PAPR Reduction Techniques for Multicarrier Transmission: A Review

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Abstract - One of the emerging technologies in the field of communications is wireless technology. It provides efficient data transmission and a growing concept for 4G and 5G communications. The concept of OFDM system states that it is a form of multi-carrier modulation. The OFDM system suffers from the drawback of high PAPR i.e. Peak to average Power Ratio. Numerous Techniques such as SLM, PTS, Tone Reservation, Clipping and filtering etc. have been discussed in this review paper which is used to reduce the PAPR effect in OFDM systems. Different parameters such as distortion Rate, data rate, power raise etc. are analyzed with the study of different PAPR reduction techniques.

Keywords - OFDM, PTS, SLM, BER, PAPR, PSK

1. INTRODUCTION

In the present scenario, the demand for high speed data transmission has increased with accelerated growth in the field of wireless technology. Wireless communication has seen sudden rise in its development as a large number of wireless devices are being innovated day by day for efficient transmission. These wireless devices have access to internet, the transmission of data faces distortion and hence the distortion factor is reduced. The basic principle of OFDM systems is that it is a form of multi-carrier modulation. It is a type of signal modulation that provides a high data rate modulating stream placing them onto many slowly modulated space carriers [10] which are orthogonal to each other. The main advantages of using OFDM Scheme is that it provides high spectral efficiency [8], increased system efficiency for reliable transmission, improves bandwidth efficiency. It can handle multipath interference and ISI i.e. Intersymbol Interference. Recently studied data depicts that there are several limitations which are being suffered by the OFDM Systems .One of the major drawback is that OFDM systems exhibit High PAPR i.e. Peak to Average Power ratio[9]. Several techniques such as SLM(Selective Mapping)[3],PTS (Partial Transmit Sequence)[8],[11],Tone Reservation, clipping and filtering[7],Companding[5],etc are being discussed in this paper which are used for minimizing the effect of PAPR i.e. Peak to Average Power Ratio. The OFDM communication systems finds it’s applications in Digital television and audio broadcasting, DSL Internet access, wireless networks and 4G mobile communications[9].

2. PAPR Reduction Techniques

There are three different way to divide the PAPR:

The first way:

PAPR reduction techniques can be categorized into deterministic and probabilistic approaches. Deterministic approaches guarantee that the PAPR of an OFDM signal does not exceed a predefined threshold, whereas the probabilistic approaches minimize the probability that the PAPR of an OFDM signal exceeds a predefined threshold. These categories will be discussed in the following sections:

Deterministic Approach

Deterministic PAPR reduction approaches can be classified into techniques that perform either time-domain based clipping or frequency-domain based coding. The simplest approach for PAPR reduction is to deliberately clip the amplitude of the signal to a predefined value before amplification. However, the technique suffers from various drawbacks, such as signal distortion and spectral regrowth. Therefore, clipping alone is not a suitable option for PAPR reduction. Modified clipping techniques exist, which fall under the probabilistic approach explained in the next section. Coding techniques are applied to OFDM signals in order to map symbols to codes with smaller PAPR values. Each symbol has a choice of two or more codes, where the code yielding the lowest PAPR is selected. However, this technique works well only when the number of subcarriers is small.

Probabilistic Approach

Probabilistic approaches attempt to minimize the number of occurrences of OFDM symbols with PAPR values exceeding a predefined threshold, while simultaneously minimizing the signal distortion and spectral growth. Probabilistic approaches can be classified according to whether time domain processing or frequency domain processing is involved:

Time Domain-Based Processing:

Time domain-based processing approaches focus on manipulating the power of the signal in the time domain. This approach can be further classified into blind and non-blind techniques. Blind techniques imply that the receiver is oblivious to the changes made at the transmitter side, whereas non-blind techniques imply that the receiver requires a prior knowledge about the modifications made at the transmitter side for correctly demodulating the received signals. Thus, non-blind techniques require additional side information in order to operate, whereas blind techniques might degrade the error performance of the system since the receiver is transparent to the changes made at the transmitter side. The simplest blind technique for PAPR reduction is to clip the amplitude of the signal to a predefined value and filter the signal to suppress the out-of-band interference. The clipping process might result in spectral regrowth, whereas filtering the signal might result in some peak regrowth. Therefore, clipping may not be an effective technique when reducing the PAPR of the OFDM signals as long as the transmitted OFDM signal is strictly band-limited. Among the non-blind techniques, several companding4 techniques for compressing the large peaks of an OFDM signal in time domain, including μ-law companding and exponential companding, have been proposed in literature. By compressing the large peaks of an OFDM signal by companding, the dynamic range of the D/A converters are reduced. However, the receiver needs to expand the compressed signal for correct demodulation.

