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PAPR REDUCTION IN OFDM SYSTEMS USING SELECTIVE MAPPING AND PEAK WINDOWING

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ABSTRACT

One of the key enablers of high data rate is Orthogonal Frequency Division Multiplexing (OFDM). One of the major disadvantages of OFDM is high Peak to Average Power Ratio (PAPR). This paper focuses on the Selective Mapping (SLM) Technique which exhibits high PAPR reduction capability without degrading the BER performance of the system. In this paper, we propose a novel weighted normalization-SLM technique for PAPR reduction in OFDM systems. It normalizes the peaks throughout the entire signal period using normalizing weights. It has been shown that the proposed technique outperforms conventional SLM with ease. A comparative analysis of the proposed technique with conventional SLM is also provided.

Keywords: OFDM, PAPR, High Power Amplifier, SLM, Normalization Weights, OFDM.

I. INRTODUCTION

Orthogonal frequency division multiplexing (OFDM) is one of the most powerful modulation technique s being used today where high data rates are needed both in wired and wireless systems. The major advantages of this technique are high spectral efficiency and efficient digital implementation. The drawback lies in the fact that the amplitude variations of OFDM signals is large , which requires large back-off in the transmitter amplifier and hence HPAs are not efficiently used.

In order to reduce the distortion caused by a HPA without setting it to large back-offs, several techniques have been introduced that limit the peak of the envelope of the signal (**clipping)**[1],[5], a problem that is usually referred to as peak-to-average power ratio (PAPR) reduction. These techniques have varying PAPR-reduction capabilities, power, and bandwidth and complexity requirements. PAPR is a very well-known measure of the envelope fluctuations of a multicarrier (MC) signal and plays a decisive role in the adoption of any particular technique. The problem of reducing the envelope fluctuations with the aim to increase the system performance (reduce both BER and the out-of-band radiation) has boiled down to reducing PAPR. In this paper we introduce the basic concepts related to OFDM, the significance of PAPR and various techniques devised to reduce PAPR in OFDM systems.[1],[5].

II. OFDM THEORY

Orthogonal Frequency Division Multiplexing is a special form of multicarrier modulation which is particularly suited for transmission over a dispersive channel.

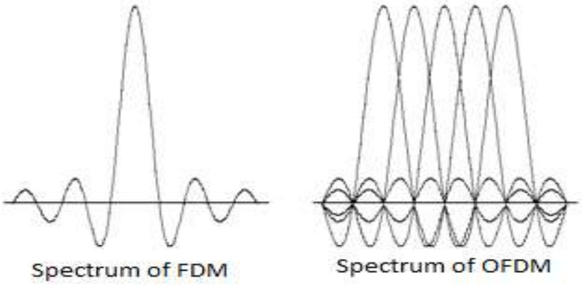

Fig-1:- Spectrum of FDM & OFDM

Here the different carriers are orthogonal to each other, that is, they are totally independent of one another. This is achieved by placing the carrier exactly at the nulls in the modulation spectra of each other.

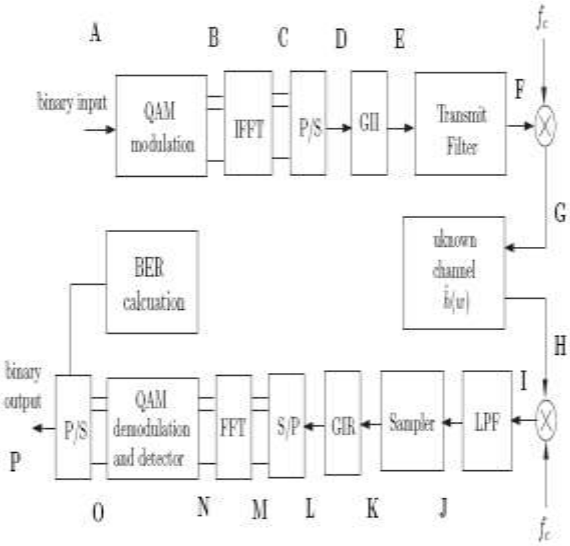

Fig-2:- OFDM Transceiver Structure

III. PEAK-TO-AVERAGE POWER RATIO (PAPR)

PAPR depends on the ratio between the maximum power of the complex pass-band signal and the mean power of it, we can calculate the PAPR. The value of PAPR can be calculated as following equation:
$PAPR = \max\{x^2(t)\} / mean\{x^2(t)\}$

