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A PAPR Reduction Scheme using Modified Weighted OFDM

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Abstract –**OFDM is successfully used in many wireless digital communication system over multipath channels. One of the principle disadvantages of OFDM is the occurrence of high PAPR. OFDM signals are very sensitive to nonlinear effects due to the high PAPR, which leads to the power inefficiency in the RF section of the transmitter. This paper is focused on analyzing PAPR reduction by undertaking various methods to reduce the PAPR in the system like normal OFDM, clipping & filtering scheme, convolution scheme, weighted OFDM and modified weighted OFDM system.**

Keywords – **Clipping Level, Modified OFDM, PAPR.**

I. Introduction

With the arrival of new high data rate wireless applications, demand of the spectrum is rapidly increasing. Communications governmental and regulatory agencies impose regulations on spectrum usage, such as control of allocations and priorities, as well as its features. At this time, most of the prime spectrum has been assigned and it is difficult to find spectrum for the new wireless applications. It can be made available for either expands existing infrastructures or invent new services. Orthogonal Frequency Division Multiplexing (OFDM) is promising candidate for flexible spectrum pooling in communication systems.

For a long time, usage of OFDM in practical systems was limited. Main reasons for this limitation were the complexity of real time Fourier Transform and the linearity required in RF power amplifiers. However since 1990s, OFDM is used for wideband data communications over mobile radio FM channels, High-bit-rate Digital Subscriber Lines (HDSL, 1.6Mbps), Asymmetric Digital Subscriber Lines (ADSL, up to 6Mbps), Very-high-speed Digital Subscriber Lines (VDSL, 100Mbps), Digital Audio Broadcasting (DAB), and High Definition Television (HDTV) terrestrial broadcasting.

OFDM has many advantages over single carrier systems. The implementation complexity of OFDM is significantly lower than that of a single carrier system with equalizer. When the transmission bandwidth exceeds coherence bandwidth of the channel, resultant distortion may cause intersymbol interference (ISI). Single carrier systems solve this problem by using a linear or nonlinear equalization. The problem with this approach is the complexity of effective equalization algorithms. OFDM systems divide available channel bandwidth into a number of subchannels. By selecting the subchannel bandwidth smaller than the coherence bandwidth of the frequency selective channel, the channel appears to be nearly flat and no equalization is needed. Also by inserting a guard time at the beginning of OFDM symbol during which the symbol is cyclically extended, intersymbol interference (ISI) and intercarrier interference (ICI) can be completely eliminated, if the duration of guard period is properly chosen. This property of OFDM makes the single frequency networks possible. In single frequency networks, transmitters simultaneously broadcast at the same frequency, which causes intersymbol interference. Additionally, in relatively slow time varying channels, it is possible to significantly enhance the capacity by adapting the data rate per subcarrier according to the signal-to-noise ratio (SNR) of that particular subcarrier. Another advantage of OFDM over single carrier systems is its robustness against narrowband interference because such interference affects only a small percentage of the subcarriers.

Beyond all these advantages, OFDM has some drawbacks compared to single carrier systems. Two of the problems with OFDM are the carrier phase noise and frequency offset. Carrier phase noise is caused by imperfections in the transmitter and receiver oscillators. Frequency offsets are created by differences between oscillators in transmitter and receiver, Doppler shifts, or phase noise introduced by nonlinear channels. There are two destructive effects caused by a carrier frequency offset in an

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OFDM system. One is the reduction of signal amplitude since sinc functions are shifted and no longer sampled at the peak, and the other is the introduction of ICI from the other carriers. The latter is caused by the loss of Orthogonality between the subchannels. Sensitivity to phase noise and frequency offsets increases with the number of subcarriers and with the constellation size used for subcarrier modulation. For single carrier systems, phase noise and frequency offsets only give degradation in the receiver SNR, rather than introducing ICI. That is why the sensitivity to frequency offsets and phase noise are mentioned as disadvantages of OFDM relative to single carrier systems.

The most important disadvantage of OFDM systems is that highly linear RF amplifiers are needed. An OFDM signal consists of a number of independently modulated subcarriers, which can give a large Peak-to-Average Power Ratio (PAPR) when added up coherently. When N signals are added with the same phase, they produce a peak power that is N times the average power. In order to avoid nonlinear distortion, highly linear amplifiers are required which cause a severe reduction in power efficiency. Several methods are explained in the literature in order to solve this problem.

