PERFORMANCE IMPROVEMENT IN OFDM THROUGH PAPR REDUCTION USING HIGHER ORDER LINEAR PREDICTIVE CODING

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ABSTRACT-The ideology of OFDM is developed in 1966 however it reached its sufficient development for the preparation in customer systems throughout. OFDM is the multiple carrier transmission technique which has single high rate is split into various low rate stream and that is modulated sub carrier which square size orthogonal to every other. The high speed communication of OFDM information is requires sizable amount of the orthogonal carrier and every of the carrier is being modulated at high rate by the applicable spacing between the carrier they're orthogonal to every alternative. OFDM has many functioning like the high spectral power, flexibility ,easy effort to channel attenuation that create a lot of advantageous for the high speed transmission over alternative transmission technique. OFDM has PAPR (Peak to Average Power Ratio) that is that the main disadvantage of the OFDM and that degrades the performance of the OFDM. The efforts here are to reduce the PAPR using higher order linear predictive filtering. The results show that the method performs better than the existing ones.

***KEYWORDS*-OFDM, FFT, PAPR, LPC, BER, CCDF**

INTRODUCTION

New era has begun evolving new technologies like LTE, LTE-Adv to fulfill the demand of wireless spectrum scarcity by utilizing the breakthrough techniques, OFDM and MIMO. The Orthogonal Frequency Division Multiplexing (OFDM) becomes most fit and most favorable and preferred access technique to deploy high speed data access environments due to its inherent tendency to immune frequency selective fading, deliver high spectral efficiency and offer greater data rate [1]. In OFDM data is transmitted through different subcarriers in a parallel fashion where whole bandwidth is divided into number of orthogonal subcarriers [2]. To avoid inter-symbol interference (ISI), cyclic prefix (CP) is used but at the cost of bandwidth consumption; this may even consume more than 20% of total available bandwidth [3-4]. The high value of Peak to Average Power Ratio (PAPR) is the most severe bottleneck for OFDM applications, which is caused by interference between adjacent sub-carriers [5]. A large PAPR increases the complexity of the analog to digital and digital to analog converter and reduces the efficiency of the radio frequency (RF) power amplifier. Regulatory and application constraints can be implemented to reduce the peak transmitted power which in turn reduces the range of multi carrier transmission. This leads to the prevention of spectral growth and the transmitter power amplifier is no longer confined to linear region in which it should operate. This has a harmful effect on the battery lifetime. Thus in communication system, it is observed that all the potential benefits of multi carrier transmission can be outweighed by a high PAPR value.

Researchers have proposed many techniques to remove performance barricades of an OFDM system. Apart from many PAPR reduction techniques available in the literature, proposed technique linear predictive coding (LPC) offer PAPR reduction without degrading error probability and optimal system computational complexity. This technique can be used with any modulation schemes with any number of subcarriers under both additive white Gaussian noise and wireless Rayleigh fading channel environment. Many wireless communication applications that uses advance technologies, like 3G-4G, LTE, IoT etc utilizes OFDM to enhance performance in term of data rate, bandwidth, BER can be further improved with LPC hybridization.

2. Peak to Average Power Ratio

OFDM became the most preferable choice for deployment of latest technologies in wireless communication. Apart from delivering high spectrum efficiency, great channel robustness, resistance to interferences, flexible and easy equalization, OFDM is severely affected by undesirable effects of high PAPR [6].

The major disadvantages of a high PAPR are-

1. Inflated Energy loss in analog to digital and digital to analog convertor.
2. Highly sophisticated design of power amplifiers.
3. Cost of operation for stable amplification.

In general, the PAPR of a continuous time baseband OFDM signal s(t) is defined as ratio of the maximum instantaneous power to its average power.

$$PAPR\left(s(t)\right) = \frac{\max_{0\le t\le T_s}\left[|s(t)|^2\right]}{P_{av}} \quad (1)$$

Where P_{av} is the average power and can be computed in frequency domain because IFFT is a unitary transformation.

