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# Hybrid Peak to Average Power Reduction Technique in OFDM

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## ABSTRACT

**Two major limitations of OFDM systems are Peak-to-Average Power Ratio (PAPR) and Inter Carrier Interference (ICI). Previously reported schemes like clipping and filtering, selected mapping, partial transmit sequence, tone reservation, and tone insertion provide PAPR reduction. Peak regrowth in clipping and filtering causes the transmitted signal to exceed the clipping level at some points. In case of selected mapping and partial transmit sequence technique; the transmitter needs some side information. Overall it is noticed that these techniques have large computational overhead. So, in this paper we used unmodified OFDM, SLM and Hybrid approachcomparison for following parameters: Symbol Error Rate (SER) at various output Back-Off (OBO) levels and performance analysis in terms of Complementary Cumulative Distribution Function (CCDF) at various threshold values.**

## 1. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) has grown to a popular communication technique for high speed communication in the last decadeIt is based upon the principle of frequency division multiplexing (FDM) [1] where each frequency channel is modulated with simpler modulation scheme. It splits a high rate data stream into several lower rate streams that are transmitted simultaneously over several orthogonal subcarriers [2]. Orthogonality is achieved by ensuring that the carriers are placed exactly at the nulls in the modulation spectra of each other. The increase of symbol duration for the lower rate parallel subcarriers reduces the relative amount of dispersion in time caused by multipath delay spread. Therefore, OFDM is an advanced modulation technique which is suitable for high-speed data transmission due to its advantages in dealing with the multipath propagation problem, high data rate and bandwidth efficiency [3].

## 2. LITERATURE SURVEY

A high PAPR requires a wide dynamic range for the power amplifier at the transmitter, or more commonly the power amplifier needs to be backed off to accommodate high peaks. This results in significant reduction of the transmission power which leads to very low power efficiency. It is therefore preferable to reduce the PAPR of the signal. Several methods have been proposed by researchers to reduce PAPR, such as Clipping, Clipping and Filtering, Selected Mapping, and Partial Transmit Sequence [4].Clipping is the simplest technique for reducing the PAPR, however it causes both in-band and out-of band distortion [5]. Filtering can be employed to alleviate out-of-band distortion but results peak re-growth. Repeated clipping and filtering can lead to degradation in BER. Windowing is another approach that offers reduced out-of-band radiation, but window has to be as narrow as possible in the frequency domain and the impulse response in the time domain should not last too long, otherwise more signal samples are affected. Tone reservation is also an effective technique for reducing the PAPR of OFDM signals but causes a reduction in data through-put as data carriers are used to generate an effective cancellation signal in the time domain to reduce high peaks. SLM and PTS schemes can handle any number of subcarriers. But the drawback associated with the schemes is the overhead of side information that needs to be transmitted to the receiver's end [6] [7].

The other major limitation of OFDM is its sensitivity against carrier frequency offset which causes attenuation and rotation of subcarriers, and inter-carrier interference (ICI) [8]. Because of the orthogonality of the sub-carriers, we are able to extract the symbols at the receiver as they do not interfere with each other. Orthogonality is preserved as long as sub-carriers are harmonics to each other. If at the receiver's end there is a change in frequency of the sub-carriers due to any reason, then the orthogonality among them are lost and ICI occurs. As a result the signal degrades heavily. This change in frequency is called frequency offset. There are two main reasons for frequencies offset which are frequency mismatch between transmitter & receiver and Doppler Effect. The undesired ICI degrades the performance which is discussed in [9]. Several methods have been presented to reduce ICI, including self-cancellation schemes [10], frequency domain equalization, and time domain windowing at the receiver. Among them frequency domain equalization and time domain windowing methods are not so efficient because they do not address to the major cause of ICI which is due to the frequency mismatch between the transmitter and receiver, and Doppler shift. The drawback of the ICI self-cancellation method is that the same data is modulated into two or more carriers, thus reducing the spectral efficiency.

