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DIFFERENT TECHNIQUES TO REDUCE THE PAPR IN OFDM SYSTEM

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***Abstract*: In the modern wireless Communication system high data rate must require. Orthogonal Frequency Division Multiplexing (OFDM) is well known technique for transmitting large data over radio waves. In the OFDM system, orthogonally placed sub – carriers are used to carry the data from the transmitter end to the receiver end. More bandwidth is required for transmitting data at higher rate. Orthogonal frequency division multiplexing is a special form of multicarrier modulation which is particularly suited for transmission over a dispersive channel.**

OFDM has gained a tremendous interest in recent years because of its robustness in the presence of severe multipath channel conditions with simple equalization, robustness against Inter-symbol Interference (ISI); multipath fading in addition to its high spectral efficiency. OFDM system used in microwave communication due to high data rate. But main drawback of OFDM system is PAPR (Peak to average power ratio) nothing but several sinusoidal leads. It restricts the efficiency of the transmitter. Numbers of techniques have been proposed in the literature for reducing the PAPR in OFDM systems. All techniques has been discussed in this thesis report and from all techniques two techniques name Tone Reservation & Clipping has been discussed and simulated in this thesis for reducing PAPR in OFDM system.

I. INTRODUCTION

In today's high-tech era, Communication is a very important aspect in Human Life. Without communication the world is not technically fulfilled in current generation. So the communication plays a very important role for current technological decades. So the everyday human activities are related to the communication technology. And looking forward to the advanced future speed is necessary to gear up the technology for that high-speed data transmission required. The concentration of this report is basically somewhat around the high-speed data transmission with different kinds of techniques invented by various technocrats.

In the earlier generation, when the communication technology born, the different techniques such as signature communication were used, and as the time passes this technology become more advanced with the techniques such as paging system, short message service, telephony, cordless phones and mobile technology, etc… now the world moves on a high speed communication such as video calling, high-speed internet access. Furthermore, the technology classified in the generation like 1G, 2G, 2.5G and 3G and latest era of 4G. Furthermore, there are various multiple access techniques have been used to support these generation techniques such as FDMA, TDMA, CDMA, etc… here the project is on the way of FDMA advancement techniques. The report basically moves around the OFDM access technique, which is known as ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING. This method is more compatible with the 3G, 4G, and Microwave communication like advanced and future technologies. OFDM also generally used in DVB (Digital Video Broadcasting), DAB (Digital Audio Broadcasting) Using a microwave link. OFDM is very vast technology for transmitting data at very high data rate. OFDM is the technology based on a multipath propagation. However, as per the technology aspect, there is some merits & demerits of every technology. Like that in OFDM System, there is some drawback related to powering aspect. And the main drawback of OFDM system is PAPR (Peak to Average Power Ratio). The nonlinear distortion causes both in-band and out-of-band interference of signal. The in-band interference increases the BER of the received signal through warping of the signal constellation and intermediation, while the out-of-band interference causes adjacent channel interference through spectral spreading [10].

II. BASICS OF DIGITAL COMMUNICATION

Basically, the ways of communication have changed due to Digital Communication. Digital Communication provides different new technologies. Digital communication can be defined as the exchange of data in the form of 0's and 1's between two devices using a transmission medium.

The move to digital modulation provides more information capacities, compatibility with digital data services, higher data security, better quality communications, and quicker system availability. Developers of communications systems face these constraints: available bandwidth, permissible power, inherent noise level of the system. Now let us see the diagram of Analog and Digital Communication.

As shown in figure as per the analog communication system, there are basic three devices is used to establish basic communication Transmitter, Receiver& Channel. Basically, aim of a communication system is to transfer the information from one point to another point. Basically, the message or information generated from one point is not an electrical signal so first it is converted into time varying electrical signal by input transducer.