Where $x(t)$ is presented in the equation to denote the amplitude of the complex pass-band signal. To calculate the probability of having PAPR greater than the threshold value for the OFDM signal, we could use Complementary Cumulative Distribution Function (CCDF). By simulating the CCDF, we compare the theoretical values with the simulation results and the PAPR keeps increasing when the number of carriers increases. In the simulation part there is a figure showing the CCDFs of OFDM signals with different number of subcarriers.[9] The Input-Output characteristics of an HPA are shown below

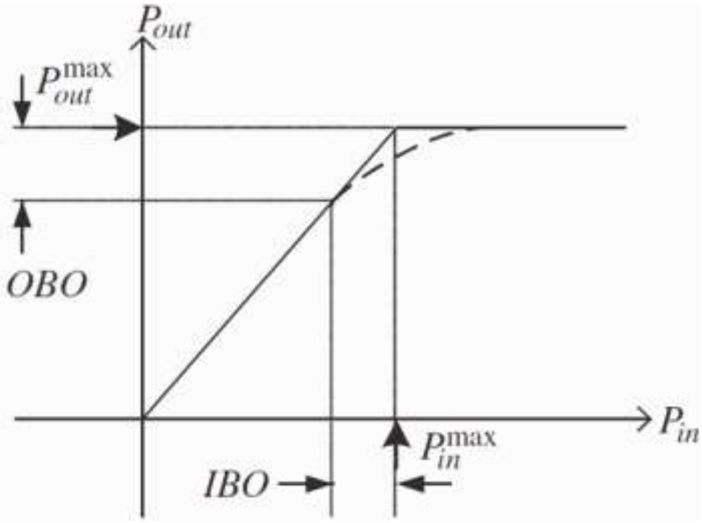

Fig-3:- Graph showing linearity between output and input power

In this diagram, the input power is denoted by Pin while the outputs power is represented by $Pout$. To keep the linearity, the maximum output power is limited by the value $Poutmax$ and the maximum input power is pounded by $(P)in_{\max}$. Both the input and output power are backed off to insure a linear operation and the area of the backing off is termed by Input Bach-Off (IBO) and Output Back-Off (OBO)[5],[9] Due to the limit imposed on the maximum peak of the OFDM signal by the HPA, an increase is encountered in both the in-band and out-of-band distortions. The second causes undesirable increase in the power of the side lobes of the *power spectral density* (PSD) of the OFDM signal. This effect is referred to as spectral spreading or spectral re growth. As demonstrated in the figure, when the nonlinearity of the HPA is higher, IBO is smaller, and the spectral spreading is higher. Spectral spreading leads to higher interference between the sub bands of the OFDM signal, unless the frequency separation between adjacent subcarriers is also increased to maintain orthogonally. However, this solution has the disadvantage of lowering the spectral efficiency.

IV. SELECTIVE MAPPING (SLM)

Selective mapping is the most fundamental and highly efficient technique to reduce PAPR. It provides a high performance as compared to normal OFDM. In this method set of m different symbols ranging from $x^{(m)}$; 0 $\leq$m $\leq$ m-1 each of length N and the interesting concept is that all represents the same set of information, out of these m symbols the symbol with minimum PAPR is transmitted, which is given by