## 3. PROPOSED SCHEME

A high PAPR requires a wide dynamic range for the power amplifier at the transmitter, or more commonly the power amplifier needs to be backed off to accommodate high peaks. This results in significant reduction of the transmission power which leads to very low power efficiency. To evaluate the performance of the proposed PAPR reduction technique and to approximate the effect of nonlinear power amplifier in the transmitter, we adopt Rapp's model for amplitude conversion. I.e. approximation of non-linearity effect is calculated. the difference in PAPR improvement between the proposed technique and the ordinary SLM technique is closely related to the value of n, k or the code rate r = k/n.

The simulation model OFDM system is presented in fig 1.1. This model consists of a transmitter, a channel and a receiver. A brief description of the model is provided below.

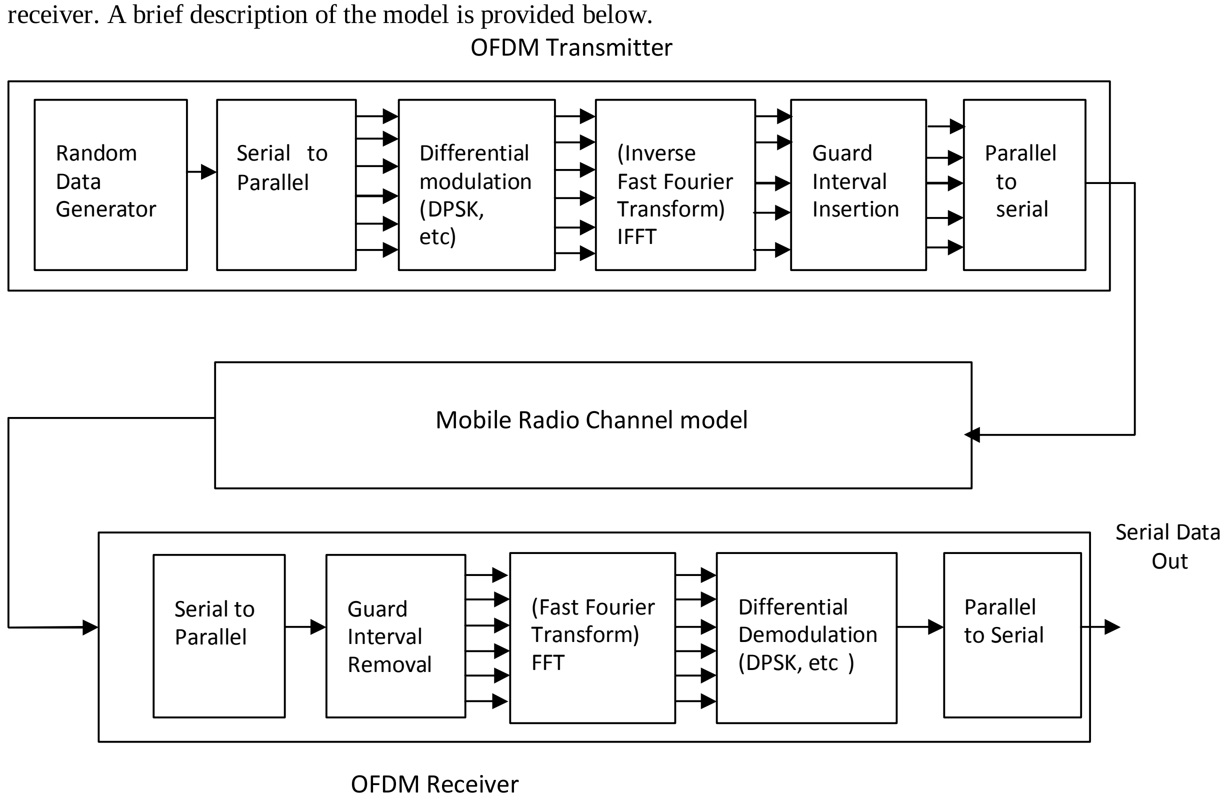


**Fig 1.1 OFDM model used for simulation**

## 4. RESULT & SIMULATION

### Approximation of effect of Non-linearity

We use MATLAB simulations to evaluate the performance of the proposed PAPR reduction technique. To approximate the effect of nonlinear power amplifier in the transmitter, we adopt Rapp's model for amplitude conversion [11]. The relation between amplitude of the normalized input signal g(A) and amplitude of the normalized output signal of the nonlinear power amplifier is given by

$$g(A) = A/(1+A^{2p})^{1/(2p)} \qquad (1)$$

Where p is a parameter that represent the nonlinear characteristic of the power amplifier. The power amplifier approaches linear amplifier as p gets larger. We choose p=3 which is a good approximation of a general power amplifier [12]. The phase conversion of the power amplifier is neglected in this paper. Fig. 4.1 shows the input-output relation curve of the Rapp's power amplifier model when p=3.

