Performance Evaluation of Peak To Average Power Ratio Reduction Technology In Orthogonal Frequency Division Multiplexing For Improved Wireless Communication

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Abstract- *Wireless communication has got lot of changes regarding the transmission technique and demand of high data rate services as the new technologies are introduced .Single carrier system being switched to multicarrier system for improved transmission technology. According to the demand of advance communication field there should be high data rate in addition to both power efficiency and lower bit error rate. This demand of high data rate can be fulfilled by the single carrier modulation with compromising the trade off between the power efficiency and bit error rate. Again in the presence of frequency selective fading environment, it is very difficult to achieve high data rate for this single carrier modulation with a lower bit error rate performance. With considering an advance step towards the multi carrier modulation scheme it is possible to get high data rate in this multipath fading channel without degrading the bit error rate performance. To achieve better performance using multi carrier modulation we should make the subcarriers to be orthogonal to each other i.e. known as the Orthogonal Frequency Division Multiplexing (OFDM) technique. The OFDM gives high data rate but it has disadvantage of high Bit Error Rate and high Peak-to average power ratio (PAPR). The Selected Mapping (SLM) and improved PTS is combined with SW technique has overcome drawback of high BER because of its full transmission diversity with higher capacity. But large Peak to average Power ratio (PAPR) of OFDM . Proposed paper gives comparative study of different PAPR technique with respect to BER calculation and improvement in SNR.Further this paper gives performance of papr in AWGN channel and rician channel.*

I. RELATED WORK

The main idea behind the OFDM is that since low-rate modulations are less sensitive to multipath, the better way is to send a number of low rate streams in parallel than sending one high rate waveform. This can be exactly done in OFDM. The OFDM divides the frequency spectrum into sub-bands small enough so that the channel effects are constant (flat) over a given sub-band. Then a classical IQ modulation (BPSK, QPSK, M-QAM, etc) is sent over the sub-band. If designed correctly, all the fast changing effects of the channel disappear as they are now occurring during the transmission of a single symbol and are thus treated as flat fading at the received.

A large number of closely spaced orthogonal subcarriers are used to carry data. The data is divided into several parallel data streams or channels, one for each subcarrier. Each subcarrier is modulated with a conventional modulation scheme such as Quadrature Amplitude Modulation (QAM) or Phase Shift Keying (PSK) at a low symbol rate. The total data rate is to be maintained similar to that of the conventional single carrier modulation scheme with the same bandwidth .

Multi-Carrier Modulation is a technique for data-transmission by dividing a high-bit rate data stream is several parallel low bit-rate data streams and using these low bit-rate data streams to modulate several carriers. Multi-Carrier Transmission has a lot of useful properties such as delay-spread tolerance and spectrum efficiency that encourage their use in un tethered broadband communications. OFDM is a multi-carrier modulation technique with densely spaced sub-carriers, that has gained a lot of popularity among the broadband community in the last few years.

PAPR In OFDM :

Let $X(0), X(1),\ldots, X(N-1)$ represent the data sequence to be transmitted in an OFDM symbols with N subcarriers. The baseband representation of the OFDM symbol is given by

$$\mathrm{PAPR} = 10\log_{10} \frac{\max[|x(t)|^2]}{\frac{1}{T}\int_0^T |x(t)^2|\,dt}$$

Where T is the duration if the OFDM symbol. According to the central limit theorem, when N is large, both the real and imaginary parts of $x(t)$ become Gaussian distributed, each with zero mean and variance of E[|$x(t)$|2]/2, and the amplitude of the OFDM symbol follows a Rayleigh distribution. Consequently it is possible that the maximum amplitude of OFDM signal may well exceed its average amplitude. Practical hardware (e.g. A/D and D/A converters, power amplifiers) has finite dynamic range; therefore the peak amplitude of OFDM signal must be limited. That PAPR reduction may be achieved by decreasing the numerator max[|$x(t)$2|], increasing the denominator.

The effectiveness of a PAPR reduction technique is measured by the Complementary Cumulative Distribution Function (CCDF), which is the probability that PAPR exceeds some threshold, i.e.

