International Journal of Research
Available at https://edupediapublications.org/journals
p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 03 Issue 08
April 2016

Reduction of Peak to Average Power Ratio of OFDM Signals by Using a Weighted OFDM Signal Scheme

[1]K.SteffeGraph; 2Dr.CH.Balaswamy & [3]Dr.NagendraRao
[1]P.G Student, Dept of ECE, Qis College of Engineering and Technology, PrakasamDist,AndhraPradesh,India.
[1]Steffe.prathyu@gmail.com
[2]M.tech.,MISTE.,Phd, H.O.D of ECE Dept Qis College of Engineering and Technology, PrakasamDist,AndhraPradesh,India[2]ch.balaswamy7@gmail.com
[3]M.tech.,Phd.,Professor of ECE Dept,Qis College of Engineering and Technology
Prakasam Dist, Andhra Pradesh,India

ABSTRACT :

Orthogonal frequency division multiplexing has drawn explosive attention as a new type of high data rate transmission scheme for wireless communication system. OFDM allow the transmission of high data rates over broadband channel due to the spectral bandwidth efficiency, robustness to the multipath delay etc. However OFDM signal are very sensitive to nonlinear effects due to the high peak-to-average power radio (PAPR), which is one of the major drawback of OFDM system. which results in significant inter modulation, inter carrier interference(ICI) ,bit error rate(BER) performance degradation and undesirable out-of-band radiation when an OFDM signal passes through nonlinear devices such as high power amplifier(HPA). The complexity of analogto-digital converter (ADC) and digital-to- analog converter (DAC) also get increased if the PAPR of OFDM signal is high. Thus in OFDM system one of the important research areas is reduction of PAPR, which concern with OFDM signal performance. In this paper we describe the PAPR reduction techniques and PAPR of OFDM by using selected mapping (SLM).

KEYWORDS: Complementary Cumulative distribution function (CCDF); Orthogonal frequency division multiplexing (OFDM); peak-to-average power ratio (PAPR); partial transmit sequences (PTS); selected mapping (SLM).

1. INTRODUCTION

OFDM has becomean essential technique for high speed wireless communication on system because of its robustness to multipath fading channels and high spectral efficiency. OFDM has several significant advantages:

- High spectral efficiency to broadband wireless communication.
- Robustness against frequency selective fading, inter symbols interference (ISI) and narrowband interference.
- Lower implementation complexity in comparison to the single-carrier solution

Due to these advantage OFDM (orthogonal frequency division multiplexing) has been adopted as a standard for various wireless communication system such as digital audio broad casting(DAB),terrestrial digital video broad casting(DVB-T),wireless local area network(WLANs) . The main disadvantage of OFDM is its large peak-to-average power radio (PAPR) which results in significant inter-modulation and undesirable out-of band radiation .When an OFDM signal passes through high power amplifier (HPA), which is a nonlinear device [1]. OFDM has been considered as a promising candidate to achieve high rate data transmission in a mobile environment. The OFDM systems significantly increase bandwidth efficiency by allowing overlapping of the sub channel, while maintaining orthogonality between them. Moreover, robustness against

frequency selective fading channels can be easily achieved [2]. In general to reduce the distortion caused by the non-linearity of HPA, it requires a large back-off from the peak power due to which the power efficiency get degrades .The complexity of the digital-to-analog converter (DAC) also get increased due to the large value of PAPR[3]. Therefore in OFDM system the PAPR reduction is one of the most important research areas. There are several PAPR reduction techniques which can be classified according to some specific criteria