Frequency Domain-Based Processing

Frequency domain-based processing approaches focus on minimizing the correlation of the input signals since it is known that the PAPR of an OFDM signal is high when the input sequences are highly correlated. It has been shown that by altering the phase and/or power of the input sequence, it is possible to lower the correlation of the input sequence, thereby reducing the PAPR of an OFDM signal. Frequency domain-based processing approaches can be further classified into blind and non-blind techniques. In blind phase adjustment-based techniques, the phase of the subcarriers are adjusted in order to reduce the coherence between the different subcarriers such that the PAPR value of the OFDM signal is reduced. The phase adjustments should be kept relatively small so as to minimize bit-error-rate (BER) performance degradation. For example, *signal set expansion* technique maps original signal set into an expanded signal set with two or more points, such as binary phase shift keying (BPSK) into quadrature phase shift keying (QPSK), which provides more freedom for phase selection and yields lower PAPR values for the OFDM signal.

Blind power-based techniques alter the power level of the subcarriers such that the PAPR of an OFDM signal is reduced. These techniques are suitable only for the MPSK-based OFDM system since the receiver is unaware of the information about the transmit power levels. In blind power and phase-based techniques, both the phase and the power of the subcarriers are altered such that the PAPR of an OFDM signal is reduced. If the total transmit power needs to be kept constant, these techniques are suitable only for low order modulation techniques since the error robustness of the higher modulation techniques degrades rapidly with the blind phase and power alterations at the transmitter. When the order of the modulation techniques in-creases, the complexity (and limitations) of the algorithm increases as well as transmit power level increases.

Non-blind power-based techniques, as well as power and phase-based techniques, would be suitable for the higher modulation schemes such as MQAM. Non-blind phase adjustment-based techniques update phases of the input sequence such that the PAPR of an OFDM signal is reduced. The information about the phase updates is transmitted to the receiver for correct demodulation. Several modified algorithms are proposed in literature, which avoid the requirement of explicit side information. For example, selective mapping (SLM), partial transmit sequences (PTS), random phase updating techniques add random phase factors to each subcarriers in order to reduce PAPR with the information about the phase factors transmitted to the receiver. The blind techniques reduce the PAPR values at the cost of slight increase in the bit error rate of the system or increased transmit power level since the adjustments would result into increased noise level at the receiver, whereas the non-blind techniques reduce the PAPR values at the cost of a reduced information rate since the information about the adjustments made at the transmitter need to be transmitted to the receiver for the correct demodulation.

The second way:

- Distortion Based Techniques
- Scrambling Techniques

Distortion Based Techniques

The schemes that introduce spectral re-growth belong to this category. Distortion based techniques are the most straightforward PAPR reduction methods. Furthermore, these techniques distort the spectrum, this spectrum distortion or “spectral re-growth” can be corrected to a certain extent by using filtering operation. These methods reduce the PAPR by distorting the OFDM signal non-linearly. The methods like clipping and filtering, peak windowing, and non-linear companding are the example of these techniques. These techniques are applied after the generation of OFDM signal (after the IFFT). The distortion category attempts to reduce PAPR by manipulation of signal before amplification. Clipping of signal prior to amplification is a simplest method but it causes increase in both out-of-band (OOB) as well as in-band interference thus compromises upon performance of system. Amongst this category better techniques include companding, peak windowing, peak power suppression, peak cancellation, weighted multicarrier transmission etc. Any technique which is used to reduce PAPR should not only have high spectral efficiency but must be compatibility with the existing modulation schemes and at the same time must not be computational complex.