CCDF = Probability(PAPR > p0)

PAPR Reduction Techniques

The high Peak-to-Average Power Ratio (PAPR) or Peak-to-Average Ratio (PAR) or Crest Factor of the Orthogonal Frequency Division Multiplexing (OFDM) systems can be reduced by using various PAPR reduction techniques namely

- Tone Reservation (TR).
- Constellation Shaping.
- Phase Optimization.
- Tone Injection (TI).
- Block Coding.
- Multiple Signal Representation Techniques.
  - Partial Transmit Sequence (PTS).
  - Selective Mapping (SLM).
  - Interleaving.
- Active Constellation Extension Methods.
  - Clipping-BasedActive Constellation Extension (CB-ACE) Algorithm.
  - Adaptive Active Constellation Extension (Adaptive ACE) Algorithm.

One of the most serious problems with OFDM transmission is that, it exhibits a high peak-to-average ratio. In other words, there is a problem of extreme amplitude excursions of the transmitted signal. The OFDM signal is basically a sum of N complex random variables, each of which can be considered as a comp 2.1 lulated signal at different frequencies. In some cases, a.. ... ..gnal components can add up in phase and produce a large output and in some cases, they may cancel each other producing zero output. Thus the peak-to-average ratio (PAR) of the OFDM system is very large. The problem of Peak-To-Average Ratio is more serious in the transmitter. In order to avoid clipping of the transmitted waveform, the power-amplifier at the transmitter frontend must have a wide linear range to include the peaks in the transmitted waveform. Building power amplifiers with such wide linear ranges is a costly affair. Further, this also results in high power

consumption. The DAC's and the ADC's must also have a wide range to avoid clipping. There has been a lot of research put into the study of overcoming the PAR problem in OFDM.

II. INTRODUCTION

OFDM is a form of multicarrier modulation. An OFDM signal consists of a number of closely spaced modulated carriers. When mo 2.2 ı of any form - voice, data, etc. is applied to a carrier, then sidebands spread out either side. It is necessary for a receiver to be able to receive the whole signal to be able to successfully demodulate the data. As a result when signals are transmitted close to one another they must be spaced so that the receiver can separate them using a filter and there must be a guard band between them shown in Figure 1 This is not the case with OFDM. Although the sidebands from each carrier overlap, they can still be received without the interference that might be expected because they are orthogonal to each another. This is achieved by having the carrier spacing equal to the reciprocal of the symbol period.

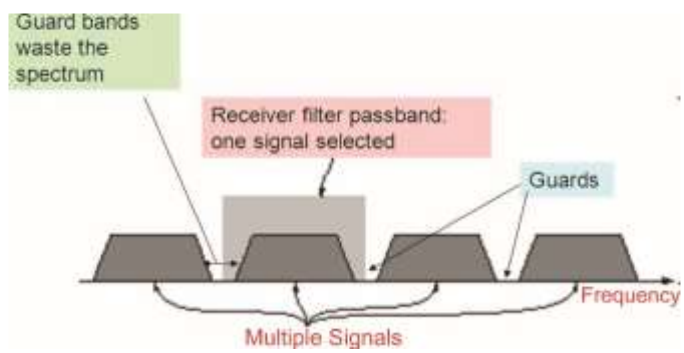


Figure 1 Traditional View of Receiving Signals Carrying Modulation

DATA ON OFDM

The data to be transmitted on an OFDM signal is spread across the carriers of the signal, each carrier taking part of the payload. This reduces the data rate taken by each carrier. The lower data rate has the advantage that interference from reflections is much less critical. This is achieved by adding a guard band time or guard interval into the system shown inFigure1.3 . This ensures that the data is only sampled when the signal is stable and no new delayed signals arrive that would alter the timing and phase of the signal.

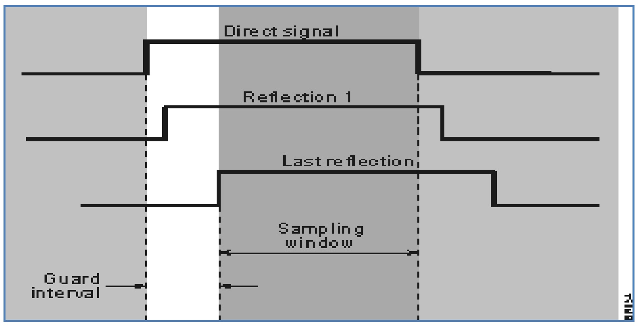


Figure2 Guard Interval

The distribution of the data across a large number of carriers in the OFDM signal has some further advantages. Nulls caused by multi-path effects or interference on a given frequency only affect a small number of the carriers, the remaining ones being received correctly. By using error-coding techniques, which does mean adding further data to the transmitted signal, it enables many or all of the corrupted data to be reconstructed within the receiver. This can be done because the error correction code is transmitted in a different part of the signal.

