PAPR Reduction in OFDM System using Tone Reservation Technique

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Abstract---Orthogonal frequency-division multiplexing (OFDM) has been considered for many high-speed wireless applications. Indeed, the orthogonal properties among subcarriers of OFDM lead to high spectral efficiency and excellent ability to cope with multipath fading environment. However OFDM systems have two major drawbacks: high peak-to-average ratio (PAPR) due to summing up of large number of subcarriers data together and inter-carrier interference (ICI) because the orthogonal properties are easily broken down byfrequency offset errors caused by oscillator inaccuracies. In this thesis, a coding technique is proposed to reduce both drawbacks. The scheme has tightly bounded PAPR and good error correction capability while reducing ICI significantly. The proposed technique is based on Tone Reservation.

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 4GOFDM 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 intermodulation, 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.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.

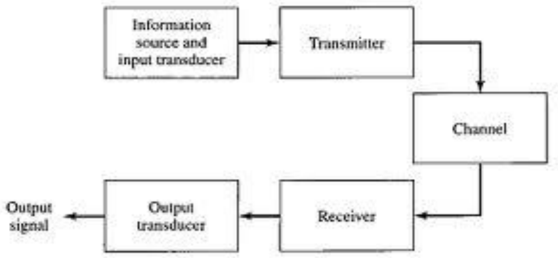

Fig: 1: Block Diagram of Analog Communication

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

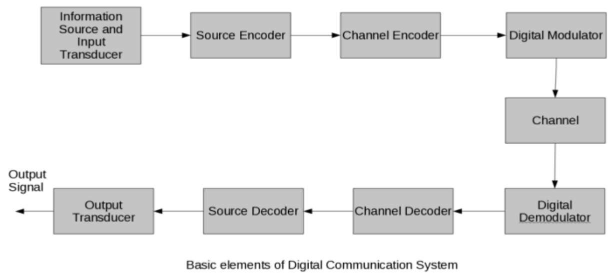

Fig. 1(b): basic elements of digital communication system

Above figure-1(b) 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 fig.: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.CHANNEL ENCODER / DECODER:- Error control is accomplished by the channel coding operation that consists of systematically adding extra bits to the output of the source coder. These extra bits do not convey any information but helps the receiver to detect and / or correct some of the errors in the information bearing bits.

A. Block Coding:

The encoder takes a block of k information bits from the source encoder and adds r error control bits, where r is dependent on k and error control capabilities desired.

B. Convolution Coding:

The information bearing message stream is encoded in a continuous fashion by continuously interleaving information bits and error control bits. The Channel decoder recovers the information bearing bits from the coded binary stream. Error detection and possible correction is also performed by the channel decoder. The important parameters of coder / decoder are: Method of coding, efficiency, error control capabilities and complexity of the circuit.

C. Modulator:

The Modulator converts the input bit stream into an electrical waveform suitable for transmission over the communication channel. Modulator can be effectively used to minimize the effects of channel noise, to match the frequency spectrum of transmitted signal with channel characteristics, to provide the capability to multiplex many signals.

D. Demodulator:

The extraction of the message from the information bearing waveform produced by the modulation is accomplished by the demodulator. The output of the demodulator is the bit stream. The important parameter is the method of demodulation.

E. Channel:

The Channel provides the electrical connection between the source and destination. The different channels are: Pair of wires, Coaxial cable, Optical fiber, Radio channel, Satellite channel or combination of any of these. The communication channels have only finite Bandwidth, non-ideal frequency response, the signal often suffers amplitude and phase distortion as it travels over the channel. Furthermore, the signal power decreases due to the attenuation of the channel. The signal is corrupted by unwanted, unpredictable electrical signals referred to as noise. The important parameters of the channel are signal to Noise power Ratio (SNR), usable bandwidth, amplitude and phase response and the statistical properties of noise. In Digital communication Different Modulating Scheme can be used ASK.PSK, FSK, BPSK, QPSK and different Multiplexing Scheme like FDMA, TDMA, SDMA, and OFDM.Basically, OFDM (Orthogonal Frequency Division Multiplexing) is widely used for the higher data rate Communication. In OFDM system multipath, Communication is occurred.

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.

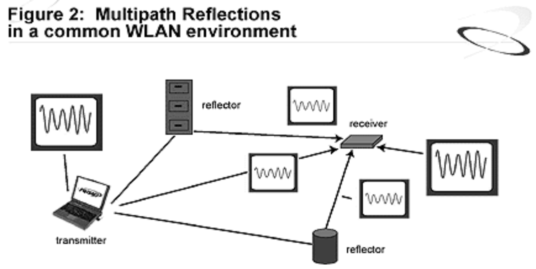

Fig. 2: Multipath Channels

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 . 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.