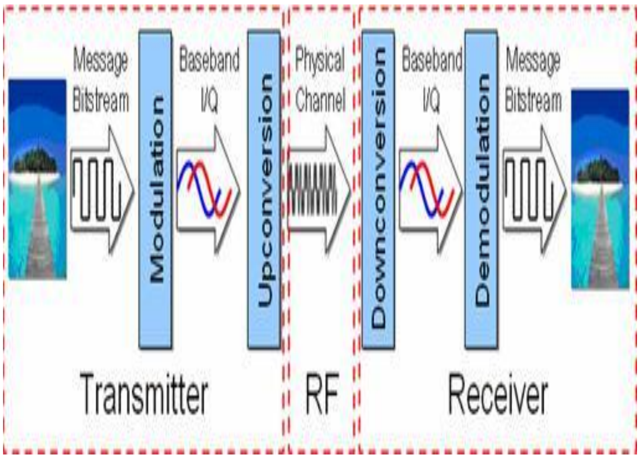

Fig.1. Block Diagram of Analog Communication

Now we will focus on Digital Communication.

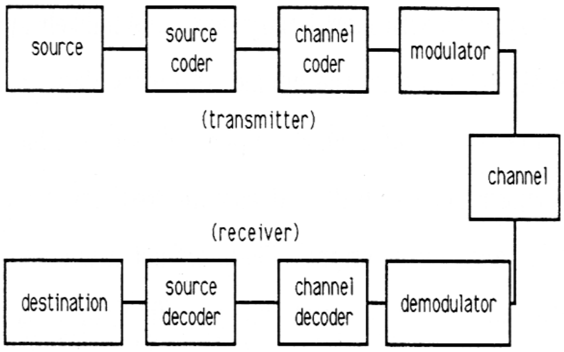

Fig.2. Block Diagram of Digital Communication

Above figure shows the diagram of a basic digital communication system.
The Source encoder (or source coder) converts the input, i.e. symbol sequence into a binary sequence of 0s and 1s by assigning code words to the symbols in the input sequence. For example: If a source set is having hundred symbols, then the number of bits used to represent each symbol will be 7 because 27=128 unique combinations are available. The important parameters of a source encoder are block size, code word lengths, average data rate and the efficiency of the coder. At the receiver, the source decoder converts the binary output of the channel decoder into a symbol sequence. The decoder for a system using fixed – length code word is quite simple, but the decoder for a system using variable – length code words will be very complex. Aim of the source coding is to remove the redundancy in the transmitting information, so that bandwidth required for transmission is minimized. Based on the probability of the symbol code word is assigned. Higher the probability, shorter is the codeword.

III. MULTIPATH CHANNELS

The transmitted signal faces various obstacles and surfaces of reflection, as a result of which the received signals from the same source reach at different times. This gives rise to the formation of „echoes" which affect the other incoming signals. Dielectric constants, permeability, conductivity and thickness are the main factors affecting the system.
Multipath channel propagation is devised in such a manner that there will be a minimized effect of the echoes in the system in an indoor environment. Measures are needed to be taken in order to minimize echo in order to avoid ISI.
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Fig.3. Multipath Channels

IV. OFDM (ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING)

Orthogonal Frequency Division Multiplexing (OFDM) is a popular modulation technique used in many new and emerging broadband technologies either wired like ADSL (asymmetric digital subscriber line) or wireless as in DAB (digital audio broadcasting), DVB-T (digital video broadcasting-terrestrial), WLAN (Wireless LAN), and so forth [1]. The main advantage of OFDM is its robustness to multi-path fading, its great simplification of channel equalization and its low computational complexity implementation based on using Fast Fourier Transform (FFT) techniques [2].Despite many advantages, a major drawback of OFDM is its high Peak-to-Average Power Ratio (PAPR) problem, which makes system performance very sensitive to nonlinear distortions [3 , 4]. Indeed, when the OFDM signal with high PAPR passes through a nonlinear device, the signal may suffer significant nonlinear distortions and severe power penalty which is unaffordable for battery powered portable wireless terminals. To reduce the PAPR of OFDM signals, several PAPR reduction techniques have been proposed [1]. In this paper we focus on PAPR reduction techniques based on nonlinear functions. Two well-known examples are clipping techniques which use a clipping function for PAPR reduction and filtering techniques which use at the transmitter side for PAPR reduction [5, 6]. However, since the OFDM signal consists of a number of independently modulated subcarriers, it produces severer peak-to-average power ratio (PAPR) than single-carrier signals. The large PAPR of the signal causes clipping when the signal is passed through the non-linear amplifier. Such clipping produces clipping noise that will result in performance degradation. In addition, clipping will also cause spectral re-growth in out-of-band which may cause interference to other systems.