.These PAPR techniques can be categorized as additive and multiplicative schemes with respect to the computational operation. The examples of multiplicative schemes are PTS (partial transmit sequence) and SLM (selected mapping technique) [4]. On the other hand clipping and peak cancelling are deterministic schemes and tone reservation is the example of additive scheme. The low complexity PAPR reduction schemes may be applicable to mobile communication systems [5] .Comparison of PAPR reduction techniques is based on average power increase, BER degradation, computational complexity and data rate loss Orthogonal frequency-division multiplexing (OFDM), essentially identical to coded OFDM (COFDM) and discrete multi-tone modulation (DMT), is a frequency-division multiplexing (FDM) scheme used as a digital multi-carrier modulation method. A large number of closely-spaced orthogonal sub-carriers are used to carry data. The data is divided into several parallel data streams or channels, one for each sub-carrier. Each sub-carrier is modulated with a conventional modulation scheme (such as quadrature amplitude modulation or phase-shift keying) at a low symbol rate, maintaining total data rates similar to conventional single-carrier modulation schemes in the same bandwidth. OFDM has developed into a popular scheme for wideband digital communication, whether wireless or over copper wires, used in applications such as digital television and audio broadcasting, wireless networking and broadband internet access. The primary advantage of OFDM over single-carrier schemes is its ability to cope with severe channel conditions (for example, attenuation of high frequencies in a long copper wire, narrowband interference and frequency-selective fading due to multipath) without complex equalization filters. Channel equalization is simplified because OFDM may be viewed as using many slowly-modulated narrowband signals rather than one rapidly-modulated wideband signal. The low symbol rate makes the use of a guard interval between symbols affordable, making it possible to eliminate inter symbol interference (ISI) and utilize echoes and time-spreading (that shows up as ghosting on analogue TV) to achieve a diversity gain, i.e. a signal-to-noise ratio improvement. This mechanism also facilitates the design of single frequency networks (SFNs), where several adjacent transmitters send the same signal simultaneously at the same frequency, as the signals from multiple distant transmitters may be combined constructively, rather than interfering as would typically occur in a traditional single-carrier system.

Example of applications

The following list is a summary of existing OFDM based standards and products. For further details, see the Usage section at the end of the article.

Cable

- ADSL and VDSL broadband access via POTS copper wiring.
- DVB-C2, an enhanced version of the DVB-C digital cable TV standard.
- Power line communication (PLC).
- ITU-T G.hn, a standard which provides high-speed local area networking over existing home wiring (power lines, phone lines and coaxial cables).
- Trail Blazer telephone line modems.
- Multimedia over Coax Alliance (MoCA) home networking.

Wireless

- The wireless LAN (WLAN) radio interfaces IEEE 802.11a, g, n and HIPERLAN/2.
- The digital radio systems DAB/EUREKA 147, DAB+, Digital Radio Mondiale, HD Radio, T-DMB and ISDB-TSB.
- The terrestrial digital TV systems DVB-T and ISDB-T.
- The terrestrial mobile TV systems DVB-H, T-DMB, ISDB-T and Media FLO forward link.
- The wireless personal area network (PAN) ultra-wideband (UWB) IEEE 802.15.3a implementation suggested by Wi Media Alliance.

The OFDM based multiple access technology OFDMA is also used in several 4G and pre-4G cellular networks and mobile broadband standards:

- The mobility mode of the wireless MAN/broadband wireless access (BWA) standard IEEE 802.16e (or Mobile- Wi MAX).
- The mobile broadband wireless access (MBWA) standard IEEE 802.20.
- The downlink of the 3GPP Long Term Evolution (LTE) fourth generation mobile broadband standard. The radio interface was formerly named High Speed OFDM Packet Access (HSOPA), now

  named Evolved UMTS Terrestrial Radio Access (E-UTRA).

Key features

The advantages and disadvantages listed below are further discussed in the Characteristics and principles of operation section below.

Summary of advantages:

- Can easily adapt to severe channel conditions without complex time-domain equalization.
- Robust against narrow-band co-channel interference.
- Robust against inter symbol interference (ISI) and fading caused by multipath propagation.
- High spectral efficiency as compared to conventional modulation schemes, spread spectrum, etc.
- Efficient implementation using Fast Fourier Transform (FFT).