PAPR can be defined in the passband as given below.

$$PAPR = \frac{max[|s(t)|^2]}{E[|s(t)|^2]} \quad (2)$$

In addition to the mean and variance, the complementary cumulative distribution function (CCDF) is often used as performance metric.

CCDF (x) = Pr (PAPR>x) (3)

3. PAPR Reduction Techniques

In the literature, many techniques have been used to reduce the PAPR in OFDM system. According to the system requirement, techniques for PAPR reduction may be selected. Primarily, PAPR reduction techniques are segregated into either signal distortion techniques or signal scrambling techniques. There are signal distortion techniques, which reduce the peak amplitudes simply by nonlinearly distorting the OFDM signal at or around the peaks, for example, clipping, companding, peak windowing, and peak cancellation [7]. The other group of techniques scrambles each OFDM symbol with different scrambling sequences and selects the sequence that gives the smallest PAPR. While it does not suffer from the out-of-band power, the spectral efficiency decreases and the complexity increase as the number of subcarrier increases. Selected Mapping (SLM), Coding Techniques, Partial Transmit Sequence (P T S) Technique, Tone Reservation (TR), Interleaving Technique and Tone Injection (TI) are the few examples of signal scrambling techniques available in the current literature. However in this paper, detailed discussion of each PAPR reduction technique is not the primary focus but the weighted OFDM is evaluated for PAPR reduction with higher order linear predictive filters.

4. PROPOSED METHDOLOGY

In the recent literature weighted OFDM scheme is used to reduce PAPR with signal clipping and windowing techniques [8]. The weighted OFDM signal gives better performance than other OFDM signals. There are quite good examples of articles which advocates the use of linear prediction in the analysis of discrete signals [9]. The signal can be modeled as a linear combination of its past and present values of hypothetical input to a system. A spectral interpretation may extract the normalized minimum prediction error which can be subsequently used for further performance improvements [10].

The proposed approach may implement prediction based coding technique in order to reduce the effective PAPR. Predictive coding is a remarkably simple concept, where prediction is used to achieve efficient coding of signals to yield enhanced results. Linear prediction has gained much popularity in digital signal processing due to its feasibility in variety of applications such as speech signal processing, image processing, and noise suppression in communication systems. Determination of the linear filter for prediction requires the solution of a set of linear equations that have some special symmetry. Linear prediction is an attempt to de-correlate the signals by subtracting the best possible linear prediction from the input signal while preserving other aspects of the signal, leaving a residual signal which will be shown to have a very less PAPR. The basic idea of linear prediction is to transmit the prediction error signal instead of the original signal [11]. Figure 1 shows the basic linear prediction model.

