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# Peak to Average Power Ratio Reduction Techniques for 5G System – A Review

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**ABSTRACT:** Orthogonal Frequency Division Multiplexing (OFDM) in 5G system has a main drawback of high Peak-to-Average Power Ratio (PAPR). Diverse techniques of PAPR diminishment and criteria for selection of PAPR diminishment methods are discussed in this paper.

**KEYWORDS:** CCDF, HPA, OFDM, PAPR, SLM.

### I. INTRODUCTION

Currently, fourth generation wireless communication systems have been employed in most of the countries in the world. However, there are still some challenges like an explosion of wireless mobile devices and services, which cannot be accommodated even by 4G, such as the spectrum scarcity and high energy consumption [1]. Wireless system designers are continuously facing the increasing demand for mobility required and high data rates by new applications and that's why they have started research on fifth generation wireless systems that are expected to be employed beyond 2020. 5G technology stands for fifth generation mobile technology which is the standard beyond 4G and LTE-advanced. Filter bank multi carrier is a technique in which a bank of filters are used in transmitter and receiver side. Transmitter filter is called synthesis filter bank and receiver filter is called analysis filter bank. Interestingly, FBMC is the multicarrier technique, which was developed prior to OFDM. Chang is the first person who came with the idea of FBMC in the 1960s and also presented the conditions required for signaling a parallel set of pulse amplitude modulated(PAM)symbols going through a bank of overlapping vestigial side-band (VSB) modulated filters. A year later,[3] Saltzberg extended the idea of chang and showed how the method could be modified for transmission of quadrature amplitude modulated (QAM) symbols. Saltzberg showed that we can achieve the maximum spectral efficiency in FBMC system if a half-symbol space delay between the in-phase and the quadrature phase components of QAM symbols is maintained. In 1980s, Hirosaki works on FBMC and proposed an efficient polyphase implementation for the Saltzberg method. The method which is proposed by Saltzberg is called OFDM based on offset QAM or OFDM-OQAM. The offset comes from the fact that there is half symbol delay between the in-phase and quadrature component of each QAM symbol with respect to each other [4]. This method is called staggered modulated multitone (SMT), where the word staggered comes from the fact that the in-phase and quadrature phase components in each QAM symbols are time staggered. In the 1990s the use of cosine modulated filter banks for data transmission was widely studied. The improvement in digital subscriber line (DSL) technology led to more work on two classes of FBMC communication systems, namely, filtered multitone (FMT) and discrete wavelet multitone (DWMT) modulation. It has been shown that DWMT is using cosine-modulated filterbanks [5]. Therefore, DWMT was renamed to cosine-modulated multitone (CMT). CMT uses vestigial sideband (VSB) modulation to transmit PAM symbols. FMT is

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another FBMC method which is proposed for DSL applications. In FMT, no overlapping occurs between adjacent subcarriers. Therefore FMT is not bandwidth efficient compared to SMT and CMT.

Wireless channels are characterized by multipath fading. Which result in inter-symbol interference (ISI) in wireless channels. ISI in a channel is proportional to delay spread and also inversely proportional to symbol duration. Therefore by increasing the symbol period we can decrease ISI but it also decrease the data rate. In an MCM systems, a data stream is multiplexed into N parallel substreams, each of which has a N times slower rate. Therefore, the effect of ISI is reduced by factor N. The parallel data streams are modulated at N subcarriers and added together at the transmitter. At the receiver side N streams of symbols are separate band demultiplexes them to the original higher rate stream of symbols. In multicarrier communication system OFDM is mostly used. OFDM is alternative technique for OFDM. In OFDM cyclic prefix is used to combat channel distortion. This channel distortion problem is solved in FBMC by using filtering technique. If we choose proper filter then interference is only between adjacent channels and there is no interference between non-adjacent channels. Thus FBMC technique is more suited for high mobility applications and here orthogonality may be destroyed which will not produce ICI unlike OFDM. Also big side lobes in OFDM is a problem which makes it difficult in cognitive radio application. To suppress the side lobes there would be up to 50% loss in bandwidth. So FBMC is a suitable candidate for 5G communication.

## II. DEFINITION OF PEAK TO AVERAGE POWER RATIO (PAPR) -

PAPR is of two types:

### A. Continuous -time PAPR

It is proportion among the highest instantaneous power and normal power of base-band signal  $x(t)$ .

$$PAPR[x(t)] = \frac{\max_{0 \leq t \leq NT} [|x(t)|^2]}{P_{av}}$$

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where the normal power of  $x(t)$  is  $P_{av}$ .