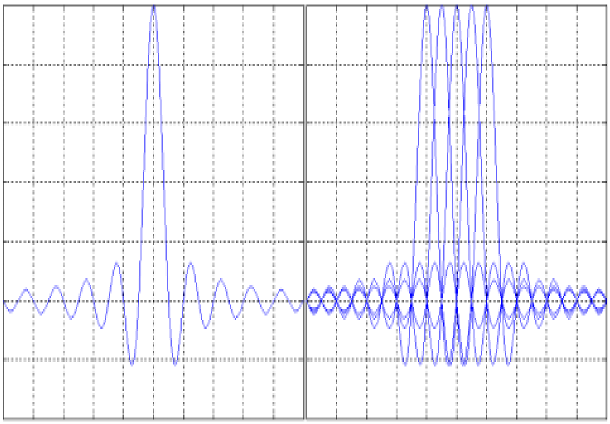

Fig.4. Spectra of (a) an OFDM subchannel and (b) and OFDM signal

The OFDM signal, multiplexed in the individual spectra with a frequency spacing b equal to the transmission speed of each subcarrier, is shown in Figure 1.8(b). Shows that at the center frequency of each subcarrier, there is no crosstalk from other channels. Therefore, if we use DFT at the receiver and calculate correlation values with the center of frequency of each subcarrier, we recover the transmitted data with no crosstalk.

V. MATHEMATICAL DESCRIPTION

The signals are orthogonal over [0, *T]* as illustrated below:

$$\frac{1}{T}\int_0^T \exp(j2\pi\frac{m}{T}t).\exp(-2j\pi\frac{l}{T}t)dt = \delta_{ml}$$

If N sub-carriers are used, and each sub-carrier is modulated using M alternative symbols, the OFDM symbol alphabet consists of M^N combined symbols.

The low-pass equivalent OFDM signal is expressed as:

$$s(t) = \Re\left\{\nu(t)e^{j2\pi f_c t}\right\}$$
$$= \sum_{k=0}^{N-1} |X_k|\cos\left(2\pi[f_c + k/T]t + \arg[X_k]\right)$$

$$\nu(t) = \sum_{k=0}^{N-1} X_k e^{j2\pi kt/T}, \quad 0 \le t < T,$$

Where $\{X_k\}$the data are symbols, N is the number of sub-carriers, and T is the OFDM symbol time. The sub-carrier spacing of $\frac{1}{T}$ makes them orthogonal over each symbol period; this property is expressed as:

$$\frac{1}{T}\int_0^T \left(e^{j2\pi k_1 t/T}\right)^* \left(e^{j2\pi k_2 t/T}\right) dt$$
$$= \frac{1}{T}\int_0^T e^{j2\pi(k_2-k_1)t/T} dt = \delta_{k_1 k_2}$$

where $(\cdot)^*$ denotes the complex conjugate operator and δ is the Kronecker delta.

To avoid intersymbol interference in multipath fading channels, a guard interval of length T_g is inserted prior to the OFDM block. During this interval, a cyclic prefix is transmitted such that the signal in the interval $-T_g \le t < 0$ equals the signal in the interval $(T-T_g) \le t < T$. The OFDM signal with cyclic prefix is thus:

$$\nu(t) = \sum_{k=0}^{N-1} X_k e^{j2\pi kt/T}, \quad -T_g \le t < T$$

The low-pass signal above can be either real or complex-valued. Real-valued low-pass equivalent signals are typically transmitted at baseband—wireline applications such as DSL use this approach. For wireless applications, the low-pass signal is typically complex-valued; in which case, the transmitted signal is up-converted to a carrier frequency f_c. In general, the transmitted signal can be represented as

A. Inter – Symbol Interference

Inter – symbol interference (ISI) is a form of distortion of a signal in which one symbol interferes with subsequent symbols. This is an unwanted phenomenon as the previous symbols have similar effect as noise, thus making the communication less reliable. ISI is usually caused by multipath propagation or the inherent non – linear frequency response of a channel causing successive symbols to blur together. The presence of ISI in the system introduces error in the decision device at the receiver output. Therefore, in the design of the transmitting and receiving filters, the objective is to minimize the effects of ISI and thereby deliver the digital data to its destination with the smallest error rate possible.