The input signal is normalized by a normalization factor to appropriately fit the input signal into the desired range in the input-output relation curve. The normalized output signal is processed back into original scale before normalization. The amount of nonlinear distortion depends on the output back-off (OBO) which is defined as

$$OBO = P_{max}/P_{avg}(2)$$

Where $P_{max}$ is the output power at the saturation point and $P_{avg}$the power of the output signal.

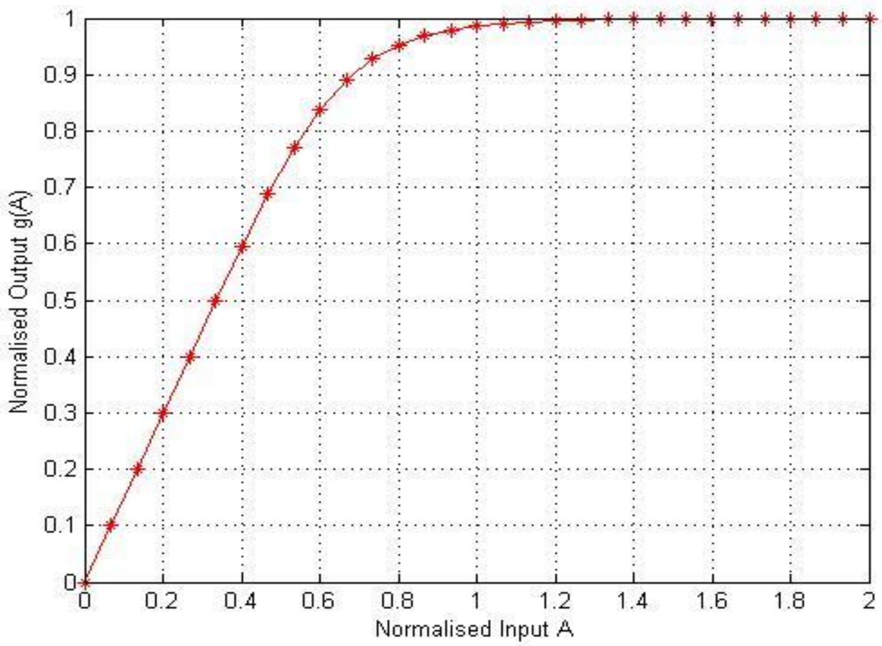


**Fig. 1.2Input–output relation curve showing non linearity when p=3.**

**Performance analysis in terms of Symbol Error Rate (SER)**

Fig. 1.2, 1.3, 1.4 shows SER analysis of the proposed technique, ordinary SLM technique and unmodified OFDM. Proposed scheme perform better than ordinary SLM scheme over entire range. To quantify results take Eb/No=5db, here SER for unmodified scheme is $10^{-2}$, for ordinary SLM it is $9*10^{-3}$ and for proposed scheme it is $2*10^{-4}$.The performance difference between the proposed technique and the ordinary SLM technique is due to the fact that, in the proposed technique, the phase sequences have a limitation on their structure and thus the improvement of PAPR provided by the proposed technique is not so much as the that from the ordinary SLM technique.

In fact, the difference in PAPR improvement between the proposed technique and the ordinary SLM technique is closely related to the value of n, k or the code rate r = k/n. If code rate is close to 0, there is little difference between the CCDF of the proposed technique and that of the ordinary SLM technique. On the contrary, the higher the code rate is, the larger the difference is. But the difference remains quite small when compared with the difference between the proposed technique and unmodified OFDM signal if the code rate is lower than about a half.