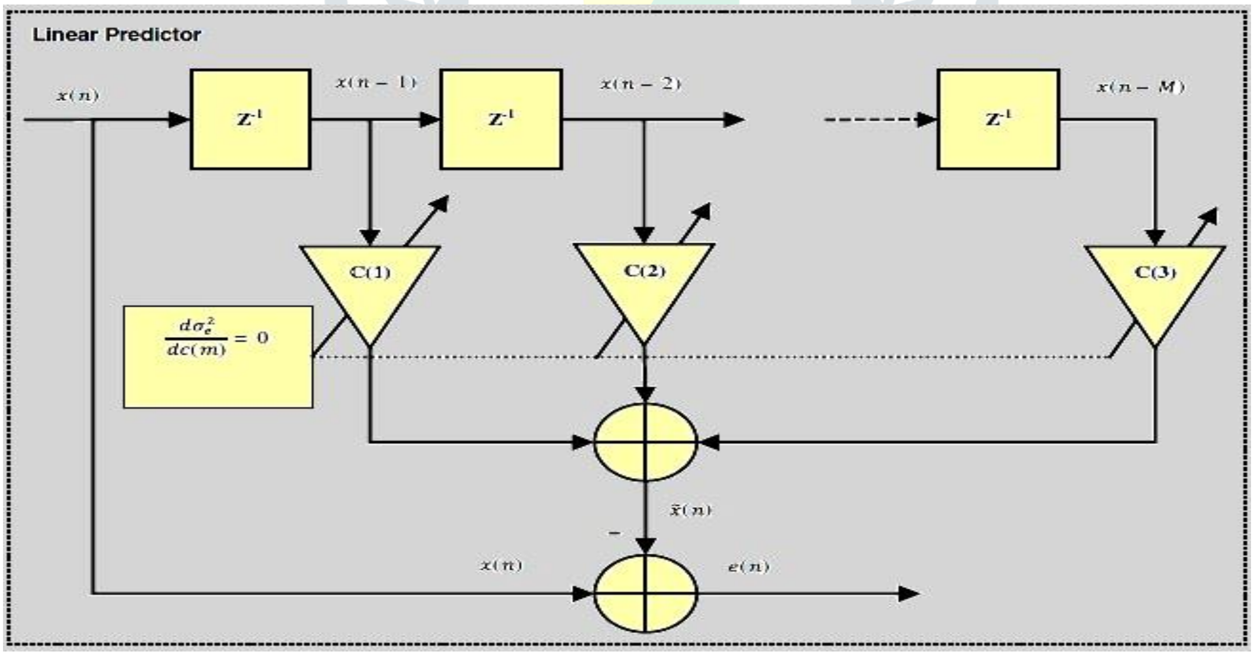

Figure 1. Block diagram of proposed OFDM system [11]

As depicted in the above model, we define the predicted sequence $\tilde{x}(n)$ in terms of M co-efficient c(n) by the expression:

$$\tilde{x}(n) = \sum_{k=1}^{M} c(k)x(n-k) \quad (4)$$

The Levinson-Durbin algorithm is used to compute the prediction coefficients for LPC analysis of the autocorrelation sequence of speech samples.

Following are the steps used for linear prediction in the proposed method:

Step1: Assuming the predicted sequence $\hat{x}(n)$ in terms of M coefficients of a discrete-time series $x(n)$ by the expression:

$$\hat{x}(n) = \sum_{k=1}^{M} \beta \propto_k^{\gamma} x(n-k) \quad (5)$$

$\propto_k^{\gamma}$= coefficients with LPC of order γ for the k^{th} data sample and β is the controlling parameter

Step2: The prediction error series $e(n)$can be defined as the dissimilarity between the unique Sequence and the predicted sequence:

$$e(n) = x(n) - \hat{x}(n) \quad (6)$$

Step3: Assuming coefficients $\propto_k$ in prediction error series is uncorrelated and prediction error is whitened data series comprised to have a small PAPR. We define the linear predictor error filter as the γ^{th} order finite impulse response (FIR) filter with coefficients $\propto_k$, which proceeds the prediction error sequence $e(n)$ when applied to a data sequence $x(n)$.

$$e(n) = x(n) - \sum_{k=1}^{M} \beta \propto_k^{\gamma} x(n-k) \quad (7)$$

Step 4: Taking Z-transform, the sequence can be represented as

$$E(z) = X(z) - \sum_{k=1}^{M} \beta \propto_k^{\gamma} z^{-k} X(z) \quad (8)$$

$$X(z) = \frac{E(z)}{1 - \sum_{k=1}^{M} \beta \propto_k^{\gamma} z^{-k}} \quad (9)$$

$$\frac{E(z)}{X(z)} = 1 - \sum_{k=1}^{M} \beta \propto_k^{\gamma} z^{-k} = G(z) \quad (10)$$

Where *G(z)* is called analysis filter for the given input sequence $x(n)$ and output sequence $e(n)$.

Step5: At the receiver, the signal is reconstructed by passing the received signal through the synthesis filter. The implementation step 5 of is called the synthesis filter S*(z).*

$$S(z) = \frac{1}{1-\sum_{k=1}^{M} \beta \propto_k^{\gamma} z^{-k}} = \frac{1}{G(z)} \quad (11)$$

3. RESULTS AND ANALYSIS

The results for the proposed method are compared with weighted OFDM for different coefficient values. Simulations is done with MATLAB software for the basic FFT based OFDM using 4QPSK modulation under AWGN channel conditions. Table 1 shows the parameter used for LPC filter based OFDM. In simulations, an OFDM system is considered 512 sub-carriers, the subcarriers are divide into 16 sub-blocks and 1000 signals are generated. The transmitted signal is oversampled by factor of 4 using QPSK modulation.