One of the challenges of the OFDM is high peak-to-average power ratio (PAPR). A high PAPR brings disadvantages like an increased complexity of the A/D and D/A converters and reduced efficiency of radio frequency (RF) power amplifier [3]. OFDM signal consists of a number of independent modulated subcarriers that leads to the problem of PAPR. If all subcarriers come with same phase, the peak power is N times the average power of the signal where N is the total number of symbols in an OFDM signal. Thus, it is not possible to send this high peak amplitude signals to the transmitter without reducing peaks. Because power amplifier used for the transmission has non-linear nature which causing inter-modulation and out-of-band radiation. The high peak of OFDM signal can be reduced in several ways.

Most widely used methods are clipping and peak windowing the OFDM signal when a high PAPR is encountered. However these methods distort the original OFDM signal resulting in an increase in the bit error probability. There are other methods that do not distort the signal. In this research work a peak-to-average-ratio (PAPR) reduction scheme based on a weighted orthogonal frequency-division multiplexing (OFDM) signal is proposed to reduce the PAPR without distortion in removing the weight at the receiver side. In the proposed scheme, a weight is imposed on each discrete 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. Meanwhile, the time duration needed to transmit the weighted OFDM signal is the same as the time duration for the original OFDM signal.

The objective of this paper is to develop a PAPR reduction system using normal OFDM, clipping & filtering scheme, convolution scheme, weighted OFDM and modified weighted OFDM system along with comparative analysis of bit error rate for above-mentioned schemes.

II. Proposed Method

PAPR Reduction using Clipping and Filtering Method

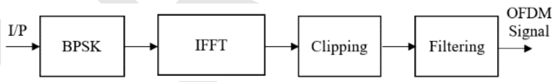

Figure 1: Block diagram for OFDM signal transmission using clipping and filtering method

Clipping and filtering is one of the simplest methods of PAPR reduction in OFDM system. This is the method of clipping the high peaks of the OFDM signal. This is done with the help of clipper that limits the signal envelop to the predetermined level known as clipping level (CL), if the signal goes beyond the CL; otherwise clipper passes signal without any change. Figure 1 shows OFDM signal transmission block diagram using simple clipping and filtering scheme.

The clipped signal is given by:

$$y(n) = \begin{cases} -CL, & if\ x(n) < -CL \\ x[n], & if\ -CL \le x(n) \le CL \\ CL, & if\ x(n) > CL \end{cases} \quad (1)$$

Where $x(n)$ is the OFDM signal, CLis the clipping level.

Clipping is a nonlinear process that causes the distortion as source of noise, which falls in both in-band and out-of-band distortions. In-band distortion can degrade the BER performance and cannot be reduced by filtering. However, oversampling by taking longer IFFT can reduce the in-band distortion effect as portion of the noise is reshaped outside of the signal band that can be removed later by filtering. While the out of band distortion causes spectral spreading and can be eliminated by filtering the clipped OFDM signal which can preserve the spectral efficiency and, hence, improving the BER performance but it can results in some peak power regrowth.

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Clipping and filtering is used with a clipping ratio (CR) of 0.9dB. The CR is associated with the clipping level by the following expression:

$$CR = 20\log_{10}\left(\frac{CL}{E\{x(n)\}}\right) \tag{2}$$

Where, $E\{x(n)\}$ represents the average of OFDM signal $x(n)$.

PAPR Reduction using Convolution Method

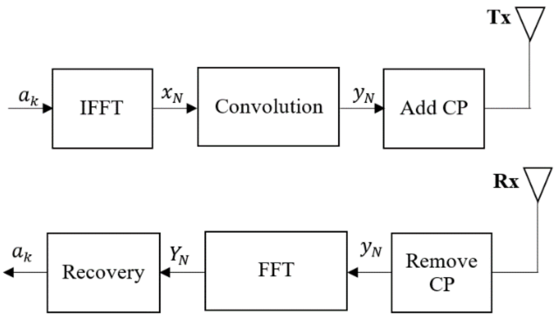

Figure 2: Block diagram for convolution method

The simplified block diagram for an OFDM system with the convolution scheme is shown in Figure 2. As described in Figure 2, the modulated data stream is carried on the multicarriers by the IFFT, and the convolution block reduces the PAPR of signal. In the following block, the cyclic prefix is added after convolution.

For a discrete data $\{a_k\}_{k=0}^{N-1}$, multicarrier-modulated signal $x_N(t)$ on $[0, NT]$ is represented as:

$$x_N(t) = \frac{1}{\sqrt{N}}\sum_{k=0}^{N-1} a_k e^{j2\pi f_k t} \tag{3}$$

Where N is the number of subcarriers, T is the original symbol period, $\Delta f = 1/NT$, and $f_k = k\Delta f$, $k = 0,\ldots,N-1$. Then the PAPR of x_N over the time interval $[0, NT]$ is expressed as:

$$PAPR(x_N) = \frac{\max_{0\le t\le NT} |x_N(t)|^2}{E(|x_N(t)|^2)} \tag{4}$$

Where $E(\cdot)$ denotes the expectation operator.

