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PAPR reduction in OFDM using SLM with M-QAM Technique

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ABSTRACT

Orthogonal Frequency Division Multiplexing (OFDM) is an efficient method of data transmission. It is a base for high speed communication systems. The main drawback of OFDM system is that it suffers from high Peak-to-Average Power Ratio (PAPR). Due to high PAPR there is inefficient use of high power amplifier and this could limit transmission efficiency. OFDM consist of large number of independent subcarriers, as a result of which the amplitude of such a signal can have high peak values. In this paper, we introduce a modified SLM technique to reduce PAPR. The simulation results show PAPR can be reduced by applying the proposed scheme. The complexity is also reduced in proposed scheme. The PAPR of original OFDM is near about 10db in my base paper and it reduces it to 6.6db using SLM. And by using the modified SLM technique PAPR is reduced nearly about 3.2dB in comparison to base paper.

Keywords: OFDM, SLM, PAPR, CCDF, QAM.

I. INTRODUCTION

The concept of OFDM was introduced by R.W. Chang in 1966 and was patented in 1970. The principle of of multi-carrier transmission is to divide the entire bandwidth into smaller bandwidths each with a different sub-carrier frequency, such that each of these narrowband signals is immune to frequency selective fading and the data-rates are improved in comparison to single-carrier system as the total bandwidth can be increased significantly. The spectrum of the sub-carriers may overlap but yet can be detected using matched filters with no inter-symbol interference (ISI). This increases spectral efficiency as there is no wastage in bandwidth required to separate two adjacent sub-carriers. Difference in frequency between these subcarriers will be integral multiples of inverse of symbol time. Such a multi-carrier modulation system is effectively termed as orthogonal frequency division multiplexing. OFDM is vastly used in digital audio broadcasting (DAB), digital video broadcasting-terrestrial (DVB-T), mobile multimedia access communication (MMAC), IEEE802.11a, IEEE802.16 and IEEE802.20 [2]. Though OFDM has many advantages like high spectral efficiency, robustness to channel fading, immunity to impulse interference, capacity to handle very strong echoes and less non-linear distortion it also has disadvantage of high PAPR [4]. It becomes very necessary to mitigate high PAPR otherwise it limits the system performance and require high power amplifier with large dynamic range which is bulky and costlier. In this paper we will study PAPR reduction technique SLM and modify it and will compare results of both.

ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING

With the ever growing demand of this generation, need for high speed communication has become an utmost priority. Various multicarrier modulation techniques have evolved in order to meet these demands, few notable among them being Code Division Multiple Access (CDMA) and Orthogonal Frequency Division Multiplexing (OFDM). Orthogonal Frequency Division Multiplexing is a frequency – division multiplexing (FDM) scheme utilized as a digital multi – carrier modulation method. A large number of closely spaced orthogonal sub – carriers is used to carry data. The data is divided into several parallel streams of channels, one for each sub – carriers. Each sub – carrier is modulated with a conventional modulation scheme (such as QPSK) at a low symbol rate, maintaining total data rates similar to the conventional single carrier modulation schemes in the same bandwidth.

The OFDM has many advantage such as high bandwidth efficiency, robustness to the selective fading problem, use of small guard interval, and its ability to combat the ISI problem. The main disadvantages of the OFDM systems is that it exhibits a high peak to average power ratio, namely the peak value of some of the transmitted signals could be much larger than the typical values. PAPR (Peak Average Power Ratio) makes the amplifiers to work in non-linear regions. This will cause inter modulation between the different sub carriers and introduce additional interference to the system.

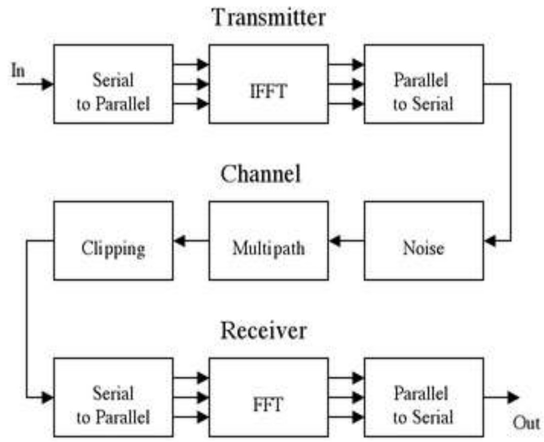

Fig 1. Basic structure of OFDM

Orthogonal Frequency Division Multiplexing is a special form of multicarrier modulation which is particularly suited for transmission over a dispersive channel. Here the different carriers are orthogonal to each other, that is, they are totally independent of one another.

Two periodic signals are orthogonal when the integral of their product over one period is equal to zero.

