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OVERVIEW OF PAPR REDUCTION TECHNIQUES IN OFDM

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Abstract: Communication is one of the most important features of life. With increasing demand, the growth in the field of communication is also increasing. Initially, the signal was sent to the analog domain but now, the signal is being sent to the digital domain more. Single carrier for improved transmissions is being switched by variable multicarrier. Multicarrier framework like CDMA and OFDM are at present being normally executed. In the OFDM framework, orthogonally put sub-carriers are being utilized to convey the data from the transmitter side to the recipient side. There are numerous issues in OFDM frameworks, the issue of ISI and commotion can be removed utilizing guard band , But the huge Peak to normal power proportion of these signal have some undesired impact on the framework. The fundamental focus on learning the fundamentals of the OFDM system and the system has various methods for reducing PAPR so that the system can be used more efficiently.
Keywords: OFDM, PAPR, Reduction techniques, ISI, CDMA, ofdm framework, guard band.

I. INTRODUCTION

In wireless communication, OFDM is a key standard, because it is employed in 4G wireless system. Ofdm is a key broadband technology. Broadband means a large bandwidth. So it is operates on huge bandwidth. In GSM, the bandwidth is 200KHz and Ofdm having 20MHz bandwidth, so this operates on large bandwidth, naturally the data rate is to be higher, so this high data rate is to be used in 4G wireless technology, that means it enable the very high data rate 100 Mbps. In cellular standards or several Wi-Fi or WLAN (Wireless Local Area Network). WLAN IEEE standards are 802.11a, 802.11g, 802.11n, 803.11ac, these standards based on OFDM[1].

The basic principle of OFDM, in typical communication system, which has a certain bandwidth known as B & single carrier placed at the centre of bandwidth of carrier frequency.

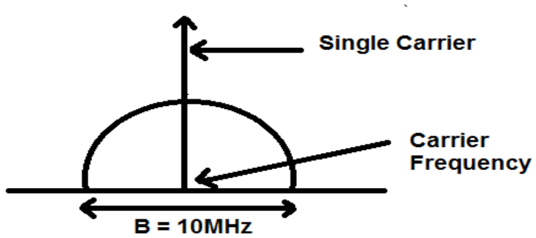

Fig 1

Example, Bandwidth of the system is 10MHz that is B = 10MHz. Symbol time is T, its formula is-

$$T = \frac{1}{B} = \frac{1}{10MHz} = 0.1\ \mu Sec$$

Therefore, we can say that the symbol time T = 0.1 μSec

Delay spread (T_d) of wireless channel is approximately 2 to 3μSec.

Therefore, T_d = 2-3 μSec

So, Symbol time T = 0.1 μSec

$T_d \simeq 2$ μSec

$$T << T_d$$

That is, Symbol time << Delay Spread.

Which means, when the delay spread T_d is large than the symbol time T, this leads to Inter Symbol Interference (ISI),that is it leads to degradation or loss of performance of wireless system. As bandwidth B is increases, our symbol time $\frac{1}{B}$ is decreases, this is the significant challenge in a broadband wireless communication system.

To avoid ISI, by using entire range of bandwidth, we split it into sub-bands. To understand this concept we will see example, as we have available broadband frequency B = 10MHz & it will be splitting into each smaller bands which are term as sub-bands. One in each sub-band term as sub-carrier. That is,

Sub-bands = N

Bandwidth of each sub-band = $\frac{B}{N}$

Bandwidth of per sub-band of each sub-band is

$\frac{B}{N} = \frac{10MHz}{1000}$ = 10 x 10^3 Hz = 10 KHz

So, the bandwidth of sub-band is 10 KHz.

Symbol time in each sub-band is,

$$T = \frac{1}{\frac{B}{N}} = \frac{N}{B} = \frac{1000}{10MHz} = 0.1 \text{ mSec} = 100\mu\text{Sec.}$$

So , from above calculations we can say that,

New symbol time 100μSec.

By comparing new symbol time with delay spread,

T_d = 2 μSec

That is, T >> T_d

100 μSec >> 2 μSec.

New symbol time >> Delay Spread.

Therefore, there is so ISI in new system with multiple sub-band & sub-carriers in each band. Such a system with multiple sub-band & sub-carriers, term as Multi-carrier Modulated (MCM) system and OFDM is a multi-carrier Modulated system[2].