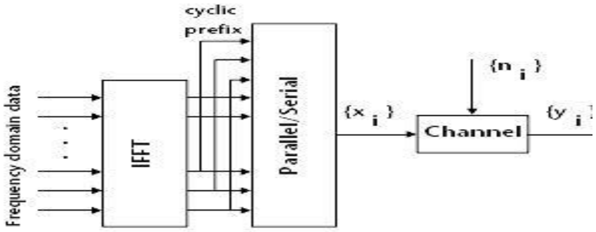
- Low sensitivity to time synchronization errors.
- Tuned sub-channel receiver filters are not required (unlike conventional FDM).
- Facilitates single frequency networks (SFNs); i.e., transmitter macro diversity.

2.ORTHOGONALITY

In OFDM, the sub-carrier frequencies are chosen so that the sub-carriers are orthogonal to each other, meaning that cross-talk between the sub-channels is eliminated and inter-carrier guard bands are not required. This greatly simplifies the design of both the transmitter and the receiver; unlike conventional FDM, a separate filter for each sub-channel is not required.

The orthogonality requires that the sub-carrier spacing is $\Delta f = \frac{k}{T_U}$ Hertz, where T_U seconds is the useful symbol duration (the receiver side window size), and k is a positive integer, typically equal to 1. Therefore, with N sub-carriers, the total pass band bandwidth will be $B \approx N \cdot f$ (Hz).

The orthogonality also allows high spectral efficiency, with a total symbol rate near the Nyquist rate for the equivalent baseband signal (i.e. near half the Nyquist rate for the double-side band physical pass band signal).



The discrete time baseband OFDM signal, are transformed in to continuous time baseband OFDM signals by a low pass filter called DAC, where the peak power can be increased while maintaining constant average power. Usually ,the PAPR of continuous time baseband OFDM signals is larger than that of discrete time baseband OFDM signals by 0.5 – 1.0dB.

3.PAPR IN OFDM

However, OFDM is not without drawbacks. One critical problem is its high peak-to-average power ratio (PAPR). High PAPR increases the complexity of analog-to-digital (A/D) and digital-to-analog (D/A) converters, and lowers the efficiency of power amplifiers. Over the past decade various PAPR reduction techniques have been proposed, such as block coding, selective mapping (SLM) and tone reservation, just to name a few . Among all these techniques the simplest solution is to clip the transmitted signal when its amplitude exceeds a desired threshold. Clipping is a highly nonlinear process, however. It produces significant out-of-band interference (OBI). A good remedy for the OBI is the so-called companding. The technique „soft‟ compresses, rather than „hard‟ clips, the signal peak and causes far less OBI. The method was first proposed in, which employed the classical -law transform and showed to be rather effective. Since then many different companding transforms with better performances have been Published. This paper proposes and evaluates a new companding algorithm. The algorithm uses the special airy function and is able to offer an improved bit error rate (BER) and minimized OBI while reducing PAPR effectively. The paper is organized as follows. In the next section the PAPR problem in OFDM is briefly reviewed.

PAPR IN OFDM

- OFDM is a powerful modulation technique being used in many new and emerging broadband communication systems.

Advantages:
Robustness against frequency selective fading and time dispersion.

Transmission rates close to capacity can be achieved.

Low computational complexity implementation (FFT).

Drawbacks:

Sensitivity to frequency offset.

- Sensitivity to nonlinear amplification.
- Compensation techniques for nonlinear effects

– Linearization (digital predistortion).

– Peak-to-average power ratio (PAPR) reduction.

– Post-processing.

- PAPR-reduction techniques:

– Varying PAPR-reduction capabilities, power, bandwidth and complexity requirements.

– The performance of a system employing these techniques has not been fully analyzed

– PAPR is a very well known measure of the envelope fluctuations of a MC signal

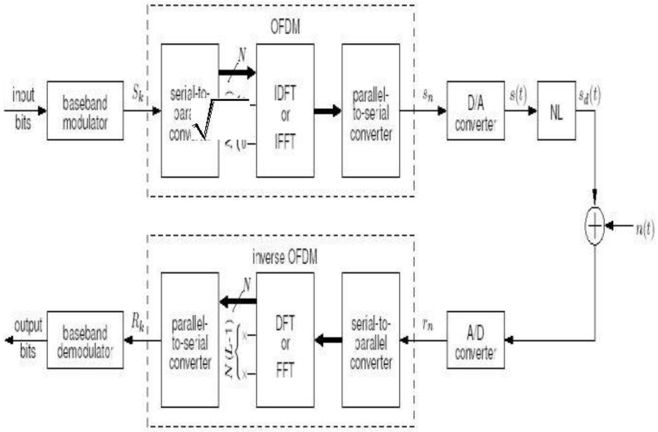
– Used as figure of merit.

