to the serial to parallel converter section, and forming a complex vector of size N. The complex vector can be represented as

$$X = [X_0, X_1, X_2, \_\_\_\_\_\_, X_{N-1}]^T$$

The obtained parallel data streams are now given to N point IFFT operation. After IFFT operation the envelop of transmitted baseband OFDM signal mathematically written as

$$x_m(t) = \frac{1}{\sqrt{N}} \sum_{k=o}^{N-1} X_{m,k} e^{j2\pi k \Delta f t} . w_k(t - mT) \quad \ldots\ldots. (3)$$

Where $X_{m,k}$ is the data to be transmitted on the k^{th} subcarrier of m^{th} transmitted data stream, and $e^{j2\pi k \Delta f t}$ is the k^{th} subcarrier.

A discrete time domain representation of the above signal can be mathematically given by the following equation.

$$x_{m,n}(n) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X(k)\, e^{\frac{j2\pi kn}{N}} \quad \ldots\ldots\ldots\ldots\ldots (4)$$

Where n is the number of discrete data point.

Here all individual subcarriers which are in-phase ware added results in large peak amplitude cause high PAPR at output. Peak –to-average power ratio can be defined in OFDM system as it is the ratio of instantaneous peak amplitude power to the average power of the signal.

Mathematically defined by

$$PAPR = \frac{max_{0 \le t \le NT} |x(t)|^2}{1/_{NT} \int_0^{NT} |x(t)|^2\, dt} \; ; \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

In discrete time domain,

$$PAPR = \frac{max_{0 \le n \le N-1} |x(n)|^2}{E\{|x(n)|^2\}} \; ; \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

This high PAPR at output requires a high power amplifier must be operated in linear region to amplify it. But in practical high

PAPR forces the power amplifier to operate in non-linear region (saturation) which results in in-band distortion and out-band radiation, which causes degrade in Bit Error rate (BER) performance .[8]

From the above equation it is seen that the peak to average power is random variable, as PAPR is function of input data stream which is random variable. Here statistical distribution most suited for calculation of PAPR.

If number of sub-carrier value is N, and all the sampled value of OFDM signal is independent in all respect then the cumulative distribution function is defined mathematically as

$$Pr(PAPR \leq PAPR_0) = \left[1 - e^{(-PAPR_0)}\right]^N \quad \ldots\ldots (7)$$

The complementary cumulative distributed function (CCDF) of PAPR drives the probability of a data stream exceeds threshold value of PAPR ($PAPR_0$), mathematically it can be defined as

$$Pr(PAPR \leq PAPR_0) = 1 - \left[1 - e^{(-PAPR_0)}\right]^N \quad \ldots.. (8)$$

III. THE SELECTIVE MAPPING METHOD

Selective mapping (SLM) is an optimistic technique used to reduce PAPR in OFDM system model. The main idea behind this technique is to generate number of OFDM symbols by dividing the main signal into N subcarrier as candidates and then select the one with the lowest possible PAPR from different data - blocks for wireless transmission [9] [10].

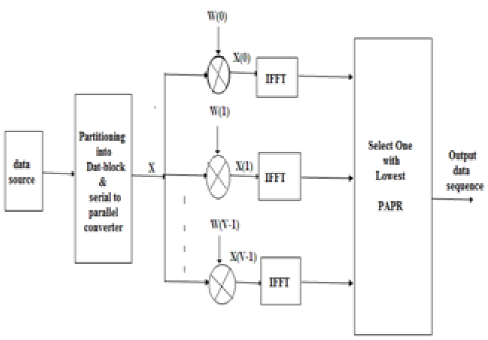

Figure 2: BLOCK DIAGRAM OF SLM METHOD

In general SLM technique, several improved data vectors are generated by multiplying the original data vectors with some random modified sequences. A number of random sequences that represent the original data signal are generated using random phase sequences consisting of different rotation vectors sequence. It is multiplied with the original data vector, phase vector in these random phase sequences rotate the phase of the original signal in such a way that it reduce the PAPR. The number of newly generated sequences vectors is called the SLM length and is denoted by U. U initially statistically independent improved vector sequences which represent the same information that are generated and then forwarded into IFFT operations simultaneously for generating the data vector. After this IFFT operation, the improved sequence which has the lowest PAPR is selected for transmission of data by the transmitter.