$$x = \min[\mathrm{PAPR}(x^{(m)})]$$

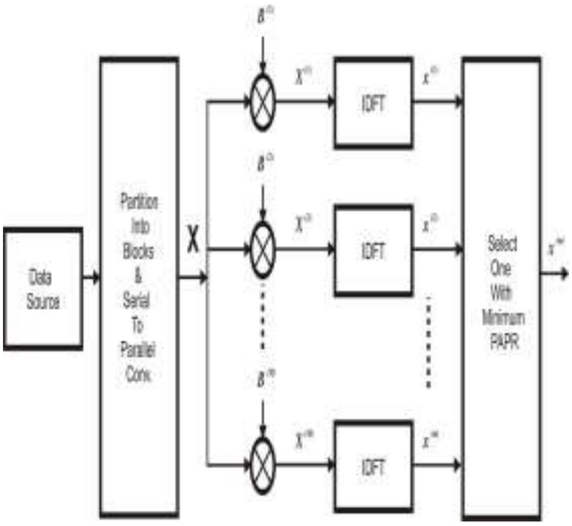

Fig-4:- Block Diagram of SLM

V. PROPOSED METHODOLOGY

In the proposed scheme, a weight is imposed on each discrete SLM-OFDM signal via a certain kind of a band limited signal, and an OFDM signal formed with the weighted discrete data is then considered before a high power amplifier (HPA), whereas the original signal can be recovered completely at the receiver side.

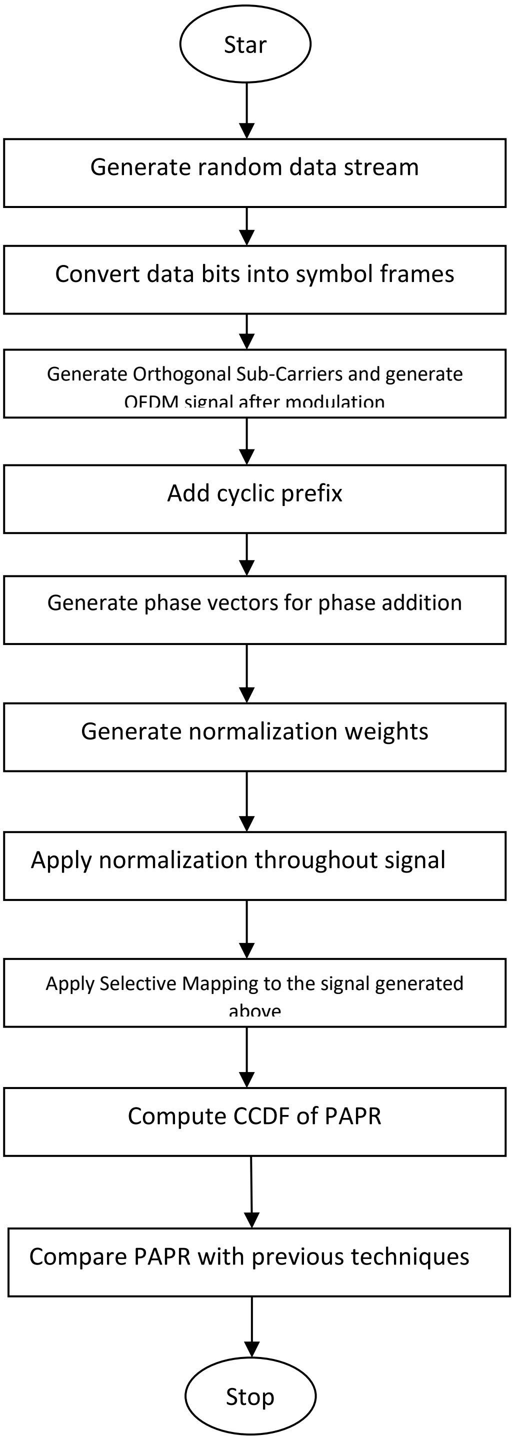

Fig-4:- Proposed Flowchart

Meanwhile, the time duration needed to transmit the weighted OFDM signal is the same as the time duration for the original OFDM signal. The base signal to be used as a weight is

$$W=1-\text{sinc}\ (m)/\pi^2.m^2$$

The entire span of the signal is multiplied using a modified weighted function which reduces the peaks of the signal. Subsequently the Selective Mapping is employed to further reduce the PAPR of the system. $\pi^2.m^2$ is called the **Normalizing Factor** of the Weighted Function.

The weighted normalizing factor is necessary to so as to negate chances of negative peaks and high PAPR.

VI. RESULTS

The results are analyzed using the CCDF curve and an earlier plummet or fall in the CCDF curve among two systems indicates that the PAPR has been reduced in the one with an earlier fall of CCDF or PAPR.