Table 1: Simulation Parameters used

FFT size	16
No. of sub-carriers	512
No. of iterations	10000
System Bandwidth	5Mz
Modulation	QPSK
Order of LPC	16
Beta (Controlling parameter)	0.08

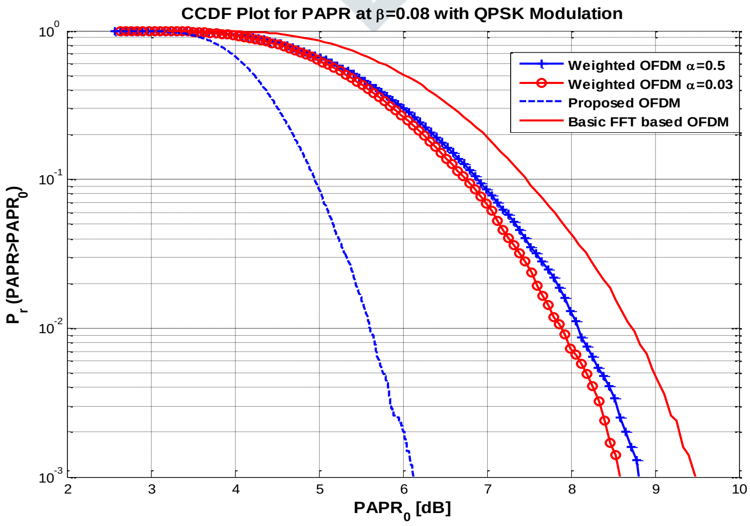

Figure 2. CCDF for the proposed OFDM at 0.08 beta

It is quite clear to observe PAPR improvements in figure2 for proposed OFDM against weighted OFDM (at different weighing coefficients) and standard OFDM. In figure 3, different value of beta factor are analysed for performance improvement of proposed OFDM in terms of PAPR reduction.