OFDM TRANSMITTER MODEL

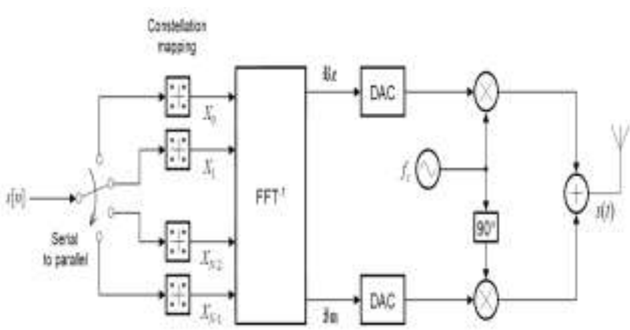


Figure 3 OFDM Transmitter Model

OFDM Transmitter Model is shown in Figure3 consists of

- Serial To Parallel Conversion
- QPSK Modulation
- DAC
- Inverse Fast Fourier –Transform

OFDM RECEIVER MODEL

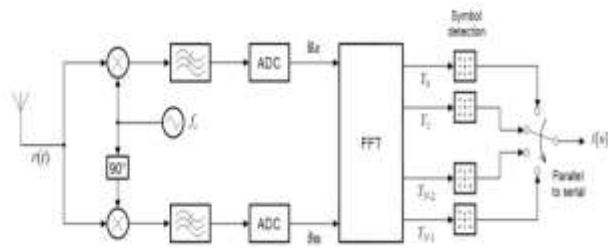


Figure4 OFDM Receiver Model

OFDM Receiver Model is shown in Figure 4 consists of

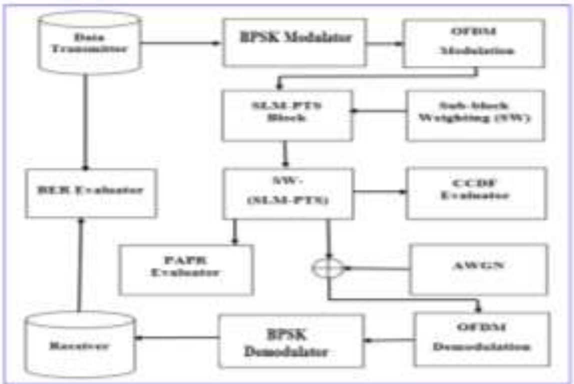
- Low pass filter
- Analog to Digital converter
- Fast Fourier Transform

$$DFT(FFT):$$

$$X(k)=\sum_{n=0}^{N-1} x(n)\cdot e^{-j\left(\frac{2\pi}{N}\right)nk} \quad (k=0,1,\ldots,N-1)$$

But the great disadvantage of the OFDM technique is its high Peak to Average Power Ratio (PAPR). As we are using the linear power amplifier at the transmitter side so it’s operating point will go to the saturation region due to the high PAPR which leads to in-band distortion and out-band radiation. This can be avoided with increasing the dynamic range of power amplifier which leads to high cost and high consumption of power at the base station. This report presents an efficient technique i.e the Selected Mapping which reduces the PAPR. Also the analysis of bit error rate performance and the computational complexity for this technique are being discussed here. In additions to the above analysis one important analysis of the mutual independence between the alternative OFDM signals generated using this technique, also being presented. One scheme proposed here which satisfies the PAPR reduction criteria with reducing the computational complexity. Also this new scheme has an important advantage of avoiding the extra bits .

III. PROPOSED SYSTEM



Selection Mapping Technique:

A major drawback of orthogonal frequency-division multiplexing (OFDM) systems has traditionally been their high peak-to-average power ratio (PAPR). To overcome this problem, a number of techniques have been developed. Selected mapping (SLM) is one of the most promising among all these techniques because it is simple to implement (at least from a conceptual viewpoint), introduces no distortion in the transmitted signal, and can achieve significant PAPR reduction.