B. Inter – Carrier Interference

Presence of Doppler shifts and frequency and phase offsets in an OFDM system causes loss in orthogonality of the sub-carriers. As a result, interference is observed between sub-carriers. This phenomenon is known as inter – carrier interference (ICI).

C. Cyclic Prefix

The Cyclic Prefix or Guard Interval is a periodic extension of the last part of an OFDM symbol that is added to the front of the symbol in the transmitter, and is removed at the receiver before demodulation.

1) The cyclic prefix has to two important benefits

The cyclic prefix acts as a guard interval. It eliminates the inter symbol interference from the previous symbol. Convolution which in turn maybe transformed to the frequency domain using a discrete Fourier transform. This approach allows for simple frequency – domain processing such as channel estimation and equalization.

D. Inverse Discrete Fourier Transform

By working with OFDM in frequency domain the modulated QPSK data symbols are fed onto the orthogonal sub-carriers. But transfer of signal over a channel is only possible in its time-domain. For which we implement IDFT which converts the OFDM signal in from frequency domain to time domain.

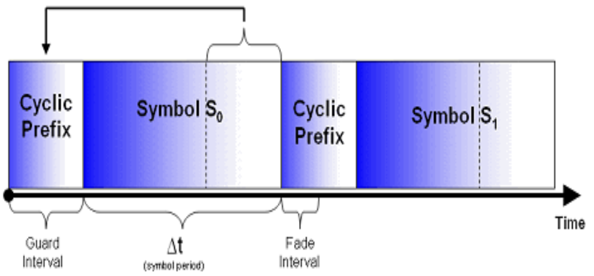

Fig.5. Cyclic Prefix

IDFT being a linear transformation can be easily applied to the system and DFT can be applied at the receiver end to regain the original data in frequency domain at the receiver end. Since the basis of Fourier transform is orthogonal in nature we can implement to get the time domain equivalent of the OFDM signal from its frequency components.

Usually, in practice instead of DFT and IDFT we implement Fast Fourier Transformation for an N-input signal system because of the lower hardware complexity of the system.
It acts as a repetition of the end of the symbol thus allowing the linear convolution of a frequency – selective multipath channel to be modeled as circular

VI. OFDM SYSTEM MODEL

In OFDM system basically for generating successfully relation between all carriers must be controlled to maintain each carrier orthogonally. 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. Different types of modulation scheme are used for OFDM system like QPSK, BPSK, 16QAM, 64QAM etc.

For transmitted the OFDM data over radio channel it must be converted into analog form. For that DAC (Digital to Analog converter) is used to convert base signals of OFDM transmitter into analog form. And after converted into RF frequency using mixer and amplified by Power amplifier then transmitted by antenna. At the receiver, the received signal is down-converted to form a base-band signal first. Then, low-pass filters and de-subcarriers are applied to separate subcarrier waveforms. Orthogonality of sub-carriers will ensure that only the targeted subcarrier waveform will be preserved in each sub-band. Ideally, the final detected symbols will be identical to those transmitted.

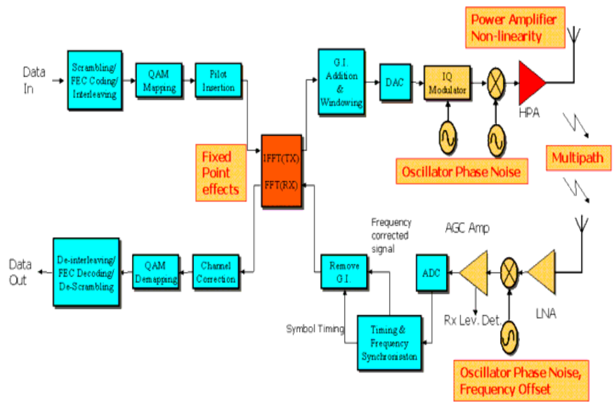

Fig.6. OFDM Transceiver Block Diagram

A. Advantage of OFDM

1. In OFDM system because of increase in symbol rate & also reduction in the delay spread guard band is removed in ISI.
2. It is very feasible to achieve higher data rate by converting signal into orthogonally subcarrier.
3. Basically it is easy to implement IFFT & FFT for conversation of time domain & frequency domain.