Peak Windowing Method:

It is an improved clipping method. The basic aim of peak windowing is to reduce the out-of-band radiation by using narrow band windows such as Gaussian window to attenuate peak signals. As a matter of fact, any window which is narrow in time domain and having good spectral properties can be used. This method, proposes that it is possible to remove large peaks at the cost of a slight amount of self-interference when large peaks arise infrequently. Peak windowing reduces PAPRs at the cost of increasing the BER and out-of-band radiation. Clipping is a one kind of simple introduces PAPR reduction technique which is self-interference. The major advantage of peak windowing is that PAPR reduction is achieved with minimal complexity for any number of sub carriers. The disadvantages include an increase in out-of-band interference and BER.

Envelope Scaling:

The key idea of this scheme is that the input envelope in some sub carrier is scaled to achieve the smallest amount of PAPR at the output of the IFFT. Thus, the receiver of the system doesn't need any side information for decoding the receiver sequence. This scheme is appropriate for QPSK modulation; the envelopes of all subcarriers are equal. Results show that PAPR can be reduced significantly at around 4 dB. In Envelope Scaling, the input envelopes of sub carriers are scaled prior to IFFT. The base for this scheme is the facts that with PSK modulation all the sub carriers input envelops are equal. Hence input envelop of some sub carriers is scaled in such a way that minimum PAPR is achieved at IFFT output.

Peak Reduction Carrier:

This technique is to use the data bearing peak reduction carriers (PRCs) to reduce the effective PAPR in the OFDM system. It includes the use of a higher order modulation scheme to represent a lower order modulation symbol. Hence the phase and amplitude of these carriers remains inside the constellation area which represents the data symbols being transmitted. This method is suitable for PSK modulation; where the envelopes of all subcarriers are the same. When the QAM modulation scheme will be implemented in the OFDM system, the carrier envelope scaling will result in the serious BER degradation. Amongst drawbacks of PRCs, one is that the overall data transmission efficiency of the system is compromised if we try to achieve maximum PAPR reduction efficiency. At the same time the BER performance is also affected adversely because of employing constellation of higher order for carrying symbols of lower order results in higher probability of error.

Companding Technique:

Non-linear companding is an especial clipping technique which offers good PAPR reduction with better BER performance, low implementation complexity, and no bandwidth expansion. The difference between clipping and companding is that the clipping process deliberately clips the large amplitude signals; therefore the signal cannot be recovered exactly. On the other hand, the companding transform compand the original signals using strict monotone increasing function; therefore the companded signals can be recovered correctly through the corresponding inversion of companding transform at the receiver. Clipping does not affect small amplitude signal, whereas companding enlarge the small signals while compressing the large amplitude signals. A lot of companding techniques are available. The basic concept of most of the companding techniques is to transform the Rayleigh distributed OFDM signal into a uniformly distributed signal.

Square-Rooting Companding Technique (SQRT) for PAPR Reduction in OFDM Systems:

By using the SQRT technique, the original OFDM output signals are processed before they are converted into analog waveforms and amplified by the power amplifier.

For the complex Gaussian distributed signals, such as OFDM output signals, SQRT process changes the Rayleigh distribution of these signals into a Gaussian-like, close to Gaussian, distribution while the Chi-square distribution is converted, according to the analysis of these signals given in the previous section, to Rayleigh distribution. The latter is because the Rayleigh distribution in such signals represents voltage, while the Chi_square distribution represents the power of the same signals. However, not only the statistical distribution is changed by the SQRT process, but the values of the mean and variance of the processed OFDM output signals are also changed, and subsequently the values of the average power and peak power of these signals are altered also. To understand the effect of SQRT process on the power values of OFDM output signals, we assume normalized average power. When the average power is normalized, the value of the peak power is diminished by *N* because for the same PAPR. This assumption is applicable for all OFDM symbols as the average power is constant. The new value of normalized peak power is always greater than one because is constantly greater than in all OFDM symbols. Therefore, the SQRT process always causes a reduction in the value of the peak power of the normalized OFDM symbols, and as a result the PAPR is reduced in all sizes of OFDM blocks.

The SQRT process changes the distribution of the power signals to Rayleigh distribution and reduces the value of average power from *N* to *N*1/2. The variance of the Rayleigh distribution is approximately equal to half the value of variance of the Gaussian distributed signals. The SQRT process in the SQRT OFDM system performs this statistical transformation, and therefore results in a constant degradation in the BER rate equal to 3 dB.