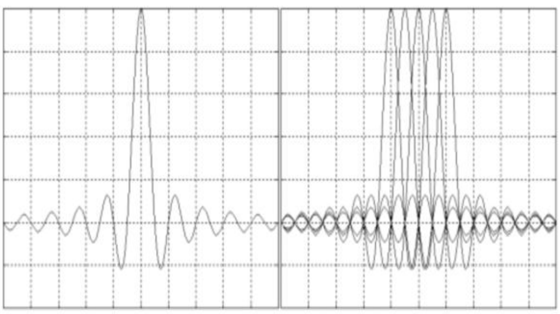

Fig. 3: Spectra of (a) an OFDM subchannel and (b) and OFDM signal

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 3.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 illustratedbelow - :

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

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:

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

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—wire line 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 frequencyf_c. In general, the transmitted signal can be represented as

$$s(t) = \Re\left\{\nu(t)e^{j2\pi f_c t}\right\}$$

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

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 orthogonally of the sub – carriers. As a result, interference is observed between subs – 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.

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.

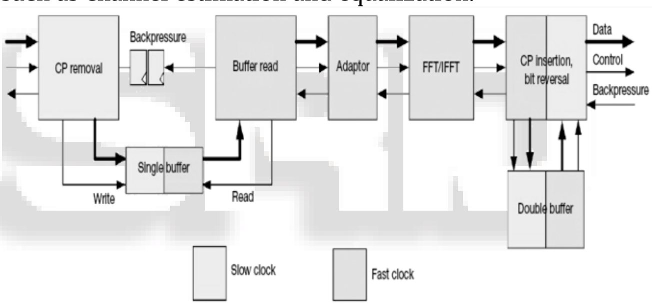

Fig. 4: Cyclic Prefix

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. 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. DISADVANTAGE OF OFDM

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

- Block Coding Techniques
- Sub Block Coding Techniques
- Selected Mapping (SLM)
- Partial Transmit Sequence (PTS)
- Linear Block code
- Interleaving
- Tone Reservation (TR)
- Tone Injection (TI)

B. Signal Distortion Techniques:

- Clipping and Filtering
- Peak Windowing
- Envelope Scaling
- Companding

VIII. TONE RESERVATION

The Tone Reservation (TR) technique is a popular PAPR reduction technique that uses aset of reserved tones to design a peak-canceling signal. The Tone Reservation (TR)scheme is developed for digital subscriber line (DSL) system to reduce the PAPR. In theDSL system, subcarrier is also called as a tone. The TR scheme reserves some tones for generating a PAPR reduction signal instead of data transmission. Previously in an active-set approach has been developed to efficiently compute the peak-canceling signal. Since the inverse Fourier transform is a linear operation, the OFDM signal corresponds to the summation of the data signal and the PAPR reduction signal. tone-reservation technique exploits a small number of unused subcarriers (reserved tones)to generate a peak-canceling signal [38]. This peak-canceling signal does not distort data-bearing subcarriers. This technique not only eliminates the need for side information, but also prevents the BER degradation, as occurs with other techniques. Tone-reservationrequires the efficient generation of the peak-canceling signal. One method is iterativeclipping and filtering under tone-reservation constraints [39]. In every iteration, the time-domain OFDM signal is clipped to a predefined threshold and filtered to eliminate theclipping noise on the data tones and outside the OFDM band. In this case, the peak-canceling signal is simply the filtered clipping noise. While time-domain filtering via aband-pass filter [16] or frequency-domain filtering by exploiting Fast Fourier Transform(FFT)/Inverse Fast Fourier Transform (IFFT) is feasible, the latter has significantly lowercomplexity than the former [39]. A drawback of iterative clipping and filtering is thepeak re-growth. Depending on the number and positions of reserved tones, peak re-growth may be large and the convergence rate may be slow after several iterations.

IX. SIMULATIONS AND RESULTS

A. Tone Reservation

Here by using MATLAB software by the coding below simulation are performed.

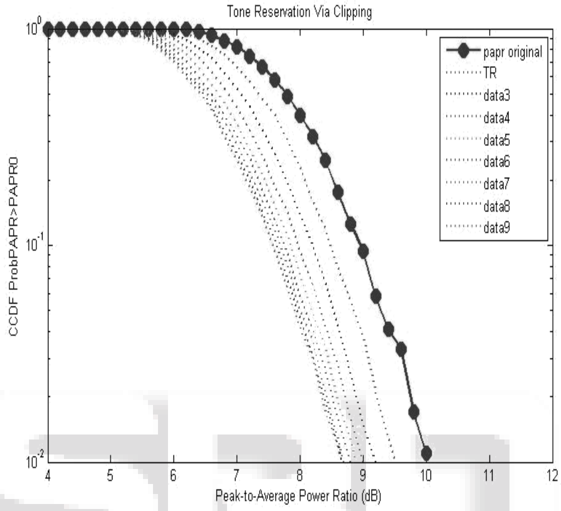

Fig. 5: Result-1

As per the technique above Result-1 shows the previous simulation by keeping CR= 1, that why reduction in the PAPR can be done up to 1.5dB only but the times always wants some changes so by this technique due to some changes better result can be display. In table 8 the data shows reduction in CCDF of PAPR.now as per the graph this simulation contain 9 data which is different from another. And here this will be helpful.

TR	Power in dB	Difference in dB
PAPR Original	10	
TR	9.5	1.5
Data3	9.3	0.2
Data4	9.2	0.1
Data5	9.0	0.2
Data6	8.9	0.1
Data7	8.8	0.1
Data8	8.6	0.2
Data9	8.5	0.1

Table. 1: Data of reduction in PAPR

X. CONCLUSION FUTURE WORK

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 here.tone reservation technique is used.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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