In the SLM technique is shown Figure2.1 in the transmitter generates set of sufficiently different candidate data blocks, all representing the same information as the original data block, and selects the most favourable for transmission. A block diagram of the SLM technique is shown in Fig. Each data block is multiplied by Udifferent phase sequences, each of length N, $\mathbf{B}(u) = [bu,0, bu,1, \ldots, bu,N–1]T$, $u = 1, 2, \ldots, U$, resulting in U modified data blocks. To include the unmodified data block in the set of modified data blocks, we set $\mathbf{B}(1)$ as the all-one vector of length N. Let us denote the modified data block for the uth phase sequence $\mathbf{X}(u) = [X0bu,0, X1bu,1, \ldots, XN–1bu,N–1]T$, $u = 1, 2, \ldots, U$. After applying SLM to $\mathbf{X}$, the multicarrier signal becomes Among the modified data blocks $\mathbf{X}(u)$, $u = 1, 2,\ldots, U$, the one with the lowest PAPR is selected for transmission.

Information about the selected phase sequence should be transmitted to the receiver as side information. At the receiver, the reverse operation is performed to recover the original data block. For implementation, the SLM technique needs U IFFT operations, and the number of required side information bits is for each data block. This approach is applicable with all types of modulation and any number of subcarriers.

The amount of PAPR reduction for SLM depends on the number of phase sequences U and the design of the phase sequences. In an SLM technique without explicit side information is proposed. In the *SLM* approach, M statistically independent sequences are generated from the same information and that sequence with the lowest *PAPR* is chosen for transmission.

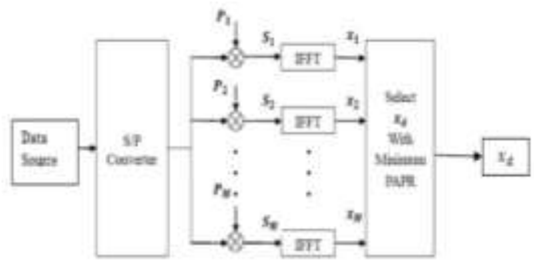


Figure .5 Selection Mapping Block Diagram

Partial Transmit Sequence:

Coding schemes are also used but these have drawbacks of using special decoders in receiver side. In SLM technique , input data sequence are multiplied by each of the phase sequences to generate alternative input symbol sequence. Each of these alternative input data sequence is made the IFFT operations, and then the one with the lowest PAPR is selected for transmission. Among the techniques, the partial transmit sequence (PTS) is one of the effective methods, where the OFDM subcarriers are partitioned into several subgroups and each group of subcarriers is multiplied by a phase factor to reduce the PAPR. The block diagram of PTS is shown in Fig. For PTS scheme, the known sub block partitioning methods can be classified into three categories adjacent partition, interleaved partition and random partition. Then, the sub-blocks are transformed into time-domain partial transmit sequences using IFFT functions to each sub block. In PTS, an input data block of length N ispartitioned into a number of disjoint sub-blocks. Then each of these sub-blocks are padded with zeros and weighted by a phase factor.

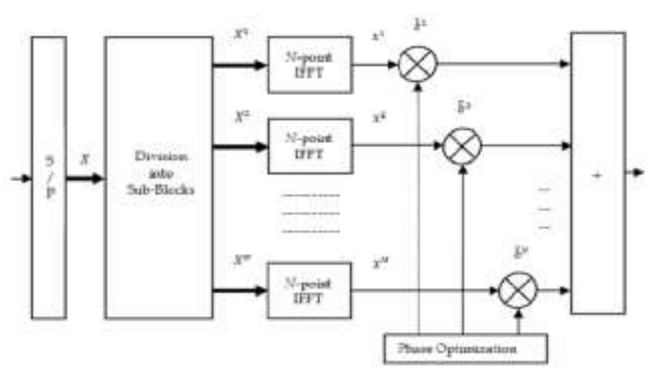


Figure.6PartialTransmit SequenceBlock Diagram

In PTS as shown in Figure6, an input data block of length N ispartitioned into a number of disjoint sub-blocks. Then each of these sub-blocks are padded with zeros and weighted by a phase factor. Time domain x_v, IFFT of X_v is called partial transmit sequence. The phase factor is chosen such that PAPR of candidate signal is minimum .For V sub-blocks and W phase weights, we have to search W^{V-1} possible candidates, as for the first block phase factor is always chosen as 1. In calculation of each candidate V-1 additions and multiplication takes place.