– The problem of reducing the envelope fluctuations has turned to reducing PAPR.

– In this paper we present a quantitative study of PAPR and NL distortion – simulate an OFDM-system employing some of these techniques

Motivation: evaluate the performanceimprovement capabilities of PAPR-reducing methods.

4. OrthogonalFrequency Division Multiplexing



The CCDF of the PAPR of a non-oversampled OFDM signal is

$$\Pr(\gamma > \gamma_0) = 1 - \left(1 - e^{-\gamma_0}\right)^N$$

- CCDF of PAPR increases with the number of subcarriers in the OFDM system.

– It is widely believed that the more

subcarriers are used in a OFDM system, the worse the distortion caused by the nonlinearity will be.

– In-band and out-of-band distortion

If N is large enough, the OFDM signal can be approximated as a complex Gaussian distributed random

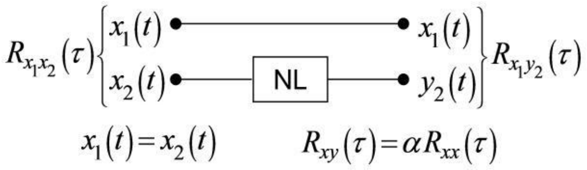
- variable. Thus its envelope is Rayleigh distributed

$$f_X(x) = \frac{2x}{\sigma^2} e^{-\frac{x^2}{\sigma^2}},$$

with $E[X] = \sigma\sqrt{\frac{\pi}{2}}$ and $\mathrm{var}[X] = \sigma^2\left(1 - \frac{\pi}{4}\right)$,

where the variance of the real and imaginary parts of the signal is

- Buss gang theorem



An interesting result is that the output of a NL with Gaussian input (OFDM) can be written as:

- In order to improve the system performance, PAPR should predict the amount of distortion introduced by the nonlinearity

– PAPR increases with the number of subcarriers in the OFDM signal.

– The distortion term and the uniform attenuation and rotation of the constellation only depend on the back-off.

The effect of a nonlinearity to an OFDM signal is not clearly related to its PAPR

- The effective energy per bit at the input of the nonlinearity is

- where E_o is the average energy of the signal at the input of the nonlinearity, K is the

- number of bits per symbol and η_p is the power efficiency.

- There will only be aa BER performance improvement when the effect of reducing the in-band distortion becomes noticeable and more important than the loss of power efficiency.

- This is not taken into account in the majority of the PAPR reducing methods.

Let (0),(1), ···, (−1) represent the data sequence to be transmitted in an OFDM symbol with subcarriers. The baseband representation of the OFDM symbol is given by:

$$x(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X(n) e^{\frac{j2\pi nt}{N}} \qquad 0 \le t \le T,$$

$$y(t) = \alpha x(t) + d(t), \text{where } \alpha = \frac{R_{xy}(\tau 1)}{R_{xx}(\tau 1)}$$

Considerations on PAPR reduction

where is the duration of the OFDM symbol. According to the central limit theorem, when is large, both the real and imaginary parts of ( ) become Gaussian distributed, each with zero mean and a variance of E[| ( )|2]/2, and the amplitude of the OFDM symbol follows a Rayleigh distribution. Consequently it is possible that the maximum amplitude of OFDM signal may well exceed its average amplitude. Practical hardware (e.g. A/D and D/A converters, power amplifiers) has finite dynamic range; therefore the peak amplitude of OFDM signal must be limited. PAPR is mathematically defined as:

$$\mathbf{PAPR} = 10\log_{10}\frac{\max[|x(t)|^2]}{\frac{1}{T}\int_0^T |x(t)|^2\,dt} \quad (\mathbf{dB}).$$

It is easy to see from above that PAPR reduction may be achieved by decreasing the numerator max[| ( )|2], increasing the denominator (1/T) · ∫ 0 | ( )|2 , or both.

