PAPR reduction techniques in OFDM: a review

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ABSTRACT

Orthogonal Frequency Division Multiplexing (OFDM) is a multicarrier transmission method. it was introduced by Robert W. Chang of Bell Labs in1966. It was initially used in military system it is very popular these days because is being used on every wireless broadband communication system. OFDM is not only the baseline for 4G and 5G, it is also a standard for digital audio broadcasting or digital video broad casting The fundamental benefit of OFDM, cross talk between the sub channels is wiped out and e carrier bands are not needed. There are many disadvantages the significant disadvantage emerges in the OFDM is known as a PAPR (Peak to average force proportion). There are many PAPR reduction techniques for OFDM systems, as clipping, coding, non-linear companding, ton reservation and ton injection, selective mapping (SLM) and partial transmit sequence (PTS)

Keyword : - OFDM ,*PAPR, PTS method, , precoding*

1. OFDM

Orthogonal Frequency Division Multiplexing (OFDM) is an efficient modulation format used in modern wireless communication systems including 5G. OFDM combines the benefits of Quadrature Amplitude Modulation (QAM) and Frequency Division Multiplexing (FDM) to produce a high-data-rate communication system. QAM refers to a variety of specific modulation types: BPSK (Binary Phase Shift Keying), QPSK (Quadrature Phase Shift Keying), 16QAM (16-state QAM), 64QAM (64-state QAM), etc.

FDM is simply the idea that multiple communication channels can coexist by designating a slice of frequency spectrum for each channel. A common example of this is FM broadcast radio: the overall (US) frequency allocation is 87.8 MHz to 108 MHz, divided into channels that are 0.2 MHz wide (Figure 1). FDM frequency allocations must not overlap and often have guard bands between the channels to minimize adjacent channel interference.

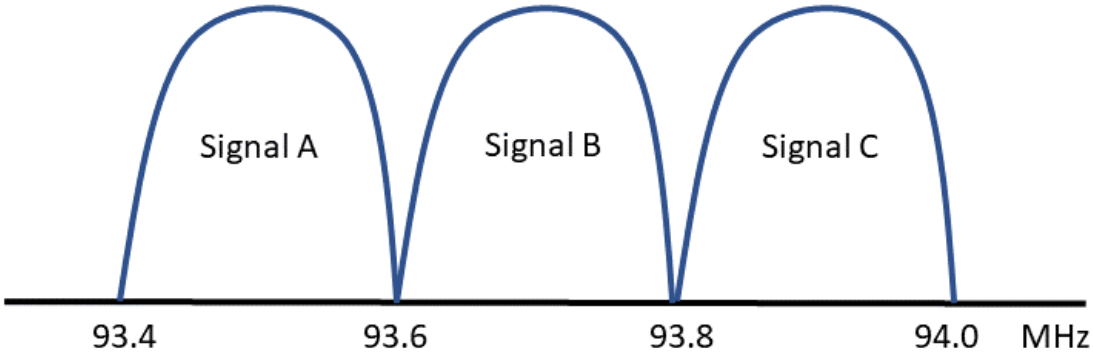

Figure 1. Frequency Division Multiplexing transmits signals on adjacent carrier frequencies.

1.1 Principle of Orthogonality

In multi-carrier system, bandwidth occupied can be minimized if we are able to decrease the frequency space used between the carriers to avoid overlapping. So by using the principle of orthogonally we can decrease the space

between carriers. From the definition of orthogonal signal, two signals are said to be orthogonal if the time average integral product of two signals is zero.
Mathematically, the orthogonality of two signals can be expressed as-

$$\frac{1}{T}\int_{t_1}^{t_1+T} f_k(t) \times f_l(t)\, dt = 0 \quad if\ k \neq l$$

here, $f_k(t)$ and $f_l(t)$ are two signals between time span [t ,t1+T], T is signal time period.

1.2 Advantages of OFDM system

- Saving of Bandwidth
- Simpler modulation and demodulation
- Easy Equalization-
- Susceptible to frequency selective fading
- Eliminates Inter symbol interference

1.3 Disadvantages of OFDM system

- High Peak to Average Power Ratio (PAPR) of transmitted signal
- Synchronization (timing and frequency) at the receiver

1.4 Applications

- Asymmetric Digital Subscriber Line (ADSL) broadband access through plain old telephone service (POTS) copper wiring
- Multimedia over Coax Alliance (MOCA) home networking
- IEEE 802.11 a/g/n
- IEEE 802.15.3a
- IEEE 802.16 d
- IEEE 802.20
- Digital Audio Broadcast (DAB) systems
- Digital Video Broadcast (DVB) terrestrial TV systems
- HIPERLAN/2

2. PAPR in OFDM

The PAPR is the relation between the maximum power of a sample in a given OFDM transmit symbol divided by the average power of that OFDM symbol. In simple terms, PAPR is the ratio of peak power to the average power of a signal. It is expressed in the units of dB. PAPR occurs when in a multicarrier system the different sub-carriers are out of phase with each other. At each instant they are different with respect to each other at different phase values. When all the points achieve the maximum value simultaneously; this will cause the output envelope to suddenly shoot up which causes a 'peak' in the output envelope. Due to presence of large number of independently modulated subcarriers in an OFDM system, the peak value of the system can be very high as compared to the average of the whole system. This ratio of the peak to average power value is termed as Peak-to-Average Power Ratio. In LTE system, OFDM signal PAPR is approx. 12dB.