Taking the circular convolution between the multicarrier-modulated signal x_N and a suitable signal Φ having compact support, the PAPR of the convolved signal can be reduced. The circular convoluted signal is expressed as:

$$y_N(t) := \frac{1}{2\pi} x_N * \Phi(t) = \frac{1}{2\pi}\int_{-\pi}^{\pi} x_N(t-\xi)\Phi(\xi)d\xi \tag{5}$$

PAPR Reduction using Weighted OFDM System

The simplified block diagram for PAPR reduction with the weighted OFDM scheme is shown in Figure 3. Here, the weighted OFDM signal is provided, where the weight is derived from a suitable band-limited signal having no zero on the real line.

As described in Figure 3 the modulated data stream is carried on the multicarriers by the weight block of the proposed scheme. In the following block, the cyclic prefix is added.

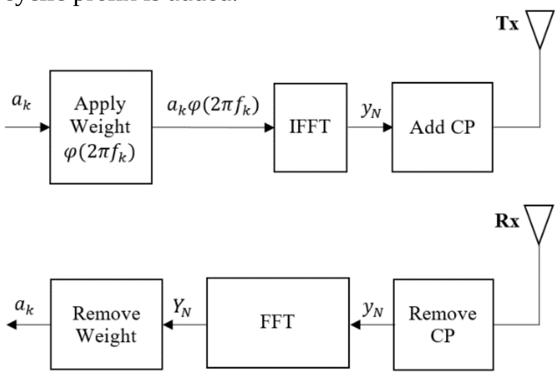

Figure 3: Block diagram for weighted OFDM method

The convoluted signal in equation (5) can be written as a simple weighted OFDM signal y_N as:

$$y_N(t) = \frac{1}{\sqrt{N}}\sum_{k=0}^{N-1} a_k\varphi(2\pi f_k)e^{j2\pi f_k t}, 0 \le t \le NT \tag{6}$$

PAPR Reduction using Modified Weighted OFDM System

The demerit of the weighted OFDM signal in equation (6) is the degradation of BER performance since the weight φ is nonuniform. To overcome this obstacle, a modified weight is considered with a positive constant α as follows [1]:

$$\varphi_\alpha(x) = \varphi(x) + \alpha/\log N \tag{7}$$

Where α is a shift parameter, and $\log N$ is obtained by experiment. Then, $\varphi = \varphi_0$. In the weighted OFDM signal in equation (6), the weight φ is replaced with φ_α for a suitable positive constant α to get the weighted OFDM signal, i.e., $z_N(t)$ as a transmitted signal instead of x_N in equation (3) which is expressed as:

$$z_N(t) = \frac{1}{\sqrt{N}}\sum_{k=0}^{N-1} a_k\varphi_\alpha(2\pi f_k)e^{j2\pi f_k t}, 0 \le t \le NT \tag{8}$$

In equation (8), weight $\varphi_\alpha(2\pi f_k)$ is imposed on the discrete data a_k, $k = 0,\ldots N-1$, and an OFDM signal is formed with the weighted discrete data $\{a_k\varphi_\alpha(2\pi f_k)\}_{k=0}^{N-1}$ to get weighted OFDM signal z_N. Also the weighted OFDM signal z_N is transmitted for the same time duration $[0, NT]$ as the original OFDM signal.

It can be noticed that weight φ is positive on the real line; therefore, the modified weight φ_α is positive on the real line. Since $\varphi_\alpha(2\pi f_k) \neq 0$ for any $k = 0,\ldots N-1$, the discrete data $\{a_k\}_{k=0}^{N-1}$ can be completely recovered. Then the PAPR of the modified weighted OFDM signal z_N is expressed as:

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$$PAPR(z_N) = \frac{\max_{0\le t\le NT} |z_N(t)|^2}{E(|z_N(t)|^2)} \quad (9)$$

III. Simulation And Results

The performance of proposed algorithms has been studied by means of MATLAB simulation.