For the case of continuous time:

$$\int_0^T \cos(2\pi n f t)\cos(2\pi m f t)\,dt = 0$$

For the case of discrete time:

$$\sum_{k=0}^{N-1} \cos\left(\frac{2\pi k n}{N}\right)\cos\left(\frac{2\pi k m}{N}\right)dt = 0$$

Where $m \neq n$ in both cases

II. PAPR IN OFDM

High Peak-to-Average Power Ratio has been recognized as one of the major practical problem involving OFDM modulation. High PAPR results from the nature of the modulation itself where multiple subcarriers / sinusoids are added together to form the signal to be transmitted. When N sinusoids add, the peak magnitude would have a value of N, where the average might be quite low due to the destructive interference between the sinusoids. High PAPR signals are usually undesirable for it usually strains the analog circuitry. High PAPR signals would require a large range of dynamic linearity from the analog circuits which usually results in expensive devices and high power consumption with lower efficiency. The PAPR of any signal is defined as the ratio between the maximum instantaneous power of signal and its average power.

The PAPR of any OFDM signal X(t) is defined as PAPR = Ppeak/Pavg = max [IXnI2]/[IXnI2] Where Xn is an OFDM signal after IFFT(Inverse Fast Fourier Transform) E[.] denotes expectation operator, it is an average power The complex baseband OFDM signal for N subcarriers is represented as

$$X(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X_n e^{j2\pi n\Delta f t} \quad , 0 \leq t \leq NT\ldots\ldots. (1)$$

III. PAPR REDUCTION TECHNIQUE

A large number of PAPR reduction techniques have been proposed over a long period during the development of OFDM technology. The main objective of these techniques is to reduce the PAPR of the OFDM signal to an acceptable value before the OFDM signal is sent to the transmitter.

These techniques are categorized as

A) Signal scrambling
B) Signal distortion

In this paper we will study signal scrambling technique selective level mapping(slm) and modified slm using quadrature amplitude modulation technique.

SELECTIVE LEVEL MAPPING:

In this technique the actual transmit signal lowest PAPR is selected from a set of sufficiently different signals which all represents the same information. SLM Techniques are very flexible as they do not impose any restriction on modulation applied in the subcarriers or on their number. Block diagram of SLM Technique is show i Fig. L t's d i data str am a t r s rial to parallel conversion as X=[X0, X1--------,XN-1]T. Initially each input Xn (u) can be defined as equation no.2 Xn(u) = Xn bn(u). . . .(2) Bn(u)can be written as

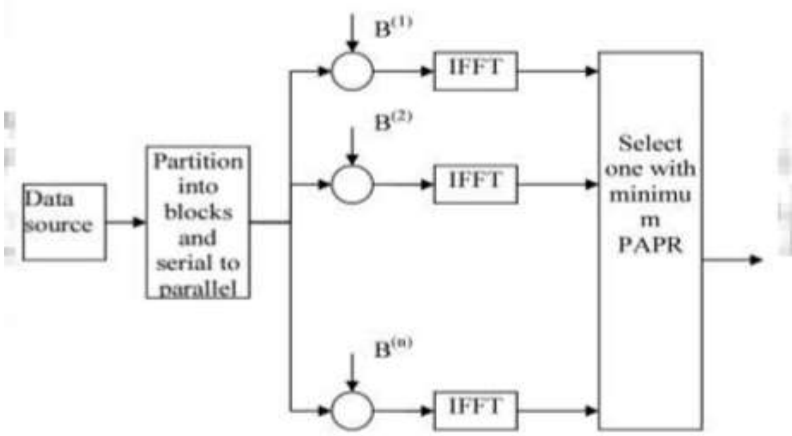

Fig 2. Block diagram of Selective level mapping

Xn(u) = [X0(u)..X1(u)……….. N-2(u)}T …..(3) Where, n = 0, 1, 2-------N-1, and u = 0,1,2...U to make the U phase rotated OFDM data blocks. All U phase rotated OFDM data blocks represented the same information as the unmodified OFDM data block provided that the phase sequence is known. After applying the SLM technique, the complex envelope of the transmitted OFDM signal becomes X(t) = , 0 Here t = 1/NT, NT is the duration of an OFDM data block. Output data of the lowest PAPR is selected to transmit .PAPR reduction effect will be better as the copy block number U is increased. SLM method effectively reduces PAPR without any signal distortion. But it has higher system complexity and computational burden. This complexity can less by reducing the number of IFFT block

IV. PROPOSED SCHEME

In this technique we have used M-Quadrature Amplitude Modulation technique instead of BPSK and QPSK as used earlier..The modulation and demodulation of OFDM signal is done with the M-QAM technique and we have taken 64 QAM as it is the best suited technique when the number of users and number of subcarriers increased in OFDM. We have used phase sequences [B(1),B(2),B(3),B(4)] = [1,-1,j,-j]. It helps in reducing the peak to average power ratio better than any other modulation technique.