B. Disadvantage of OFDM

1. Main and very effective disadvantage of OFDM system is its PAPR (Peak-to-Average power ratio) which is sinusoidal leads generated during transmission.
2. Due to PAPR efficiency of transmitter will decrease.
3. Another is ISI (inter symbol interference) due to absence of guard band.
4. Time & frequency synchronization.

VII. PAPR REDUCTION TECHNIQUES

There have been many new approaches developed during the last few years. Several PAPR reduction techniques have been proposed in the literature. These techniques are divided into two groups. These are signal scrambling techniques and signal distortion techniques. The signal scrambling techniques are:

A. Signal scrambling techniques

Signal scrambling techniques work with side information which minimized the effective throughput since they commence redundancy. Signal distortion techniques introduce band interference and system complexity also. Signal distortion techniques minimize high peak dramatically by distorting signal before amplification.

A. Overall Analysis of Different Techniques

There are several techniques has been proposed in literature. Thus, it is possible to reduce the large PAPR by using the different techniques. Note that the PAPR reduction technique should be chosen with awareness according to various system requirements.

PAPR techniques	
Signal scrambling techniques	**Signal distortion techniques**
Block coding	Signal clipping
	Peak windowing
Sub block coding	Envelope scaling
Selective level mapping	Companding
Partial transmit sequence	
Interleaving	
Linear block coding	
Tone reservation	
Tone injection	

Table.1. Classification of PAPR techniques

Name of Schemes	Name of parameters		
	Distortion Less	Power increases	Data rate loss
Clipping and Filtering	No	No	No
Coding	Yes	No	Yes
Partial Transmit Sequence(PTS)	Yes	No	Yes
Selective Mapping (SLM)	Yes	No	Yes
Interleaving	Yes	No	Yes
Tone Reservation (TR)	Yes	Yes	Yes

Table.2. Overall Analysis of Different Techniques

VIII. SIMULATIONS AND RESULTS

For the experiments, OFDM with following parameters has been considered. Total number of subcarriers N=64. Four times oversampling through zero padding has been used. Data have been mapped using QPSK. The only parameter that influences the PAPR reduction performance is a number of interleaver (ways) used. As the random character of input bit stream is expected, the amount of PAPR reduction does not depend on exact parameters of matrices to interleave. In the receiver, the matrix transposed to the matrix selected in the transmitter is used to de-interleave. The influence of on z the Complementary Cumulative Distribution Function (CCDF) of PAPR is depicted in Fig. Increasing of z results in the PAPR reduction, but the complexity is also increased. The disadvantage of interleaving method is a need for transmission of side information about the interleaver with

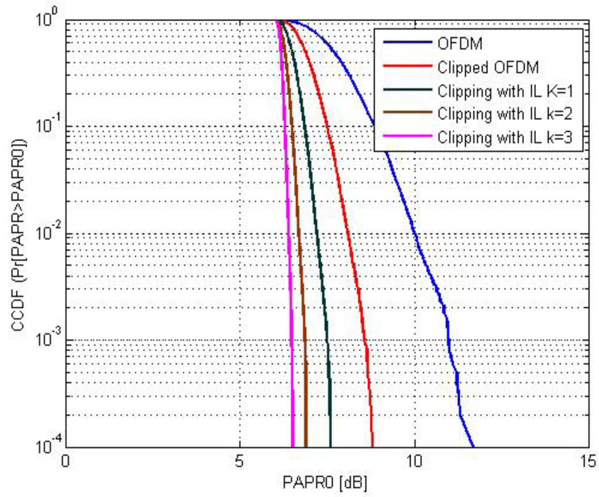

Fig.7. Reduction of PAPR using clipping up to. 5 dB

lowest PAPR through the channel. If the side information is corrupted, all data from corresponding OFDM symbol are lost. For the simulation of combined method, the interleaving with z =16 and the Simplified clipping and filtering with number of equivalent repetitions k=3 have been used. The clipping level has been set to A=3.24dB.