The effectiveness of a PAPR reduction technique is measured by the complementary cumulative distribution function (CCDF), which is the probability that PAPR exceeds some threshold, i.e.:

CCDF = Probability (PAPR > 0), where 0 is the threshold.

5.PAPR reduction methods

PAPR reduction methods have been studied for many years and significant number of methods has been developed. These methods are discussed below:

- Clipping: Clipping naturally happens inthe transmitter if power back-off is not enough. Clipping leads to a clipping noise and out-of-band radiation. Filtering after clipping can reduce out-of-band radiation, but at the same time it can cause “peak regrowth”. Repeated clipping and filtering can be applied to reduce peak regrowth in expense of complexity. Several methods for mitigation of the clipping noise at the receiver were proposed: for example reconstructing of the clipped sample, based on another samples in the oversampled signal.

- Coding: Coding methods include Golay complementary sequences, block coding scheme , complementary block codes (CBC) , modified complementary block codes (MCBC) etc. An application of the Golay Complementary sequences is limited by the fact that they can not be used with M-QAM modulation. Simple scheme, proposed in , relies on lookup tables containing sequences with lower PAPR.This method doesn‟t attempt to utilize those sequences for error correction/detection. CBC utilizes complement bits that are constructed from the subset of the information bits. MCBC is a modification of CBC suitable for large number of sub-carriers. Coding methods have low complexity but PAPR reduction is achieved in expense of redundancy causing data rate loss.

- Partial Transmit Sequences (PTS): a set of sub-carriers of an OFDM symbol is divided into non-overlapping sub-blocks . Each sub-block undergoes zero-padding and IDFT resulting in p(k), k=1…V, called PTS. Peak value optimization is performed over linear combination of PTSs: $\sum_{k=1}^{V} p(k)b(k)$,

where b(k) is optimization parameter. The optimization parameter is often limited to four rotation factors: $b(k) \in \{\pm 1 \pm j\}$.

- Selected mapping (SLM) : a set of sub-carriers of an OFDM symbol is multiplied sub-carrier wise by U rotation vectors b.Then all the rotated U data blocks are transformed into the time-domain by IDFT and then the vector with the lowest PAPR is selected for transmission.

- Interleaving : The same data block is interleaved by K different interleavers. K IDFTs of the original data block and modified data blocks are calculated. PAPR of K blocks is calculated. The block with minimum PAPR is transmitted.

- Tone Reservation (TR) : L sub-carriersare reserved for peak reduction purposes. The values of the signals to insert on peak reduction sub-carriers are computed by suitable Linear Programming algorithm.

- Tone Injection (TI) : TI maps one constellation point of the original constellation (for example QPSK) to several constellation points of the expanded constellation (for example 16QAM). PAPR redaction is achieved by choosing constellation points of the expanded constellation.

- Active Constellation Extension (ACE) : ACE modifies original constellation by moving nominal constellation points located on the outer constellation boundaries in the directions that don‟t decrease Euclidean distances between constellation points.

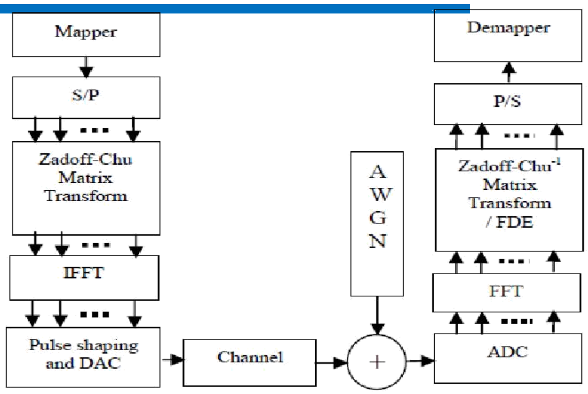


Fig. 2 A ZCT precoded OFDM system

Nonlinear

$$Y_m = \sum_{l=0}^{L-1} (e^{j\frac{\pi(mL+l)^2}{L^2}}).X_l$$

$$= e^{j\pi m^2} \sum_{l=0}^{L-1} ((e^{j\frac{\pi l^2}{L^2}}.X_l).\ e^{j\frac{2\pi m l}{L}}$$