2.1 How large PAPR effects the power amplifier

Let's start with an example, suppose desired average output power from power amplifier(PA) is 40dBm (10W), and PAPR of that system is 12dB. Then in that case PA device is choosen such that saturation point of that PA shall be 40dBm + 12dB = 52dBm (158W). It means that after selecting PA device of saturation power 52dBm, we operate that PA at 40dBm output power (keeping 12dB headroom from peak power) and operating at such a large back off, degrades the efficiency of that PA. And as we all know that PA is the most power consuming unit of the base

station. So remedies are taken to reduce the PAPR of the OFDM signal so that smaller power PA device could be used in the system.

3. PAPR reduction techniques

PAPR reduction techniques can be primarily partitioned into two domain: frequency domain and time domain. The main idea frequency domain method is to enhance the cross correlation of the input signal before IDFT and lessening the output of the IDFT peak value or average value.. Many schemes such as Selective Mapping (SLM), Partial Transmit Sequence (PTS), Precoding etc are based on frequency domain platform. Whereas ,in time domain method PAPR is decreased by distorting the signal before amplification and added of extra signals which increase the average power. Some techniques such as Clipping and filtering, Peak widowing etc. are based on time domain method. Time domain method is exceptionally basic technique since it requires extremely less computational time but distortion is introduced also it increases out of band radiation and decreases BER. On looking at between these two domain, frequency domain PAPR decrease strategy is the most proficient one due to its capacity to decrease the PAPR without misshaping the sent signal, no creation of in band distortion and out of band radiation in OFDM signals.
Comprehensively PAPR reduction methods are arranged into four segments

3.1 Signal scrambling (Probabilistic) technique

In this technique every OFDM symbol is scrambled Signal is scrambled using different scrambling technique. Then we choose the pattern that is giving minimum value of PAPR. methods like Selective Mapping (SLM) and Partial Transmit Sequence (PTS) are based on this technique.

3.2 Signal distortion technique

This method based on distortion of signal. Here PAPR is reduced by distorting the OFDM signal non-linearly. The methods like clipping and filtering, peak windowing, and non-linear companding are the based on this technique. These methods are post generation of OFDM signal (after the IFFT).

3.3 Coding technique

The coding method utilized some error correcting codes for the PAPR reduction. These techniques are applied before the generation of OFDM signal (before IFFT). At the point when N signals are added with a similar stage, they produce a peak power, which is N times the average power.
The essential thought of all coding plans to decrease the PAPR is to lessen the occurrence probability of the same phase of many signals. The coding strategies select such code words that limit or diminish the PAPR.
It causes no contortion and makes no out of band radiation, yet it effect bandwidth efficiency as the code rate is decreased. It likewise experienced the complexity to track down the best codes and to store huge look up tables for encoding and decoding, particularly for an enormous number of subcarriers. The error correcting codes like block codes, cyclic codes, Golay complementary sequence, Reed-Solomon (RS) code, Reed-Muller (RM) code, Hadamard code and Low Density Parity Check (LDPC) code can be utilized.

3.4 Pre-distortion technique

The pre-distortion method depends on the reorientation or spreading the energy of data symbol prior to taking IFFT. The pre-distortion plan incorporates DFT spreading, pulse shaping or pre-coding and constellation shaping .factors for selecting the PAPR reduction technique

4. CONCLUSION

A few variables ought to be considered for choosing the strategy that can lessen the PAPR successfully as well as can maintain high quality performance. These after factors are to be considered as :

- Without presenting in-band distortion and out-of-band radiation, PAPR decrease strategies ought to be empowered to lessen the PAPR.

- Low average power: The raise in power uses high linear operating region in HPA and subsequently decrease the BER execution.
- No BER performance degradation: The rationale of PAPR decrease is to improve system execution and BER than that of the first OFDM system.
- Addition power: Power efficiency is to be considered when we are thinking to reduce the PAPR.BER performance is decreased if additional power is used by a technique for PAPR reduction.
- No spectral spillage: The PAPR reduction technique must not change the inherent feature (orthogonality) of OFDM signal.

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