Scrambling techniques:

Signal scrambling techniques are all variations on how to scramble the codes to decrease the PAPR. Coding techniques can be used for signal scrambling. Golay complementary sequences, Shapiro-Rudin sequences, M sequences, Barker codes can be used efficiently to reduce the PAPR. However with the increase in the number of carriers the overhead associated with exhaustive search of the best code would increase exponentially. More practical solutions of the signal scrambling techniques are block coding, Selective Level Mapping (SLM) and Partial Transmit Sequences (PTS). Signal scrambling techniques with side information reduces the effective throughput since they introduce redundancy.

Coding Based:

Block Codes Schemes:

Main objective of this technique is to reduce PAPR using different block coding & set of code words. This scheme is widely used to reduce the peak to mean envelope power ratio. While selection of the suitable codeword many things must be considered like M-ray phase modulation scheme, any type of coding rate, suitable for encoding – decoding & also main thing is that error correction /error decoding.

Sub-Block Coding Schemes:

To reduce PAPR more than 3db sub block coding technique is widely used. But this can be achieved at ¾ code rate. This techniques based on ¾ code rate systematically with added last odd parity checking bit to develop lowest peak envelope power. This coding scheme is termed as systematic odd parity checking coding (SOPC). Large reduction in PAPR can be obtained by the divided large frame into sub block encoded with SOPC.

Selective Mapping (SLM):

In SLM, the basic idea is to generate a set of OFDM signals, all of them representing the same data block, and then transmitting the one with the lowest PAPR. The major drawback of SLM method is that it is more computationally complex because more than one IFFT blocks are used. It also decreases the data rate because the selected signal index, called *side information*, must also be transmitted to allow for the recovery of the original data block at the receiver side. The eventual loss of the side information during transmission significantly degrades the error performance of the system since the whole data block is lost in this case. Therefore, a lot of work has been suggested as a modified SLM to reduce the computational complexity and to reduce or to remove the side information transmitted.

In SLM, the input data sequences are multiplied by each of the phase sequences to generate alternative input symbol sequences. Each of these alternative input data sequences are then applied to IFFT operation, and then the one with the lowest PAPR is selected for transmission.

The major drawback of SLM method is that it is more computationally complex and less bandwidth efficient (side information is required). Therefore, a lot of work has been suggested as a modified SLM to reduce the computational complexity and to reduce or to remove the side information transmitted.

Partial Transmit Sequence (PTS):

In PTS, the original data block is divided into multiple non-overlapping sub-blocks. Then these sub-blocks are rotated with rotation factors which are statistically independent. After that, the signal with the lowest PAPR is chosen for transmission. There are several ways for the partition of the data sequence into multiple sub-blocks, including adjacent partition, interleaved partition and pseudorandom partition. Among them, pseudo-random partitioning has been found to be the best choice. The major drawback of PTS is also the computational complexity and low data rate. The complexity of PTS is less than SLM. In PTS method, the original frequency-domain data sequence is divided into multiple disjoint sub-blocks, which are then weighted by a set of phase sequences to create a set of candidates, finally the candidate with the lowest PAPR is chosen for transmission.

There are two main issues of any PTS scheme: to reduce the computational complexity for searching the optimal phase factors and to reduce the overhead by minimizing the side information. Suppose that there are W phase angles to be allowed, thus can has the possibility of W different values. Therefore, there are alternative representations for an OFDM symbol. The search complexity increases exponentially with the number of sub-blocks M to reduce the search complexity and overhead (by reducing/avoiding the usage of side information).These methods achieve significant reduction in search complexity with marginal PAPR performance degradation.

Interleaving Technique: A technique which uses a set of Interleavers for PAPR reduction is called Interleaving technique. In this scheme, the upraised value of PAPR is reduced by using set of interleavers but not by using the set of Phase sequences as in PTS and SLM technique. A long correlation pattern is broken down to reduce the elevated values of correlated data structures[9].By the use of this Interleaving technique, we can obtain higher code rate without expansion in bandwidth as compared to conventional OFDM systems, without increase in number of sub-carriers. This interleaving technique gets slightly complex in nature and it gets moderately complex to compute using this technique. Interweavers are used to produce permuted data blocks from the same data block. The PAPR of (K-1) permuted data blocks and that of the original data block with the lowest PAPR is then chosen for transmission. For recovery of original data block, the receiver must know which interleaver is used at the transmitter end. Therefore the number of required 'side information' bits is log2K.