$$PAPR = \frac{max[|x_n|^2]}{E[|x_n|^2]}$$

Companding Transform (NCT) : NCT compand original OFDM signal using strict monotone increasing function. Companded signal can be recovered by the inverse function at the receiver

PROPOSED SYSTEM:

Fig. illustrates the general block diagram of

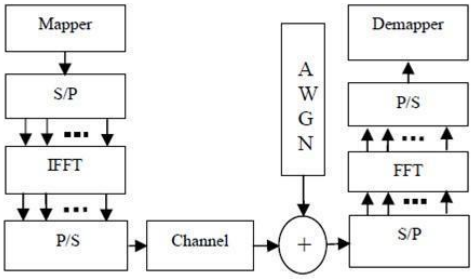


Fig. 1 A Conventional OFDM system

An OFDM system Baseband modulated symbols are passed through serial to parallel converter which generates complex vectorof size N. We can write the complex vector of size N as X = [X0, X1, X2… XN-1]T. X is then passed through the IFFT block. The complex baseband OFDM signal with N

subcarriers can be
Writtenas:-

Here j=sqrt(-1) and the PAPR of OFDM signal in (1) can be written as

$$x_n = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k . e^{j2\pi \frac{n}{N} k}, \; n=0,\, 1,\, 2 \ldots N\text{-}1$$

where E [.] denotes expectation Zadoff-Chu (ZC) Sequences and Zadoff-Chu matrix Transform (ZCT) Zadoff-Chu (ZC) sequences are class of poly phase sequences having optimum correlation properties. ZC sequences have an ideal periodic autocorrelation and constant magnitude. According to [11], ZC sequences of length N can be defined as:-

$$a_n = \begin{cases} e^{\frac{j2\pi r}{N}\left(\frac{k^2}{2}+qk\right)} & \text{for N Even} \\ e^{\frac{j2\pi r}{N}\left(\frac{k(k+1)}{2}+qk\right)} & \text{for N Odd} \end{cases} \qquad (3)$$

where k = 0, 1, 2… N-1, q is any integer, r is any integer relatively prime to N and j=√ 1. The kernel of the ZCT is defined in (4), is obtained by reshaping the ZC sequence by $k = mL + l$ as hereunder:-

$$A = \begin{bmatrix} a_{00} & a_{01} & \cdots & a_{0(L-1)} \\ a_{10} & a_{11} & \cdots & a_{1(L-1)} \\ \vdots & \vdots & \ddots & \vdots \\ a_{(L-1)0} & a_{(L-1)1} & \cdots & a_{(L-1)(L-1)} \end{bmatrix}$$

Here m is the row variable and l the column variable. In other words, the N= L2 point long ZC sequence fills the kernel of the matrix row-wise. As shown in [8], the PAPR reduces to 0 dB in this case. However, if the
kernel of the matrix is filled column wise,

where $k = m + lL,$, the PAPR does not reduce to 0 dB, instead it reduces to 7.8 dB [4].

ZCT precoded OFDM system Fig. 2 shows the ZCT precoded OFDM (ZCT-OFDM) system. In this system, the kernel of the ZCT acts as a rowwiseprecoding matrix

A of dimension $N = L \times L$ and it is applied to constellations symbols before the IFFT to reduce the PAPR. In the ZCT precoded OFDM system, the baseband

modulated data is passed through S/P converter which generates a complex vector of size L that can be written as X = [X0,

X1, … XL-1]T.