The scheme is proposed that updates the set of phase factors iteratively till PAPR drops below a specified threshold. A simple iterative flipping algorithm is proposed in to reduce the complexity of the PTS method by converging to a sub-optimal choice of the phase factors. Algorithms are described in for combining partial transmit sequences with reduced complexity and very little performance degradation. A gradient descent search for phase factors is proposed in which reduce search complexity at the expense of some performance degradation too.

Low computational complexity PTS scheme is proposed where two search steps are employed to find a subset of phase rotating vectors with good PAPR reduction performance. In first step, Kasamisequences with low correlation or quaternary sequences of family are used as initial phase rotating vectors for PTS scheme. In the second step, to find additional phase rotating vectors, a local search is performed based on the initial phase vectors with good PAPR reduction performance.

SUB-BLOCK WEIGHTING (SW)-SLM-PTS

The sub-block sequences are independently weighted by Phase Weighting Factors (PWFs). All the weighted sub-block sequences are added to achieve an OFDM candidate sequence, expressed by

$$x' = IIFT\{\textstyle\sum_{m=1}^{M} b_m X_m\};$$
$$x' = \textstyle\sum_{m=1}^{M} b_m IFFT\{X_m\} = \sum_{m=1}^{M} b_m X_m \qquad (6)$$

Where $x_m = IFFT\{X_m\}$, b_m is PWFs for the m sub-block sequence.

Number of OFDM sequences are achieved by implementing various PWFs and the one with lowest PAPR is found for transmitting. Moreover, the side information is required to help the receiver recover the input data correctly. In the proposed SW-(SLM-PTS), the SW is initially adopted for simplifying phase weighting procedure. Here, the sub-block sequences are weighted by the allowed PWFs. To diminish the PAPR in the OFDM sequence of signal, the shifting sequence of data is added in between the data signal. Summation of the OFDM symbols in the sub-carriers are being compared with an individual carrier system, from which the synthesis may lead to high PAPR. This high power is represented as the ratio between maximum power and its average power.

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

COMPUTATIONAL COMPLEXITY REDUCTION RATIO (CCRR)

In proposed SW-(SLM-PTS) scheme, the computational complexity is reduced by generating the additional sub-candidate sequences in the weighted part. To show the advantage of proposed system in complexity reduction against Conventional-(SLM-PTS), Computational Complexity Reduction Ratio (CCRR) is calculated, which is defined by Eq.

$$CCRR = \left(1 - \frac{complexity\ of\ SW-(SLM-PTS)}{complexity\ of\ C-(SLM-PTS)}\right)$$

COMPLEMENTARY CUMULATIVE DISTRIBUTION FUNCTION (CCDF) EVALUATOR

- The Complementary Cumulative Distribution Function (CCDF) System object to measure the probability of a signal's instantaneous power being greater than a specified level over its average power.
- Construct the comm.CCDF object, enable the PAPR output port, and set the maximum signal power limit to 50 dBm.
- Create an OFDM modulator having an FFT length of 1024 and a cyclic prefix length of 32.
- Determine the input and output sizes of the OFDM modulator object using the info function of the comm.OFDM Modulator object.
- Set the number of OFDM frames.
- Allocate memory for the signal arrays.
- Generate the 64- BPSK and OFDM signals for evaluation.
- Determine the average signal power, the peak signal power, and the PAPR ratios for the two signals.

- The two signals being evaluated must be the same length so the first 4000 symbols are evaluated.
- Plot the CCDF data.
- Observe that the likelihood of the power of the OFDM modulated signal being more than 3 dB above its average power level is much higher than for the BPSK modulated signal.