SLM WITH QUADRATURE AMPLITUDE MODULATION

Like all modulation schemes, QAM conveys data by changing some aspect of a carrier signal, or the carrier wave, (usually a sinusoid) in response to a data signal. In the case of QAM, the amplitude of two waves, 90° out-of-phase with each other (in quadrature) are changed (*modulated* or *keyed*) to represent the data signal. Amplitude modulating two carriers in quadrature can be equivalently viewed as both amplitude modulating and phase modulating a single carrier.
Phase modulation (analog PM) and phase-shift keying (digital PSK) can be regarded as a special case of QAM, where the magnitude of the modulating signal is a constant, with only the phase varying. This can also be extended to frequency modulation (FM) and frequency-shift keying (FSK), for these can be regarded as a special case of phase modulation.

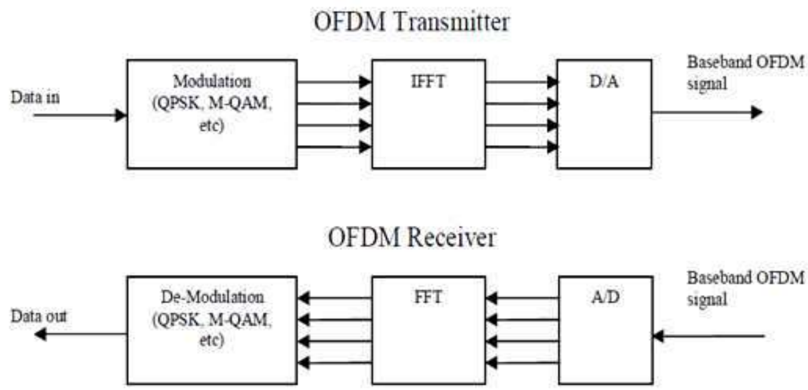

Fig 3. Block Diagram of OFDM using M-QAM

V. SIMULATION RESULT

We carried out extensive simulation using MATLAB to evaluate the PAPR reduction performance of the modified SLM technique. We have 64 QAM technique, 64 number of subbands and varying oversampling factor 1,4,8 which gives number of subcarriers 64,256 and 512 respectively. The parameters used for simulation are given below:

MODULATION	64 QAM
NO. OF SUBBANDS	64
OVERSAMPLING FACTOR	1,4,8
NO.OF SUBCARRIERS COEFFICIENTS	64,256,512
SIZE OF PHASE SEQUENCE	256

We implemented the proposed algorithm of modified SLM to obtain a design in MATLAB. The results are shown in fig 4, 5 and 6. We have compared the result of SLM and modified SLM with varying oversampling factor and it is found that proposed method worked efficiently.

In fig 4, no. of subbands are 64 and we have taken the value of oversampling factor L as 1. We found that as compared to normal SLM our proposed method reduces the PAPR value around 1.7 db.

In fig 5, we have taken the value of oversampling factor as 4 and keeping all other parameters same. We found that our method reduces PAPR value around 1.5 db.

In fig 6, we have taken the value of L as 8 and keeping all other parameters same. We found that papr value reduced by 1.6 db.