$$Y_m = \sum_{l=0}^{L-1} a_{m,l} . X_l \qquad m = 0,1, \ldots L-1 \qquad (5)$$

Then ZCT precoding is applied to this complex vector which transforms this complex vector into new vector of same length L. This new vector, of length L transformed by ZCT precoding can be written as Y=AX= [Y0, Y1, Y2… YL-1] T, where A is a precoder matrix of size
$N = L \times L$
andYm can be written as:-

meansmth row and lth column of precodermatrix.,Expanding Equation (5), using row wise sequence reshaping $k = mL + l$ and putting q=0, r=1 in Equation (3) we get:-

where $m = \; 0, 1, 2 \ldots L - 1$ Equation

(6) represents the ZCT precoded constellations symbols. The complex baseband ZCT-R-OFDM signal with L subcarriers can be written as:-

$$x_n = \frac{1}{\sqrt{L}} \sum_{m=0}^{L-1} Y_m . e^{j2\pi \frac{n}{L} m}, \; n=0,1,2,\ldots,$$

The complex passband transmit signal, x(t) of ZCT-ROFDM after Root Raised Cosine (RRC) pulse shaping and D/A of xn can be Writtenas:-

The RRC pulse shaping filter can be defined as:-

$$x(t)= e^{j\omega_c t}\sum_{n=0}^{L-1} x_n . r(t-n\check{T})$$

$$r(t)=\frac{\sin\left(\frac{\pi t}{\check{T}}(1-\alpha)\right)+4\alpha\frac{t}{\check{T}}.\cos\left(\frac{\pi t}{\check{T}}(1+\alpha)\right)}{\frac{\pi t}{\check{T}}\cdot\left(1-\frac{16\alpha^2 t^2}{\check{T}^2}\right)}$$

$$0 \leq \propto \leq 1,$$

Whereis $\propto$rolloff factor. ThePAPR of ZCT-ROFDM signal in (8) with pulse shaping can be written as:-

$$PAPR=\frac{\max\limits_{0\leq t\leq N\check{T}}[|x(t)|^2]}{\frac{1}{N\check{T}}\int_0^{N\check{T}}[|x(t)|^2]dt}$$

The PAPR of ZCT-R-OFDM signal in (7) without pulse shaping can be written as:-

$$PAPR=\frac{\max\limits_{n=0,1,\ldots,N-1}[|x_n|^2]}{\frac{1}{M}\sum_{n=0}^{N-1}[|x_n|^2]}$$

It should be pointed out that the orthogonality of the symbols after introducing precoding is maintained, as the precoding matrix is cyclic auto-orthogonal [6].

SIMULATION RESULTS

Extensive simulations in MATLAB(R) have been carried out for the PAPR analysis of ZCT-R-OFDM system with RRC pulse shaping. To show the PAPR analysis of the ZCTR- OFDM system, the data is generated randomly then modulated by QPSK. All the simulations have beenperformed based on 105 random OFDM blocks. Simulation parameters that we use are given in the following Table. 1 as under:-

$$PAPR=\frac{\max\limits_{n=0,1,\ldots,N-1}[|x_n|^2]}{\frac{1}{M}\sum_{n=0}^{N-1}[|x_n|^2]}$$

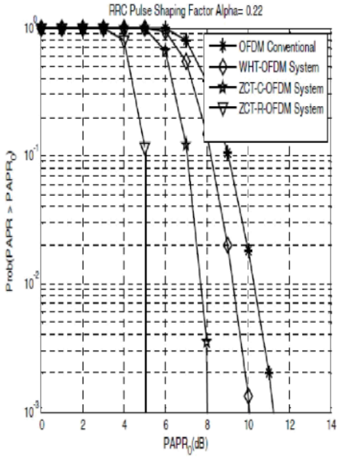
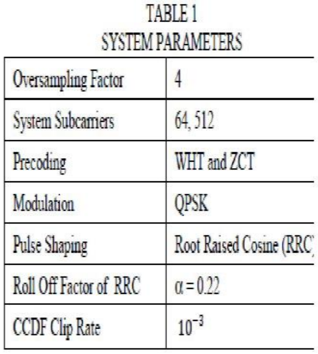
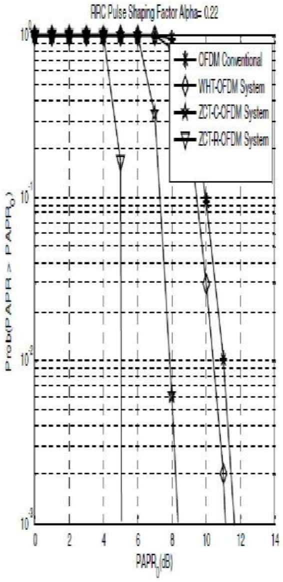