II. COPLEXITIES IN WIRELESS CHANNELS

A. Multipath Fading

Wireless channel uses a fixed path, signals in wireless channel can be reached by using multiple paths. All these signals are known as Multipath Components. Multipath components may have different channel gain and time

delaying. This combine is called Multipath fading.
That is,

$$h(t) = \sum_{\eta=1}^{N} a_n \, \delta(t - \tau_n)$$

B. Delay Spread

As outcome of multipath propagation the duration of symbol get delayed or extended, this may interfere with next symbol; this is called as, Interfere Intersymbol or cross-talk.

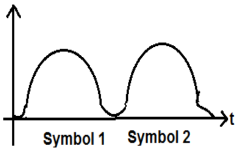

Fig 2

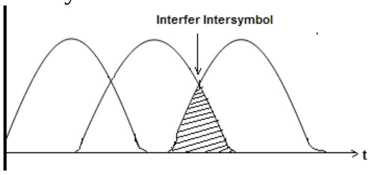

Fig3

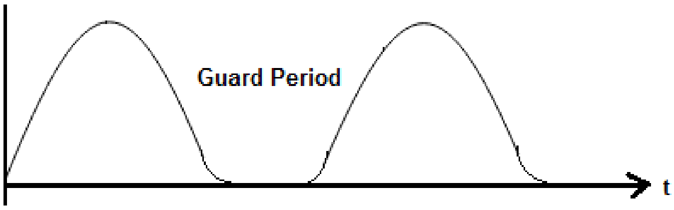

Fig 4. Guard period

Guard period is to be introduced to reduced intersymbol interference

C. Frequency Selective Fading

Signals having bandwidth higher than the coherence bandwidth of the channel faces different attenuations at the different frequencies. This ultimately distorts the signal in time domain and gives right to frequency selective fading, complex channel equalization techniques to reduce it.

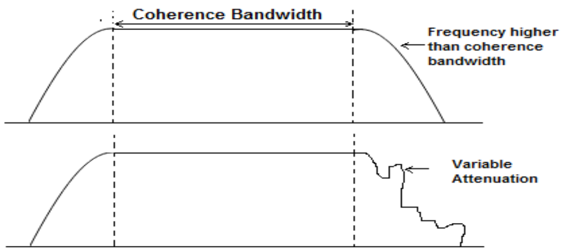

Fig. 5

D. Inter Channel Interference (ISI)

In single bandwidth the carrier frequencies overlap to each other, giving the rights to inter channel interference. Guard bands are introduced to reduced or avoid the inter channel interference.

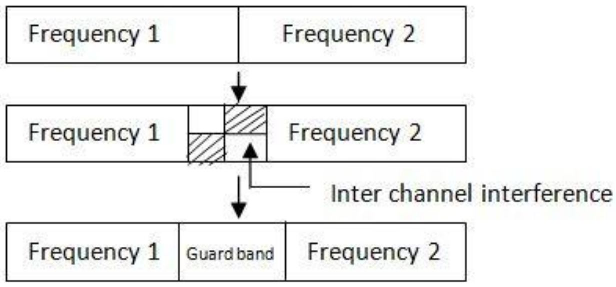

Fig 6: Inter Symbol Interference

III. PEAK TO AVARAGE POWER RATIO (PAPR)

First of all we will see the PAPR in conventional Single Carrier (SC) system. This is a critical factor in OFDM system. Consider the non – OFDM or single carrier system, with BPSK modulated symbols.

Considering,

Transmitting signals, $X(0), X(1), X(2)$ & so on,

Amplitude level of each signal, + a, - a, + a & so on

The power in each symbol is a^2, which is also the peak power.

Average power = $E\{|x(k)|^2\} = a^2$.

Hence, the ration of Peak to Average Power Ratio (PAPR) is one which is 0 dB. In practice it is not exactly one, it is closed to one that is there is no significant deviation from the mean power level. We will see the PAPR in OFDM system, in this system we are not transmitting the symbol, but we are loading the symbols in sub-carriers & then we are taking the IFFT of these symbols before transmitting the symbols.

In OFDM, when the peak deviation about average is significantly high, the signal level moves outside the dynamic linear range. Hence, high PAPR in OFDM system results in amplifier saturation thus leading to inter-carrier interference. SC-FDMA (Single Carrier-Frequency Division Multiple Access) is used to tackle the problem of PAPR in OFDM system. Firstly we will see the typical OFDM transmitter system.