Let us consider that the original input data vector $X = [X0, X1\ldots\ldots, XN-1]T$ is multiplied with independent phase vector sequences $W^{(u)} = [W_0^{(u)}, W_1^{(u)} \ldots\ldots . W_{N-1}^{(u)}]^T$ where U is the number of vector phase sequences. Both the input data vector and phase sequences vector have the same length N (= 0, 1…, U-1). After multiplication of both, inverse fast Fourier transform (IFFT) will be applied on each sequence vector the output of IFFT will generate the data block of an OFDM system that has different discrete time domain signals, with length U, and different PAPR values, $X^{(u)} = [X_0^{(u)}, X_1^{(u)}, \ldots\ldots, X_{N-1}^{(u)}]^T$. In The last step comparing of the PAPR among the independent data vectors and the candidate with the lowest PAPR will be selected for

Transmission by transmitter. The equation bellow expresses the optimal value $\overset{\square}{X}$ that has the lowest PAPR selected for transmission by transmitter.

$$\overset{\square}{X} = argmin_{0 \leq u \leq U}[PAPR(X)^{(u)}] \quad \ldots\ldots\ldots\ldots (9)$$

IV. SIMULATION AND RESULTS

The PAPR reduction and performance of BER the proposed SLM method is investigated by computer simulation of an OFDM communication system for N=64, N=128, N=256, N=512 and N=1024 results are compared with the original SLM. The phase rotation factors of phase sequences $P^{(u)}$ used in the conventional SLM method are randomly chosen from the set {1,-1} i.e. $W_k^{(u)}$ takes value 0 and pi in (9). The modulation scheme is assumed to be binary phase shift keying (BPSK). Bit error rate (BER) performance of the receiver is studied under both additive white Gaussian noise (AWGN) and Rayleigh fading channels apart from the CCDF plots.

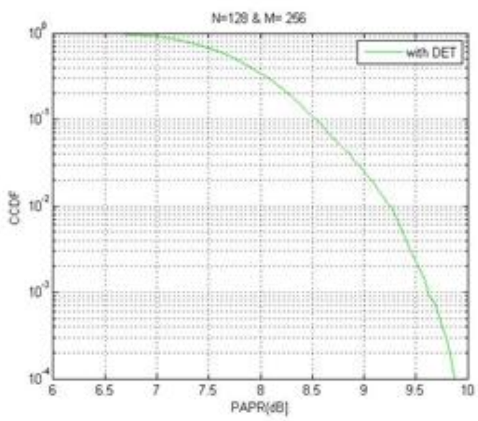

Figure 3: PAPR of Original OFDM signal.

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Figure 3 show the plot of CCDF and PAPR of original OFDM signal, which has value about 10db. Where X axis is PAPR in db and Y axis is CCDF.

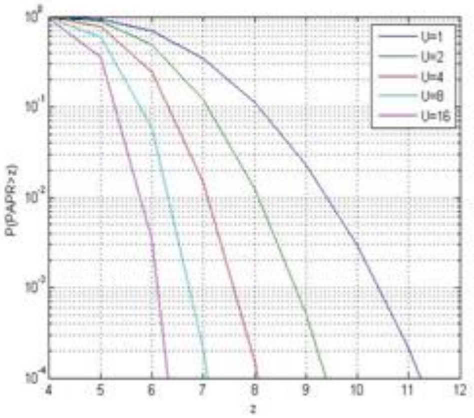

Figure 4: PAPR of OFDM signal, when N=64

Figure 4 shows the plot between CCDF and PAPR it can be shown that PAPR is fall to 6.2db. It is also seen that the power saving is up to 3.8db. When N =64.

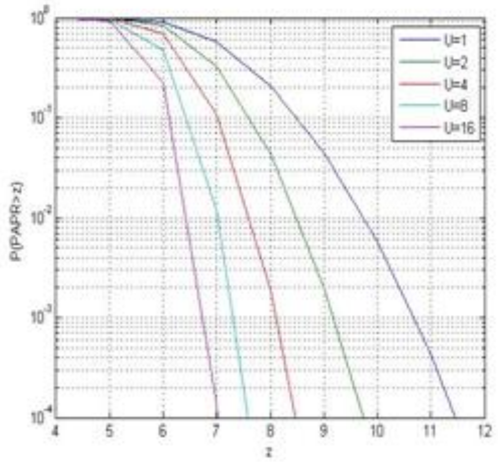

Figure 5: PAPR of OFDM signal, when N=128

Figure 5 shows the plot between CCDF and PAPR it can be shown that PAPR is fall to 7db. It is also seen that the power saving is up to 3db. When N =128.

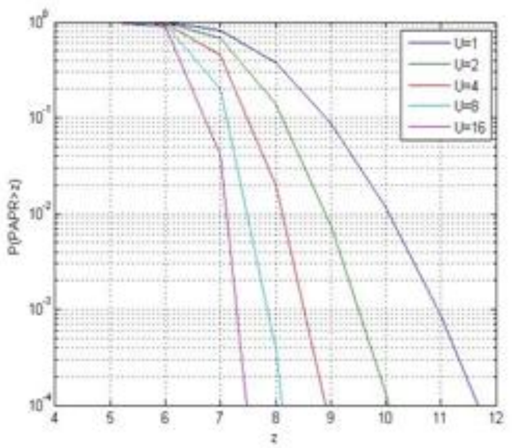

Figure 6: PAPR of OFDM signal, when N=256

Figure 6 shows the plot between CCDF and PAPR it can be shown that PAPR is fall to 7.5db. It is also seen that the power saving is up to 2.5db, when N =256.