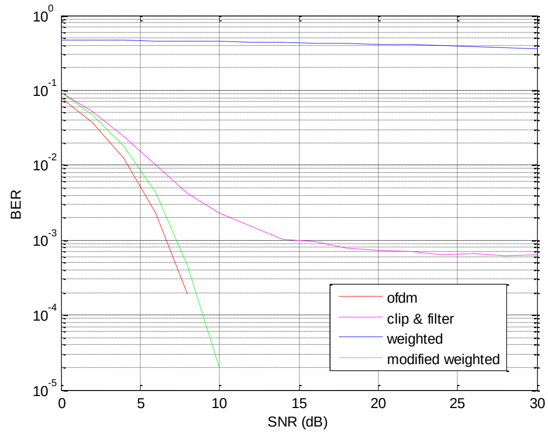

Figure 4: BER vs. SNR calculation graph for normal OFDM, clipping & filtering scheme, weighted OFDM and modified weighted OFDM

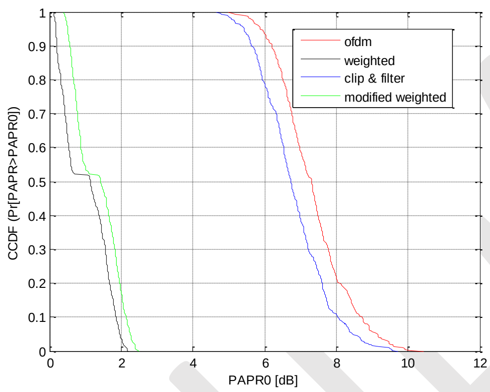

Figure 5: CCDF v/s PAPR calculation graph for normal OFDM, clipping & filtering scheme, weighted OFDM and modified weighted OFDM

The above simulation result shows the comparative graph between CCDF and PAPR with FFT-64 for normal OFDM, clipping & filtering scheme, weighted OFDM and modified weighted OFDM. The X axis indicates the PAPR value and Y axis represents CCDF. It can be observed by above graph that the weighted OFDM outperforms other methods.

IV. Conclusion

In this paper, the different properties of an OFDM system are analyzed. The bit–error–rate is also plotted against the signal–to–noise ratio to understand the performance for different methods namely; normal OFDM, clipping & filtering scheme, convolution scheme, weighted OFDM and modified weighted OFDM system.

The simulation results indicate that, application of the algorithm results in significant reduction in the PAPR values. It was observed that the PAPR of weighted OFDM method is smaller than that of other methods, and the BER performance is improved using modified weighted OFDM method.

Reference

[1] Huang, Chih-Yao, Wei-Jay Chang, and Li-Chung Chang. “A modified Low PAPR space-frequency block coding scheme for SC-FDMA.” In Communication, Networks and Satellite (ComNetSat), 2012 IEEE International Conference on, pp. 98-102. IEEE, 2012.

[2] Qi, Xiaoke, Yu Li, and Haining Huang. “A low complexity PTS scheme based on tree for PAPR reduction.” IEEE Communications Letters 16, no. 9, pp. 1486-1488, 2012.

[3] Mishra, Himanshu Bhusan, Madhusmita Mishra, and Sarat Kumar Patra. “Selected mapping based PAPR reduction in WiMAX without sending the side information.” In Recent Advances in Information Technology (RAIT), 2012 1st International Conference on, pp. 182-184. IEEE, 2012.

[4] V.B. Malode and B.P. Patil, “PAPR Reduction Using Modified Selective Mapping Technique”, IJANA, Vol. 2, Issue: 02, pp 626-630, 2010.

[5] P. S. Varahram and B.Mohd. Ali, “Partial transmit sequence scheme with new phase sequence for PAPR reduction in OFDM systems”, IEEE Transactions on Consumer Electronics, ISSN: 0098-3063, Vol. 57, Issue 2, pp. 366-371, May 2011.

[6] M. Pant and D. Nitnawwre, “Performance Improvement of OFDM System Using PAPR Reduction”, International Journal of Advanced Research in Computer Science and Software Engineering (IJARCSSE), ISSN: 2277 128X, Vol. 2, Issue 5, May 2012.

[7] R. Baranwal, A. Kumar and C. K. Shukla, “Effect of Different Modulation on PAPR and Its Reduction”, International Journal of Computer Science & Engineering Technology (IJCSET), Vol. 3, No. 8 August 2012.

[8] I. Mohd. Hussain, “Low Complexity Partial SLM Technique for PAPR Reduction in OFDM Transmitters”, International Journal on Electrical Engineering and Informatics (IJEEI) – Vol. 5, No. 1, March 2013.

[9] Shin, Chang Eon, Kyung Soo Rim, and Youngok Kim. “A weighted OFDM signal scheme for peak-to-average power ratio reduction of OFDM signals.” IEEE Transactions on Vehicular Technology 62, no. 3, pp. 1406-1409, 2013.