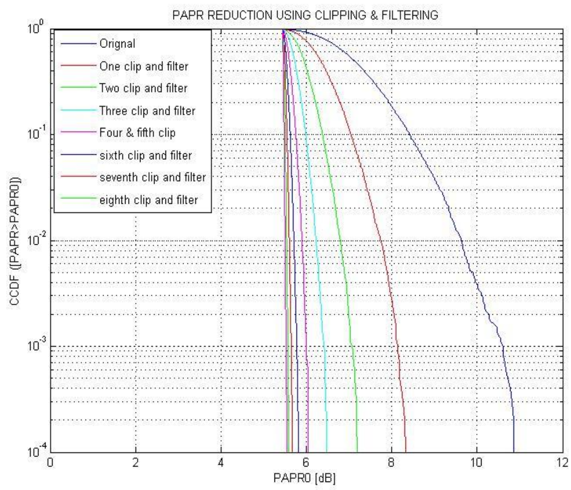

Fig.8. Shows PAPR reduction up 5.69dB

Above figure shows the clipping & Filtering technique simulation which reduce the PAPR. There are total 8 clipping shows Reduction PAPR.
In table the data shows reduction in CCDF of PAPR. Here in this technique previously 4 clips were used. But in fig. 4.2thereare 8clips showing PAPR reduction in OFDM system. The signal generated in QPSK modulation OFDM signal's peaks can be removing at the min level by using this technique. In this technique by the previous effort as per shown in fig. PAPR can be reducing at the 5.69 db.

Here signal will be generated after IFFT. And by adding the noise. By applying two technique Clipping & Filtering. After computing PAPR in OFDM system. The result can be generated as per the figure and tables. Now as per shown the fig.4 the better result can be get by keeping Clipping Ratio 4. Now in this technique OFDM signal is transmitted after perform IFFT as per the figure PAPR can be reduced up to 7.1 db also so that will widely useful for the efficient transmission of the OFDM signal. Here power level of PAPR is must PAPR>PAPR.
This clipping and filtering technique to reduce the PAPR is signal distortion technique. This technique gives better result compare to tone reservation technique.

IX. COMPANDING

The OFDM signal can be assumed Gaussian distributed, and the large OFDM signal occurs infrequently. So the companding technique can be used to improve OFDM transmission performance. U-law companding technique is used to compand the OFDM signal before it is converted into analog waveform. The OFDM signal, after taking IFFT, is companded and quantized. After D/A conversion, the signal is transmitted through the channel. At the receiver end then the received signal is first converted into digital form and expanded. Companding is highly used in speech processing where high peaks occur infrequently. OFDM signal also exhibit similar characteristic where high peaks occur infrequently. Companding technique improves the quantization resolution of small signals at the price of the reduction of the resolution of large signals, since signals occur more frequently than large ones. Due to companding, the quantization error for large signals is significantly large which degrades the BER performance of the system. So the companding technique improves the PAPR in expense of BER performance of the system.

Clipping	**Power in dB**	**Difference in Db**
Original	11.26	
1	8.56	2.7
2	7.283	1.277
3	6.504	0.779
4	6.059	0.445
5	6.00	0.059
6	5.806	0.194
7	5.657	0.149
8	5.569	0.088

Table.3. Data of Reduction in CCDF for 128

X. CONCLUSION

As now as per the overall thesis it is clear that for the use of OFDM (Orthogonal Frequency Division Multiplexing) for the high data rate transmission we have to consider its disadvantage and try to reduce it. So here our concentration is on PAPR (Peak to Average Power Ratio). So to reduce it many techniques have been proposed and in this thesis in chapter 4 Different Five techniques named tone reservation, clipping, Partial Transmit Sequence, Selected Level Mapping and Companding. So, after simulation of these techniques the better result can be achieved to reduce the PAPR problem in OFDM system so this simulation can be helpful for the efficient transmission of the OFDM system. We also conclude that by simulate each technique in different modulation like BPSK & QPSK. And changing different Parameters good result is achieved.

In future by improving these technique to Reduce PAPR in OFDM system and improving also in OFDM system better technology can be provide to the Society.

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