### B. Discrete time PAPR

The discrete time sequence's PAPR normally decides the complication of digital circuitry in terms of the number of bits important to accomplish a required signal to quantization noise for both digital operation and the DAC. For better approximation the PAPR of continuous time OFDM signal, the OFDM samples are achieved by L time over examining. The over sampled IFFT output is shown as

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$$x[n] \triangleq \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k e^{j \frac{2\pi nk}{LN}}, 0 \leq n \leq LN - 1$$

### III. PAPR DIMINISHMENT SCHEMES

#### PTS and SLM

In the PTS technique PAPR diminishment is achieved by dividing the information signal block X into M disjoint sub-blocks shown by the vectors  $( ) = \{0,1,2 \dots \dots - 1\}$  [8] as shown in Fig 1. So we get

$$X = \sum_{m=0}^{M-1} X(m)$$

where  $X(m) = [X_{m,0}, X_{m,1}, \dots \dots X_{m,N-1}]$ .

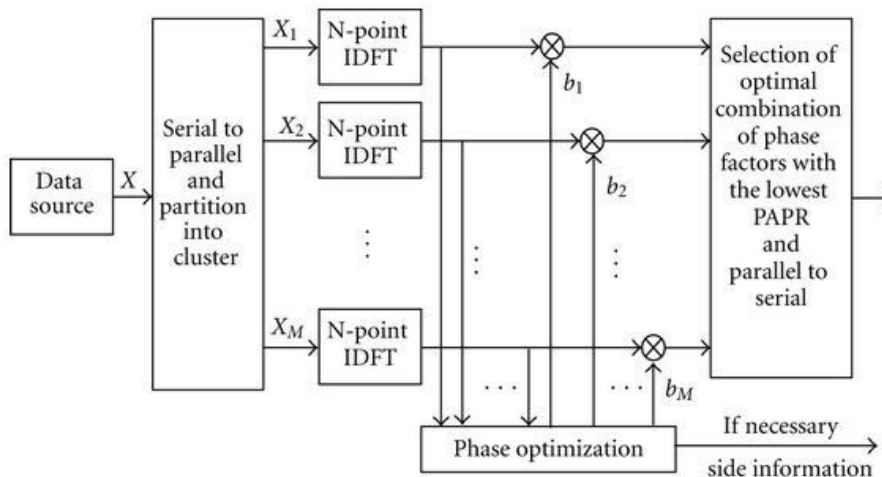


Fig. 1 PTS technique block diagram

In PTS technique, the famous sub-block dividing systems is further divided in three parts [8]: interleaved, close to and pseudo random divider. The sub-block X(m) are changed into M time –domain partial series

$$X^{(m)} = [X_0^{(m)} X_1^{(m)} \dots \dots X_{LN-1}^{(m)}] = \text{IFFT}_{LN \times N} [X^{(m)}]$$

A phase factors b is used to independently rotate these partial sequences. The OFDM signals with minimum PAPR which is acquired by joining these M sub block is

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$$X^{\sim} = \sum_{m=0}^{M-1} b_m X^{(m)}$$

But in PTS there are two vital issues ought to be illuminated : A)To decrease the high mathematical complication in finding the best possible phase factors. B) The overhead of best possible phase factors because extra data is sent to receiver to properly decode the transmitted information.