Linear Block Codes: A Tone This technique also known as standard array of linear block codes. in this scheme distinct U signal is transmitted along with transmitted sequence. U distinct signal is used constructed using proper select co –set words. Using scrambling codes no needs to transmit side information and received signal can be easily decoded. Main thing is that to select standard array of codes to reduce the PAPR. This technique also modification of the SLM techniques. In this transmitted signal with minimum PAPR using scrambling code. Technique has better performance than SLM technique.

Tone Reservation: A Tone Reservation Technique partitions N sub carriers i.e. small number of tones into data tones and peak reduction tones.(PRT's).The central idea behind this Tone Reservation scheme is that small set of tones are created for PAPR Reduction. It can be referred to as an accurate technique. This method is used to minimize the High peak values. It is based on adding a data block and time-domain signal. At the transmitter, the calculation of time domain signal can be done. The values for PAPR reduction in tone reservation approach depends on some factors such as number of reserved tones, amount of complexity and allowed power on reserved tones[9].This technique shows that by reserving even a small fraction of tones leads to large reduction in PAPR value.. The benefits of Tone Reservation method can be coined to be less complex in nature. No additional information is required to be operated at the receiver side. In this method, no side information is required at the receiver end.

Tone Injection: The Tone Injection approach was penned down by Muller, S.H., Huber, J.B [4].The basis of the tone injection scheme is general additive method which provides desired PAPR reduction. By the implementation of the additive method on the multicarrier signal, the PAPR reduction is achieved without any data rate loss. A set of equivalent constellation points is being used by this Tone Injection approach for original constellation points to minimize the effect of PAPR. The demerits of Tone Injection scheme is that this approach requires additional side information for decoding the signal at the receiver side and cause extra IFFT operation which results in complex circuitry.

Active Constellation Extension: This technique is similar to Tone Injection (TI). The only difference is that in ACE, only the outer constellation points are dynamically extended away from the original constellation. Extending outer point from decision boundary increases the spacing between the constellation point and thus reducing BER and if adjusted properly PAPR could also be reduced. Various literatures are available on ACE and suggested modification. ACE technique does not require transmission of side information and hence there is no data rate loss too. Only the drawback of this scheme is that it increases the requirement of transmission power.

The third way :

These methods are basically divided in three categories:

(1) The clipping technique

(2) Coding Methods,

(3) Probabilistic (Scrambling) Techniques

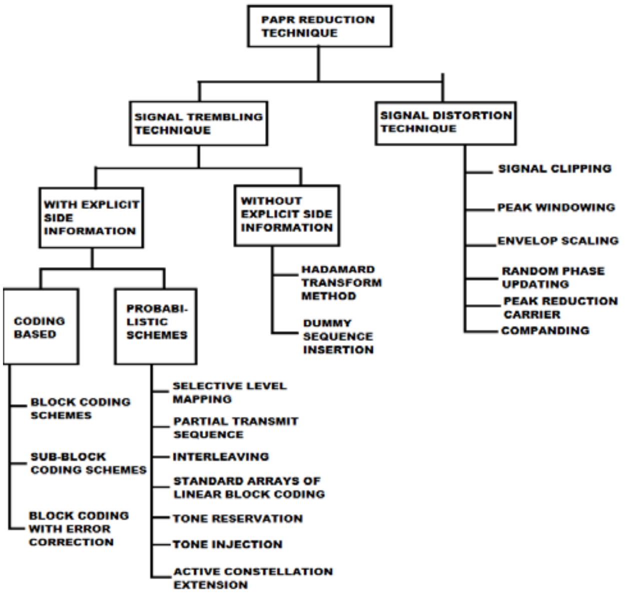

Fig 1. Taxonomy of PAPR reduction technique

The clipping technique employs clipping or nonlinear saturation around the peaks to reduce the PAPR. It is simple to implement, but it may cause in-band and out-of-band interferences while destroying the orthogonality among the subcarriers. This particular approach includes block-scaling technique, clipping and filtering technique, peak windowing technique, peak cancellation technique, Fourier projection technique, and decision-aided reconstruction technique. The coding technique is to select such code words that minimize or reduce the PAPR. It causes no distortion and creates no out-of-band radiation, but it suffers from bandwidth efficiency as the code rate is reduced. It also suffers from complexity to find the best codes and to store large lookup tables for encoding and decoding, especially for a large number of subcarriers. Golay complementary sequence, Reed Muller code, M-sequence, or Hadamard code can be used in this approach.The probabilistic (scrambling) technique is to scramble an input data block of the OFDM symbols and transmit one of them with the minimum PAPR so that the probability of incurring high PAPR can be reduced. While it does not suffer from the out-of-band power, the spectral efficiency decreases and the complexity increase as the number of subcarriers increases. Furthermore, it cannot guarantee the PAPR below a specified level. This approach includes SLM (Selective Mapping), PTS (Partial Transmit Sequence).

The pre-distortion methods are based on the re-orientation or spreading the energy of data symbol before taking IFFT. The pre-distortion schemes include DFT spreading, pulse shaping or precoding and constellation shaping. The methods like Tone Reservation (TR) and Tone Injection (TI) are the example of constellation shaping schemes.

The DFT-spreading technique is to spread the input signal with DFT, which can be subsequently taken into IFFT. This can reduce the PAPR of OFDM signal to the level of Single-carrier transmission. This technique is particularly useful for mobile terminals in uplink transmission.

Clipping and Filtering:

The clipping is the simplest method of PAPR reduction. Clipping limits the maximum amplitude of OFDM signal to a pre-specified level. The implementation of clipping is relatively easy. The simplest and most widely used technique of PAPR reduction is to basically clip the parts of the signals that are outside the allowed region.

Generally, clipping is performed at the transmitter. However, the receiver needs to estimate the clipping that has occurred and to compensate the received OFDM symbol accordingly. Typically, at most one clipping occurs per OFDM symbol, and thus the receiver has to estimate two parameters: location and size of the clip. However, it is difficult to get this information. Therefore, clipping method introduces both in band distortion and out of band radiation into OFDM signals, which degrades the system performance including BER and spectral efficiency. Filtering can reduce out of band radiation after clipping although it cannot reduce in-band distortion. However, clipping may cause some peak regrowth so that the signal after clipping and filtering will exceed the clipping level at some points.

It has following drawbacks:

(a) It causes in-band signal distortion, resulting in BER performance degradation.

(b) It also causes out-of-band radiation, which imposes out-of-band interference signals to adjacent channels. The out-of-band radiation can be reduced by filtering, but the filtering may affect high-frequency components of in-band signal (aliasing) when the clipping is performed with the Nyquist sampling rate.

(c) Filtering after clipping can reduce out-of-band radiation at the cost of peak re-growth. The signal after filtering operation may exceed the clipping level specified for the clipping operation.

To reduce peak regrowth, a repeated clipping-and-filtering operation can be used to obtain a desirable PAPR at a cost of computational complexity increase. As improved clipping methods, peak windowing schemes attempt to minimize the out of band radiation by using narrowband windows such as Gaussian window to attenuate peak signals.

Some of clipping techniques:

1. Repeated Clipping

The clipping technique is the simpler one which is used to cut the signal peak up to desired threshold level.

2. Reconstruction of Lost Clipped Signal

To remove the peak regrowth of signal oversampled sequence clipping is used which can reconstruct the clipped samples and mitigate the clipping distortion in presence of channel noise at the cost of bandwidth expansion.

3. Iterative Clipping & Filtering Technique

This technique is used to eliminate the peak regrowth due to CF technique. In each iteration peak regrowth decreases significantly. The process of iteration undergoes FFT/IFFT and one extra IFFT is required for conversion into time domain in OFDM.

4. Recursive Clipping and Filtering with Bounded Distortion (RCFBD)

In RCF the signal is clipped by repeating process many times before feeding to power amplifier. When the process of repetition exhibit on the signal the out of band spectral density and the probability of the occurrence of PAPR decreases but error rate increases due to increase in number of repetitions. The bit error rate increases due to increase in in band distortion. So to remove this increased error rate another improved technique is proposed called recursive clipping and filtering with bounded distortion (RCFBD) to achieve PAPR reduction. The idea of this technique is same as oversampled digital clipping in time domain and removing out of band components in frequency domains are used. RCFBD minimize PAPR and keeps the control on the distortion of data carried by each subcarrier. So by using this technique side information can be eliminated and receiver part becomes less complex and BER performance can be increased more.