TABLE 1
SYSTEM PARAMETERS



Oversampling Factor	4
System Subcarriers	64, 512
Precoding	WHT and ZCT
Modulation	QPSK
Pulse Shaping	Root Raised Cosine (RRC
Roll Off Factor of RRC	$\alpha = 0.22$
CCDF Clip Rate	10^{-3}



6.CONCLUSION AND FUTURE WORK

In this paper, the concept of PAPR reduction in OFDM signals is discussed. The PAPR reduction techniques like selected mapping (SLM), Partial Transmit sequence (PTS), Radial basic function (RBF) and Tone Reservation (TR) have been discussed and performance of PAPR of OFDM signals with selected mapping technique has been investigated. Simulation has been done with the help of mat lab simulink .In Fig.-5 the Simulation results show that value of PAPR reduces when SLM is used, as the PAPR reduces with these techniques, they can be used in OFDM transmitter effectively. The performance of RF Power amplifiers is enhanced as the value of PAPR decreases. In SLM technique as the number of sub blocks increases, the PAPR decreases. This technique can be applied for systems demanding high data rates. For future work the quality of service (QOS) of OFDM signals can be improved with the help of SLM technique.

REFERENCES

[1]. R. O‟neal and L. N. Lopes, “Envelope variation and spectral splatter in clipped multicarrier signals,” in Proc. PIMRC‟95, Sep. 1995, pp.71–73.

[2]. IEEE 802 .11a-1999 part 11: Wireless LAN medium access control (MAC) physical layer (PHY) specifications: High speed physical layer in the 5 GHz band.

[3]. W.Y.Zou and Y.Wu, “COFDM: an overview,”IEEE Trans, Broadcast, vol.41.no.1, pp. 1-6, Mar 1995.

[4]. J. Tellado and J. M. Cioffi, Multicarrier Modulation with Low PAR, Application to DSL and Wireless. Norwell, MA: Kluwer Academic Publisher, 2000.

[5]. Tao Jiang,Yiyan Wu, “An overview ofPAPR reduction techniques for OFDM signals”,IEEE transactions onBroadcasting,Vol.54,No.2,June 2008.

[6]. T. Jiang and Y.W.WU, “An overview: of Peak -to -average power ratio reduction techniques for OFDM signals.” IEEE Trans. Broadcast., vol. 54, no. 2, pp. 258-267, June 2008

[7]. S.H.Muller, R.W.Bauml, R.F.H.Fischer, and J.B.Huber, “OFDM with reduced peak to average power ratio by multiple signal representation.” Ann. Telecommun., vol.52, no. 1-2, pp. 58-66, feb 1997.

[8]. X. Wang, T. T. Yjhung, and C. S. Ng, “Reduction of peak-to-average power ratio of OFDM system using a companding technique,” IEEE Trans. Broadcast., vol. 45, no. 9, pp. 303-306, Sept. 1999.

K.SteffeGraph is currently working as PG student in ECE Department, QIS college of Engineering &Technology, Ongole. She received her B.Tech. From JNTUK,Kakinada in 2013. Her research interests are in the areas of Digital Electronics & Communication Systems.

Dr.CH.Balaswa completed hisB.E.fromAndhraUniversity, He received his M. Tech from Visveswaraiah Technological University, Belgaumand he completed Ph.D. from JNTUA. He is having 13 years of experience in teaching, presently working in QIS College of Engineering & Technology, Ongole as anProfessor&H.O.D in the Department of Electronics & Communication Engineering.