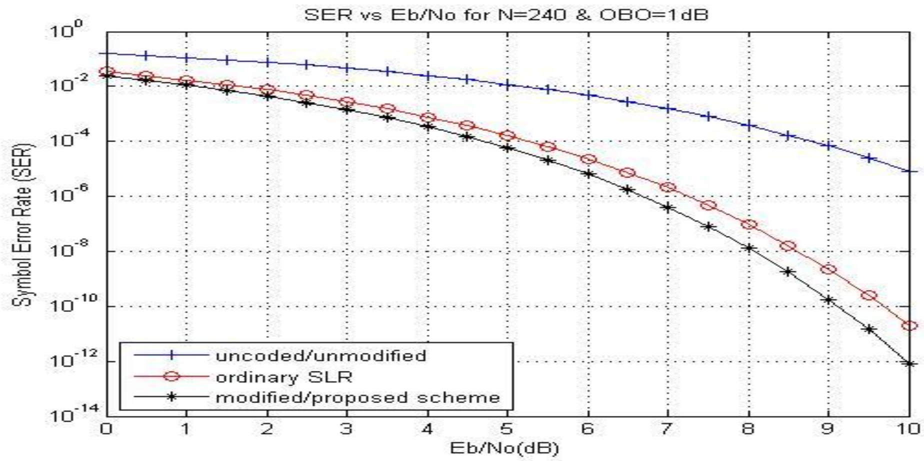


**Fig. 1.3: Comparative SER analysis OFDM, OFDM with SLM & proposed scheme atOBO =1 dB**

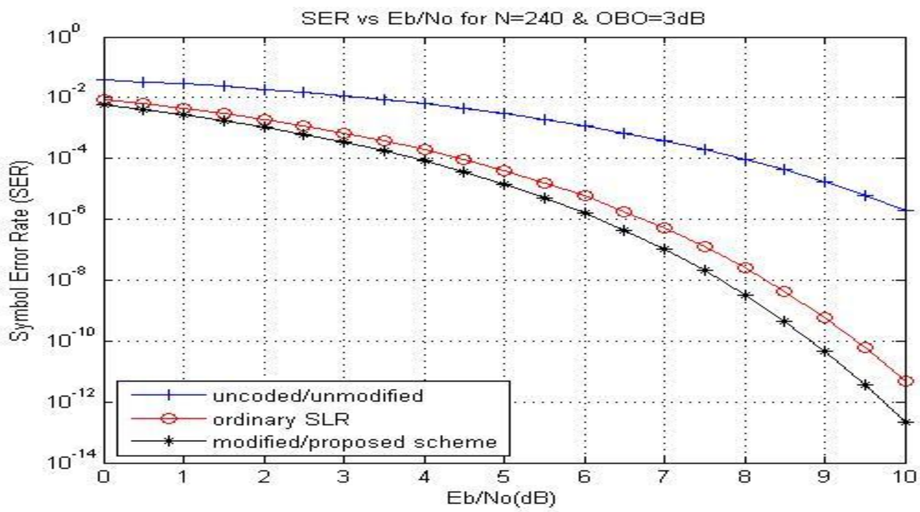


**Fig. 1.4: Comparative SER analysis OFDM, OFDM with SLM & proposed scheme atOBO =3 dB**

## 5. CONCLUSION AND FUTURE SCOPE

In this paper, an efficient PAPR reduction technique comparison with unmodified OFDM, SLM and proposed scheme has been shown. The performance difference between the proposed technique and the ordinary SLM technique is since, in the proposed technique, the phase sequences have a limitation on their structure and thus the improvement of PAPR provided by the proposed technique is not so much as the that from the ordinary SLM technique. In fact, the difference in PAPR improvement between the proposed technique and the ordinary SLM technique is closely related to the value of n, k or the code rate r = k/n. If code rate is close to 0, there is little difference between the CCDF of the proposed technique and that of the ordinary SLM technique. On the contrary, the higher the code rate is, the larger the difference is. But the difference remains quite small when compared with the difference between the proposed technique and unmodified OFDM signal if the code rate is lower than about a half.

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