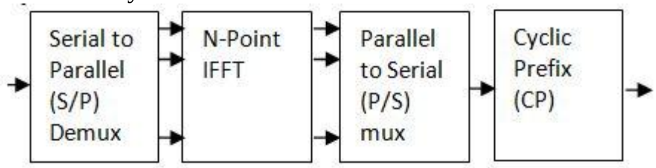

Fig 7: Typical OFDM transmitter

In OFDM transmitter, has a serial to parallel demux & followed by N-point IFFT & then parallel to serial mux operation is to be performed then we have addition of cyclic prefix (CP)[2][3]. In this typical OFDM transmitter, N-point IFFT, this is essentially causing the high PAPR in OFDM system. To solve this problem, we will modify the typical OFDM transmitter as Follows-

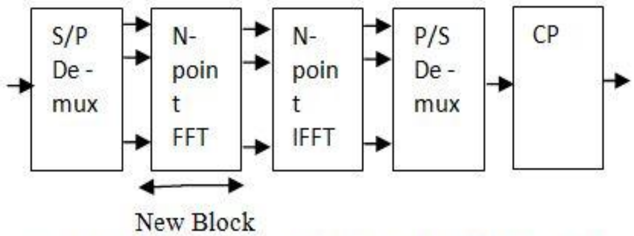

Fig: 8: Modified Diagram of typical OFDM transmitter

We will add N-point FFT in typical OFDM transmitter, N-point FET & N-point IFFT cancelled out each other, that is whatever the serial symbol as a input we get same symbols at the output, except that addition of the Cyclic Prefix. Hence, PAPR can be reduced by introducing N-point FFT block, which converts the system into a single carrier system. However, instead of using an N-point FFT block, one can employ an M < N point FFT to reduce PAPR, while still

remaining properties of the OFDM system.
Next we will see the proposed SC-FDMA schematics

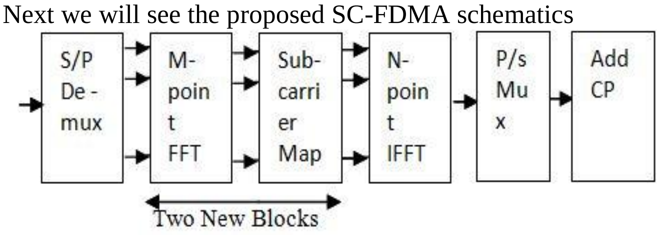

Fig.9: Proposed SC-FDMA Schematics

In this system, the symbols M in the FFT < N, the number of sub-carriers. Hence, the introduction of the M-point FFT in Sc-FDMA significantly reduces the PAPR of the system; this is the basis of SC-FDMA.

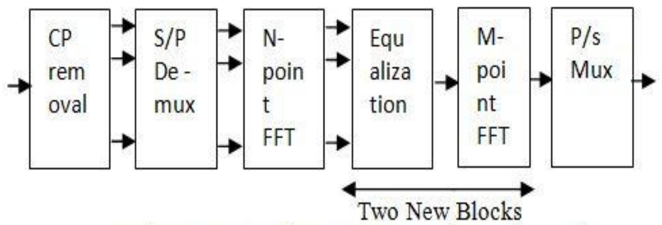

Fig.10: Proposed SC-FDMA Receiver Schematics

SC-FDMA schematic incorporates two new blocks compared to the OFDM receiver. Here, after the N-point FFT, the symbols are equalizes across all sub-carriers. The above operations they are sub-carrier demapped. Finally, the M-point IFFT is performed & the serial symbol stream is generated.

IV. LITERATURE REVIEW

Joint ICI Cancellation and PAPR Reduction in OFDM systems without side information [6].
In this paper, analysts have proposed the numerical examination of PAPR execution for ICI self-cancelation, new ICI self cancelation and ICI conjugate cancelation schemes. It requests the necessity of PAPR reduction on the grounds that PAPR execution of these schemes is either closer to or poorer than the OFDM signal. Here in this paper, scientists has presented a partial transmit scheme (PTS), which advance the PAPR execution the PAPR execution of ICI cancelation scheme.

An SDP approach for PAPR reduction in OFDM using partial transmits sequence [7].
Partial transmissions sequence algorithm is widely used in order to reduce the yield to the average energy efficiency of the OFDM system. In the required stage of PTS, the phase factor is a limited set of "BV" for starting information or information in order to reduce the impact of PAPR before transmitting it. The researcher in this paper reveals the ideal set of phase rotation elements reproduced in PTS technique.