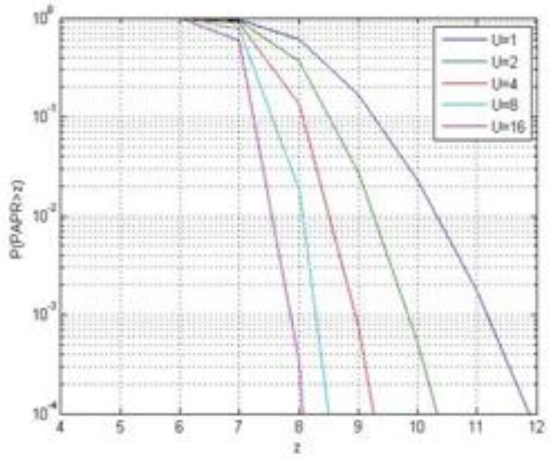

Figure 7: PAPR of OFDM signal, when N=512

Figure 7 shows the plot between CCDF and PAPR it can be shown that PAPR is fall to 8 db. It is also seen that the power saving is up to 2 db. When N =512.

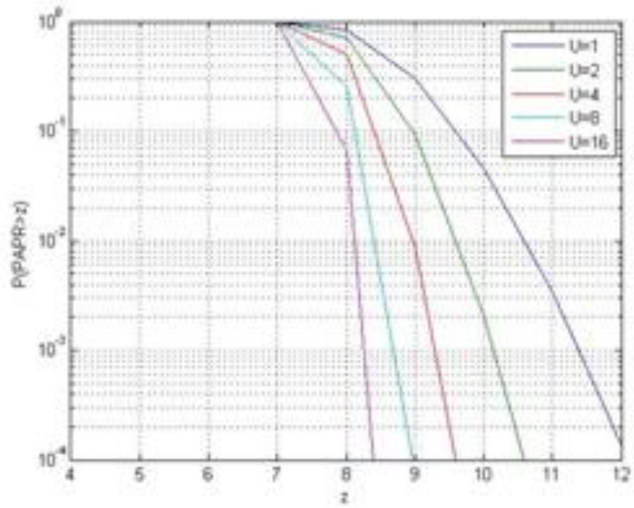

Figure 8: PAPR of OFDM signal, when N=1014.

Figure 8 shows the plot between CCDF and PAPR it can be shown that PAPR is fall to 8.2db. It is also seen that the power saving is up to 1.8db. When N =1024.

V. CONCLUSION

In this paper, we analyzed the conventional SLM method using phase sequences, here we implement the conventional SLM technique and simulate the result using MATLAB. The simulator yields the result using different modulation technique and taking different OFDM symbol. The result of conventional SLM method has been shown in the figure for different value of N=64, N=128, N=256, N=512, &N=1024.Also, it has a lower computational complexity when configured to achieve the same performance of the conventional SLM technique.

REFERENCES

[1] V.Sudha, Sneha Blan &Dr. D Sriram "Performance Analysis of PAPR Reduction in OFDM System with Distortion and Distortion-less method", IEEE conference-2014.

[2] G. Chandra ,D.K Saxena &, G.Bhandari "Performance Tradeoff of PTS & SLM Technique Using Various Modulation in 802.11g", IJEAT Volume-2,Issue-3,2013.

[3] Malhar ,Saurabh, Hardik Patel "Different Techniques to Reduce the PAPR in OFDM System" IJERA-2012

[4] Amit Shukla, Vineeta Saxena Nigam "PAPR Reduction in OFDM System Based on SLM Technique" IJITEE Volume-3,Issue-4, 2013.

[5] W.Aziz ,E.Ahmed "PAPR Reduction in OFDM using Clipping & Filtering" World Applied Science Jornal-2012.

[6] Leonard J ,Cimini Jr & Nelson R "Peak- to-Average Power Ratio Reduction of an OFDM Signal using Partial Transmit Sequence" IEEE-Communication Letter March-2000.

[7] Namitha A.S & Sameer S.M "An Improved Technique to Reduce PAPR in OFDM System using Gold /Hadamard Codes" IEEE- 2014.

[8] Leila Sahraouri ,DJ Mail & Nouredinne "Analysis and Performance Technique of PAPR Reduction for STBC MIMO-OFDM System in (4G) Wireless Communication" IJWMN Volume-5- 2013.

[9] Komal Gupta , Monika , Abhay & Arvind "PAPR Reduction of OFDM Using a New Phase Sequence in SLM Technique" IJAEEE Volume-2 , 2013.

[10] Pankaj Kumar Sharma and R.K Nagraia " An SLM based PAPR Reduction Methods using new Voltrerra Preditortion model in OFDM System" WEWAS Transaction on communication Volume-11, issue-10, 2012.