Coding techniques:

Many early papers considered how standard coding techniques could be applied toOFDM. The basic premise of coding is to insert redundant bits into the data stream which can be used for error correction at the receiver. Their application to PAPR reduction is in creating sequences of bits which will exhibit low PAPR after the IFFT.

There are two types of error detection and correction codes, *block codes* and *convolutional codes*. Most papers relate to the block coding family for PAPR reduction. During the encoding process k information bits are encoded into n code d bits, therefore (n-k) redundant non information bits are added to the k information bits. The block code is referred to as an (n,k) code, and the rate of the code as Rc=k/n.

Table-1: Comparison of important PAPR reduction techniques

S. No.	PAPR REDUCTION TECHNIQUES	PARAMETERS
1	Selective Mapping Technique	• It decreases distortion. • There is no Power raise in SLM • technique • Selects the signal with lowest PAPR value for transmission
2	Partial Transmit Sequence	• This technique helps in • No power rise. • It is complex in nature.
3	Tone Reservation	• Reduces distortion • Power gets raised in this technique. • It is less complex in nature.
4	Tone Injection	• It reduces distortion • Power raise is observed in this technique • PAPR reduction is observed without data rate loss.
5	Clipping &Filtering	• It introduces distortion. • No Power Raise. • It is one of the • • simplest techniques to apply.

Different codes exhibit different degrees of error correction ability. Another important property of codes is the *weight* of the code, which is the number of non-zero elements in the code word. Types of block codes are Hamming, Golay, and Reed- Solomon, some of which are used for PAPR reduction. The basic idea of all coding schemes for the reduction of PAPR is to reduce the occurrence probability of the same phase of N signals. The coding method selects such code words that minimize or reduce the PAPR. It causes no distortion and creates no out-of-band radiation, but it suffers from bandwidth efficiency as the code rate is reduced. It also suffers from complexity to find the best codes and to store large lookup tables for encoding and decoding, especially for a large number of subcarriers.

Coding techniques for PAPR reduction where redundant bits are added to the bit stream before the IFFT. Properly chosen, these codewords ensure that the PAPR after the IFFT is kept low. These codes can be combined with existing COFDM to reduce the redundancy and complexity inherent in coding. A disadvantage of coding is that the complexity becomes prohibitively high with an increase in the number of subcarriers (>32). Various codewords were presented such as cyclic codes, Shapiro-Rudin Sequences, Golay Complementary codes, and Reed-Muller codes. Golay codes and their subset, second order Reed Muller codes were found to have excellent PAPR properties restricting the PAPR to 3dB. This reduction could be traded off with reductions in complexity and the code length. Still complexity remains a restrictive issue in coding.

3. CONCLUSION

OFDM (Orthogonal Frequency Division Multiplexing) is a form of multi-carrier modulation technique. Wireless Communication is emerging technology in the present times and OFDM systems are in use because of its advantages such as providing High Spectral Efficiency, Increased Bandwidth Power and its robustness against multipath Interference. But the OFDM System suffers from the drawback of high values of PAPR i.e. Peak to Average Power Ratio. In this Review paper, several techniques for PAPR Reduction are being reviewed and discussed. The techniques are classified into two categories. 1. Signal Scrambling Techniques 2. Signal Distortion Techniques. Numerous techniques such as SLM, PTS, Tone Reservation, Tone Injection, Interleaving, Clipping and filtering and Companding techniques are being discussed in this review paper.

The analysis of PAPR Reduction Techniques on various Parameters is done. It has been studied that different PAPR Reduction techniques are able to reduce the PAPR effect, but there is no specific technique for PAPR Reduction which can reduce this effect for multi-carrier transmission. It is concluded that the PAPR Reduction Technique should be selected as per the system requirements.

4. FUTURE SCOPES

In future work Reduction of PAPR by various Modulation Techniques will be achieved & compared by using MATLAB. BPSK and QPSK will be used to reduce PAPR as well as try to keep BER Optimum. PAPR also depends on modulation scheme. PAPR which will be achieved is far good as compare to the results obtained by 16 QAM in previous year papers.

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