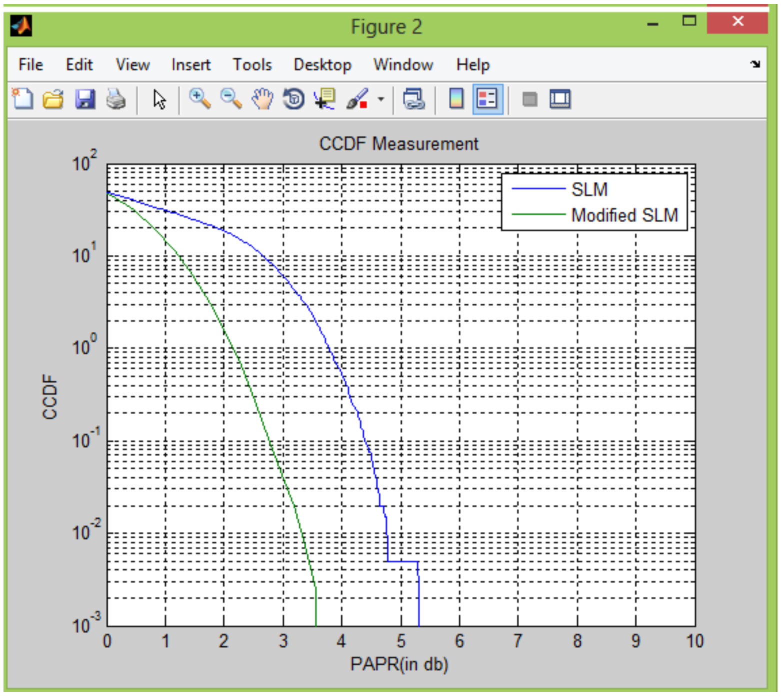

Fig 4: CCDF Plot of PAPR using slm with 64QAM when L=1

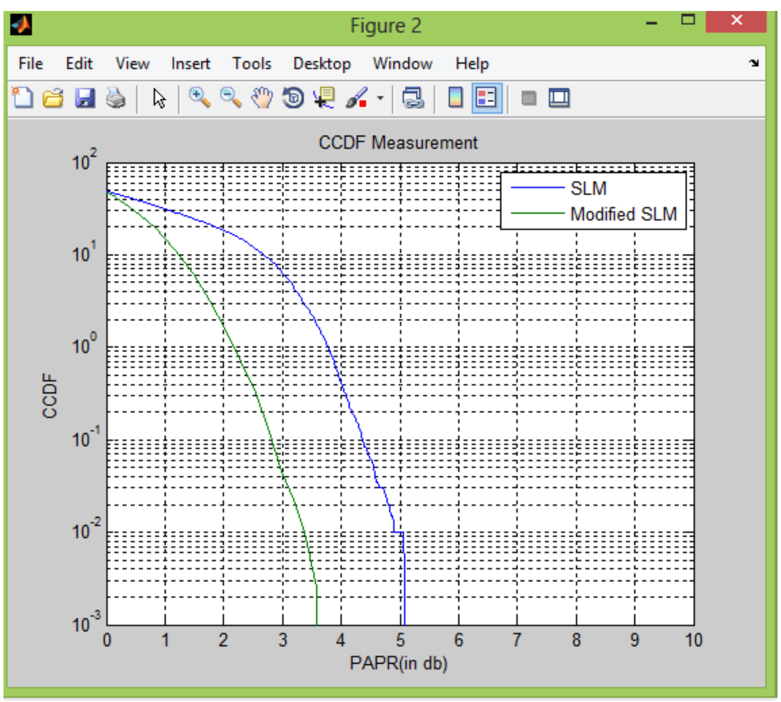

Fig 5: CCDF Plot of PAPR using slm with 64QAM when L=4

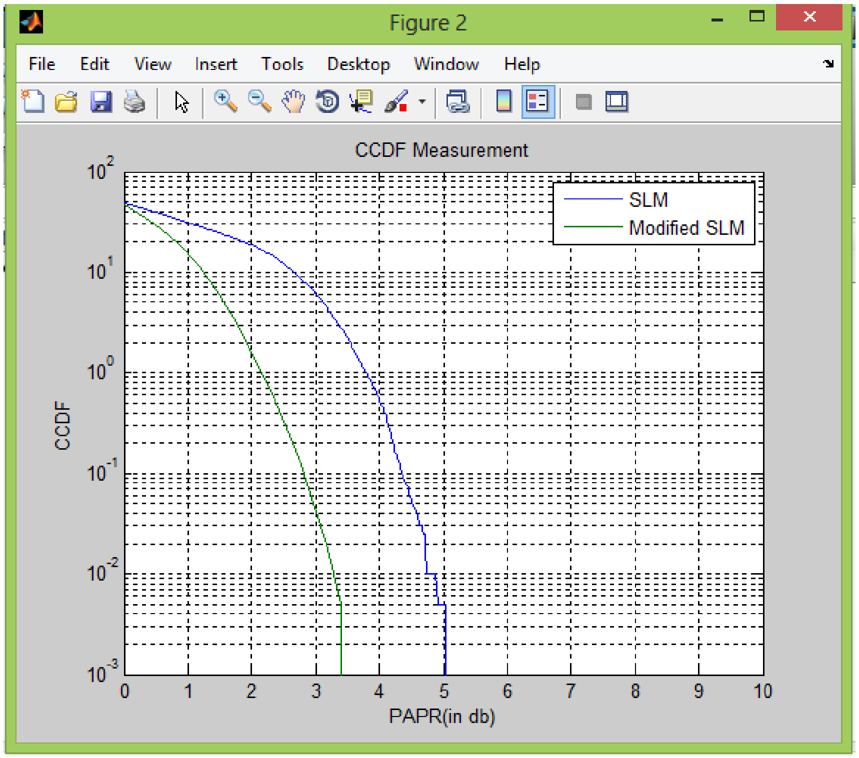

Fig 6: CCDF Plot of PAPR using slm with 64QAM when L=8

VI. CONCLUSION

In this paper, technique for reducing PAPR has been proposed. By modifying the modulation technique used in original PAPR, new technique improved the PAPR value near about 3.4dB. The PAPR reduction performances were evaluated using MATLAB simulation tool. Experimental result clearly proves that there is a significant reduction in PAPR. The proposed scheme reduced the PAPR by about 3.2dB.

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