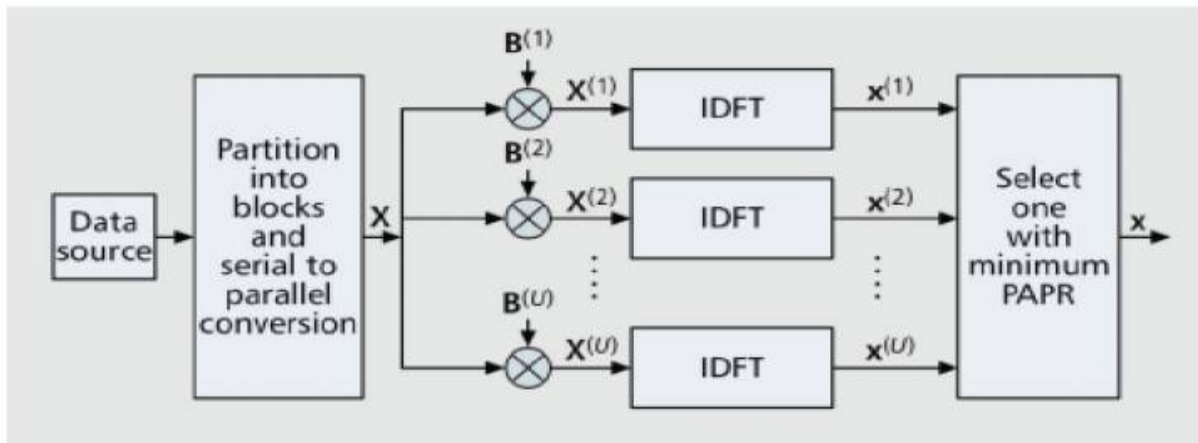


Fig.2. Deduction of PAPR

The data block which has minimum PAPR from all the blocks is transmitted. The mathematical complication and number of the bits for transmitting extra data has been diminished by some extended SLM [9].

Both PTS and SLM are distortion less scheme with no power increase and no data loss. Although, PTS performance is better than SLM, but it require more side information.

#### D. DSLM

DSLIM which stands for dispersive SLM is an extended and universal version of SLM. In it, different phase rotation vectors which are independent and identically distributed are used to rotate each symbol. One symbol from optically rotated symbols is selected on the basis of minimum PAPR which is derived over  $[0,4T]$  instead of  $[0,T]$ . This technique is called Dispersive SLM[10] because it deals with time dispersive nature of signals .

### IV. CRITERIA OF PAPR REDUCTION

While applying different methods of PAPR diminishment we have to maintain the excellent functioning of system with reference to various factors.

**A. Excellent ability of PAPR diminishment:** While choosing the PAPR diminishment method, the factor should be kept in mind that it have minimum destructive issues. For example interior band and exterior band distortion.

**B. Minimum normal power:** PAPR is reduced but normal power of system is enhanced , which results in reduction of the bit error rate performance of system .

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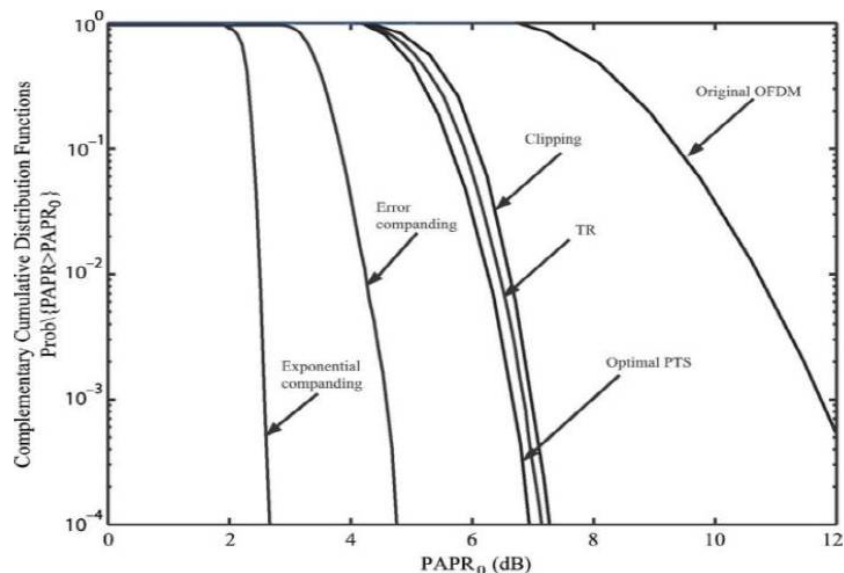
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**C. Minimum difficulty in implementation:** Usually, complex schemes provide better PAPR lessening. But time and hardware requirements should be minimum.

**D. No extension in bandwidth:** If there is expansion in bandwidth then it result into data rate loss because of side information. So it should be avoided or should be as minimum as possible.

**E. No BER performance degradation:** We should consider those methods for which there is enhancement in BER on the receiver end.

Fig. 3 shows, different plot of the CCDF for a randomly generated OFDM symbols and different PAPR lessening schemes. All the method used in given figure can reduce the PAPR to a great extent but their performance are different.



**Fig.3.Different plot of the CCDF**

## V. CONCLUSION

OFDM is broadly conveyed in wireless 5G system because of its spectral competence and robustness of channel. But high PAPR is an issue in OFDM. In this paper we studied various PAPR diminishment methods, which have both merits and demerits (loss in data rate, degraded BER, increment in signal power, increased complexity). These techniques should be utilized according to the application.

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