Reduction of PAPR in OFDM system by intelligently applying both PTS and SLM algorithm [8]
PAPR is the main problem in the OFDM system. The current mapping and partial transmittance order (PTS) current plans are effective but once again the difficulty is difficult to make the machine difficult. The typical algorithms in this Exploration Zone have multiple clipping algorithms SLM algorithms, PTS algorithms, and Objective supplement order algorithms. In this paper, the researcher found that the SLM and PTS algorithms perform better implementation of PAPR than the optional supplemental algorithm than both the computing algorithm. With the help of these lines, PAPR reduction algorithms are used by two PTS and SLM algorithms, which try to reduce the PAPR issue.

Partial Transmit Sequence for PAPR reduction of OFDM signals with Stochastic Optimization technique [9].
In the technique of orthogonal frequency, there is a high PAPR problem. Traditional PTS techniques are very effective for reducing PAPR in OFDM, but they are more efficient in multi-dimensional form. To reduce many other properties to improve PAPR information, analysts have demonstrated stenographic improvements techniques to reduce the PAPR of the OFDM system.

Peak to average power ratio reduction using adaptive digital filter [10].
OFDM is an optimistic technique against multipath fading channels for wireless communication. In this paper, researchers set up a method for converting OFDM signals to PAPR effects. Adaptive digital filters are used here to reduce the effects of PAPR.

Comparative study of PAPR reduction technique in OFDM [11].
OFDM has suffered from PAPR problems and that's a major issue for multicarrier transmission systems. The OFPM infected symbol given by the PAPR has the maximum strength ratio of the sample for the average power of that OFDM symbol. PAPR is no different from other treatments. This paper presents various PAPR reduction technologies and compares tough techniques.

V. PAPR REDUCTION TECHNIQUES

High PAPR is a summary of Sinc waves and non-constant envelop. The harmful effect of high PAPR is that the quantization of the ADC and DAC decreases the noise ratio signal, while the power amplifier's performance decreases. Therefore, there must be an RF power amplifier
Working in a very large line area, the signal peaks will enter non-linear areas and will create deformation. So there are PAPR reduction techniques, such as SLM, PTS, Tone Reservation, Clipping and filtering etc. Different parameters such as distortion Rate, data rate, power raise etc. are analyzed with the study of different PAPR reduction techniques[4]. PAPR of a signal is represented by above equation-

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

Where, $E(.)$ is the expectation operator.

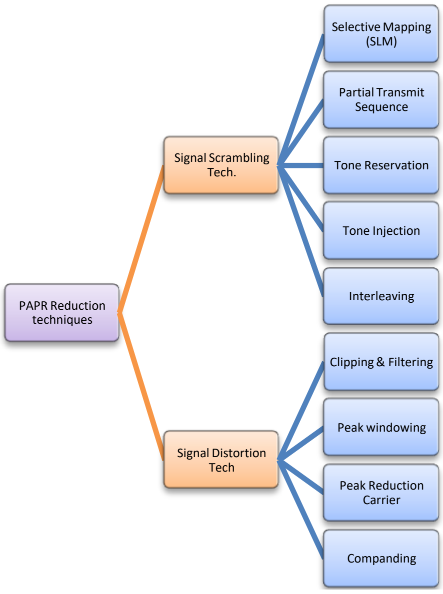

Fig 11. Types of PAPR reduction techniques

VI. ANALYSIS OF VARIOUS PAPAR REDUCTION TECHNIQUES

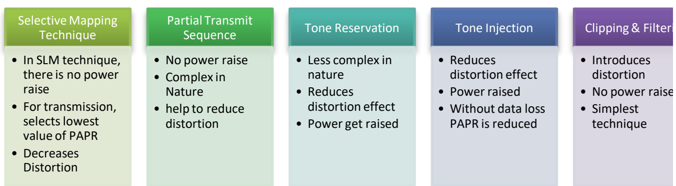

Fig 12. Analysis of PAPR reduction techniques

VII. CONCLUSION

OFDM has recently discovered wide supposition in a wide assortment of high information Communication system. OFDM is an exceptionally propel technique for multicarrier transmission and has turned out to be one of the critical standard picks for fast transmission over a correspondence channel. There are numerous issues in OFDM one of them is PAPR i.e Peak to average power ratio. PAPR essentially occurs when in the multicarrier system the diverse sub-bearer are out of phase from each other. In this paper it is expected to investigation a portion of the techniques which are utilized to diminish the high PAPR of the system. A few techniques are clipping and flittering, selective mapping, partial transmit sequence. Clipping and filtering brings about information however SLM and PTS don't affect the information. In any case, there is no particular PAPR decrease technique.

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