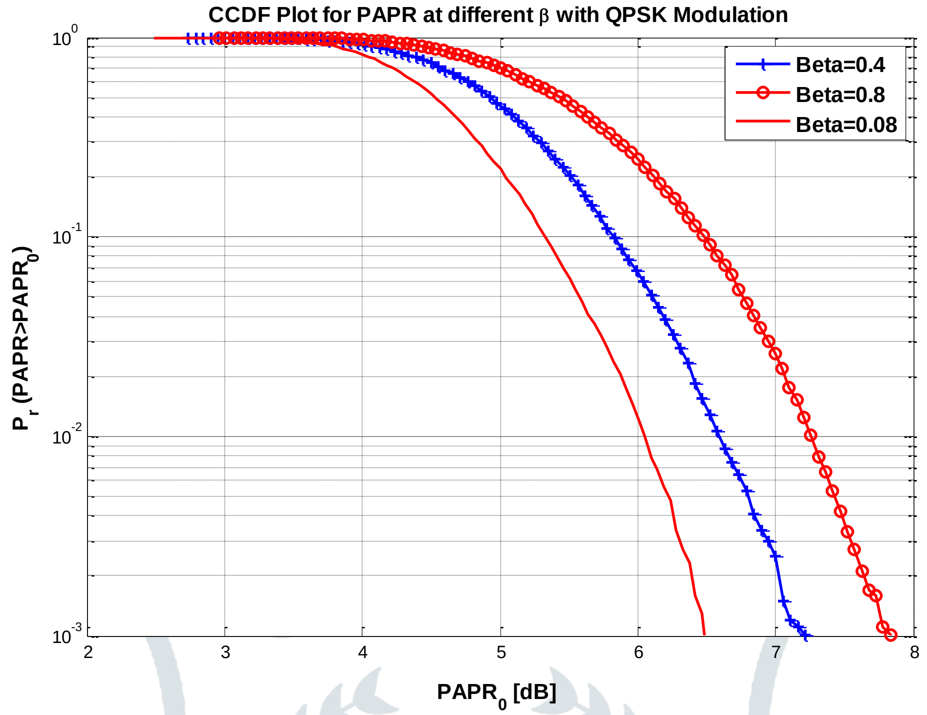

Figure 3. CCDF of proposed OFDM for the PAPR reduction at different beta values

Figure 4 demonstrates the BER performance comparison for two systems: weighted OFDM system and LPC based OFDM system. It can be seen that LPC based OFDM system is superior to basic OFDM system.

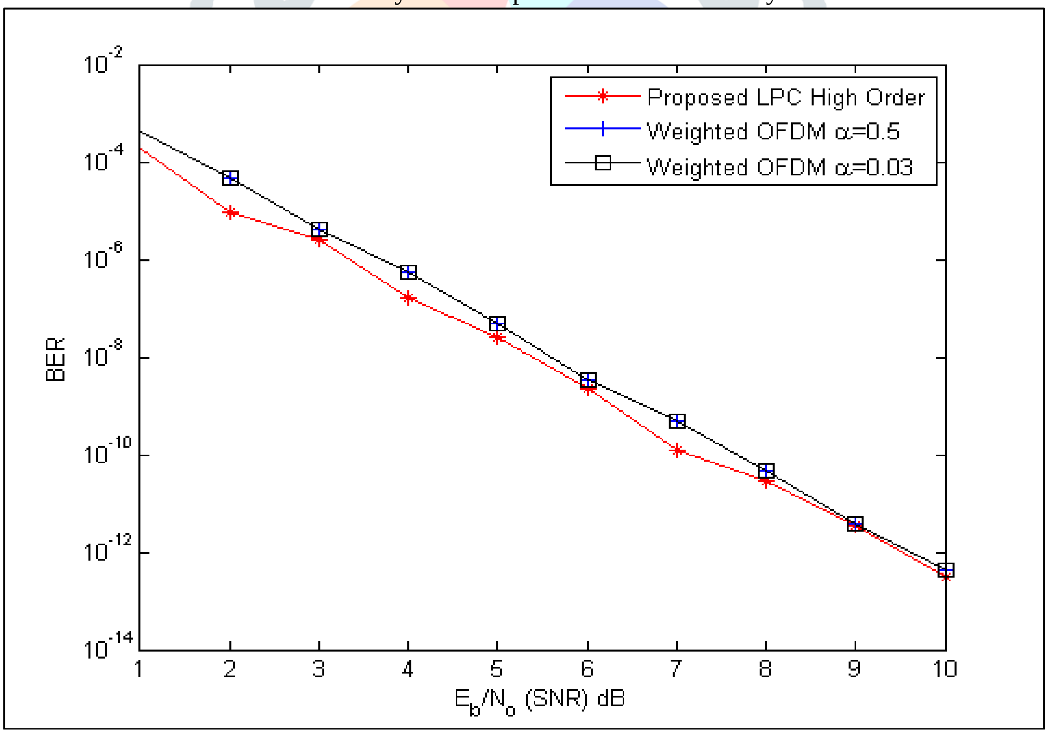

Figure 4. BER comparison of weighted OFDM and proposed OFDM

4. CONCLUSION

Simulative result analysis of proposed PAPR reduction technique using higher order LPC techniques demonstrated the positive indication of performance improvements. The result shows the significant reduction in PAPR up to 3 dB probability level with reduced BER and increased system performance. It has already been proved that PAPR increases proportionally with the number of subcarriers. As we increase the order of LPC filter, there is further reduction in PAPR. On the contrary, with the increase in value of β, PAPR increases. In figure 3, it is clearly demonstrated for three different values of β over proposed technique. There is a good prospect in future for further performance enhancements in PAPR reduction in OFDM.

5. REFERENCES

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