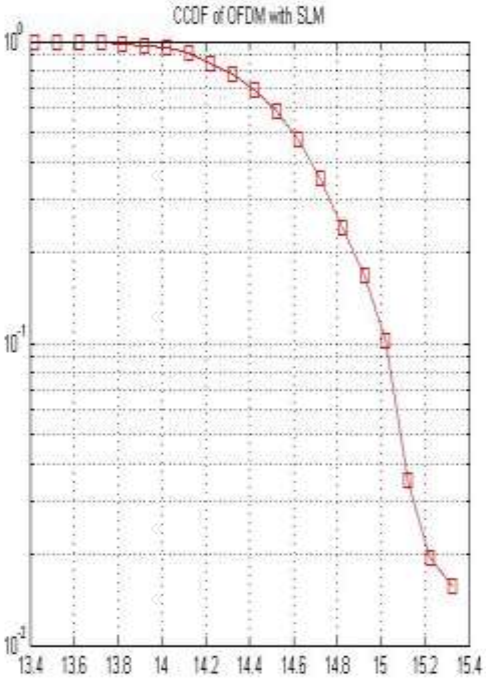

Fig-5:- CCDF of Conventional SLM

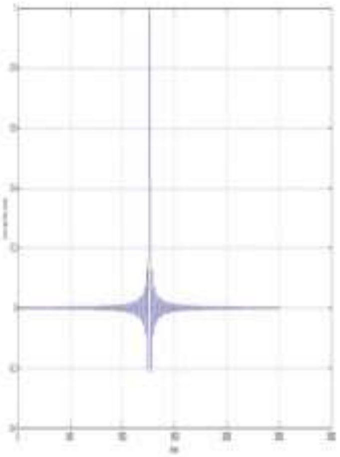

Fig-6:- Typical Sinc Function

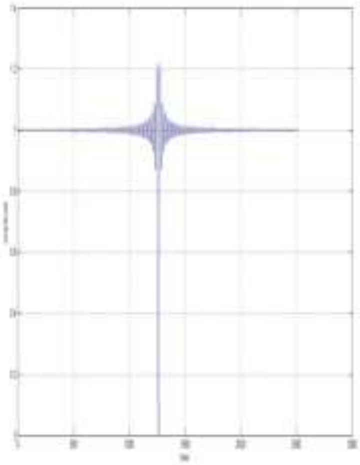

Fig-7:- Weights using 1-sinc(m) function

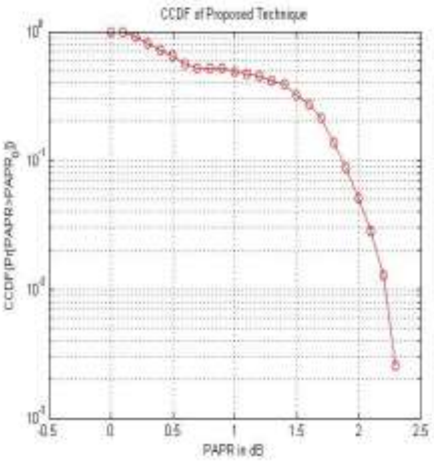

Fig-8:- CCDF Proposed Technique

Table.1

S.No	Technique	Pr(PAPR>PAPR₀)	PAPR
1	**Original OFDM**	**10^{-1}**	**21.35 dB**
2	**OFDM with Clipping**	**10^{-1}**	**17.4 dB**
3	**OFDM with SLM**	**10^{-1}**	**15 dB**
4	**Proposed Technique**	**10^{-1}**	**1.9 dB**

Table.2

S.No	Technique	Pr(PAPR>PAPR₀)	PAPR
1	**Original OFDM**	**10^{-2}**	**21.5 dB**
2	**OFDM with Clipping**	**10^{-2}**	**17.75 dB**
3	**OFDM with SLM**	**10^{-2}**	**15.2 dB**
4	**Proposed Technique**	**10^{-2}**	**2.25 dB**

VII. CONCLUSION

The results clearly indicate the fact that the proposed technique outperforms conventional SLM by far in PAPR reduction capability. The results can be attributed from the fact that inverted sinc weights result in reducded crests in the OFDM signal prior to the application of SLM. A comparative PAPR analysis tabulation has been prposed at BER of 10^{-1} and 10^{-2}. Thus it can be concluded that the proposed technique serves an extrememely effficient technique for PAPR reduction.

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