IV. CONCLUSION

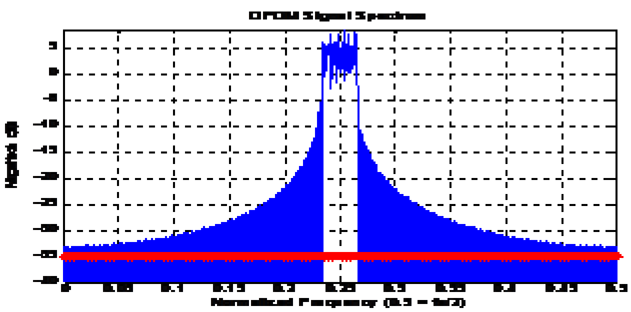


Figure10: OFDM Signal Spectrum

OFDM, orthogonal frequency division multiplexing has gained a significant presence in the wireless market place. The combination of high data capacity, high spectral efficiency, and its resilience to interference as a result of multi-path effects means that it is ideal for the high data applications that have become a major factor in today's communications scene.

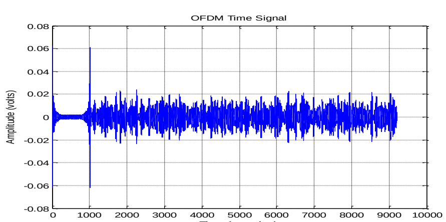
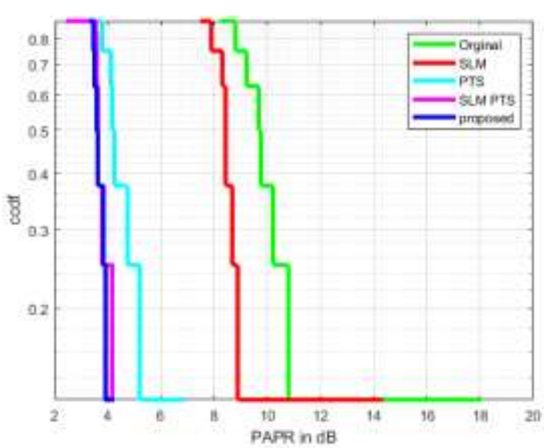
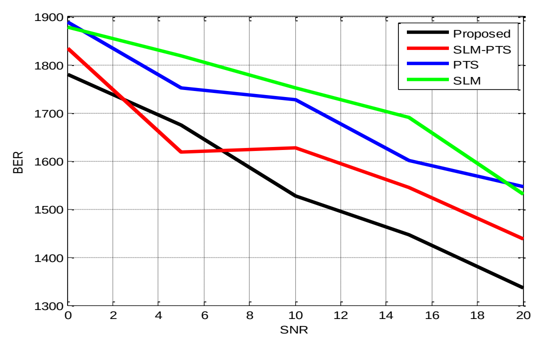


Figure 11:OFDM Time Signal

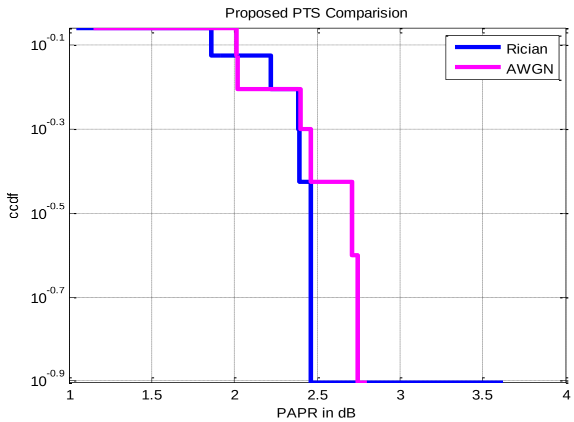


FiguFigre12: Performance Comparison

SPW method controls the phase of the subblocks in the input OFDM data block to reduce the PAPR and there are no signal distortions such as in-band distortion and spectral regrowth. Especially, it can be realized by one IFFT so that it is very efficient in the respect of system complexity and calculation burden, compared to the conventional PTS and SLM method requiring many IFFTs.. The processing time can be reduced since the weighting factor combination of the complementary sequence characteristic is used with threshold technique. The effect of the PAPR reduction on the combined SLM and PTS with S-W in OFDM systems has been carried out successfully. In the results we can get the desired PAPR reduction performance can achieve higher data rate with lower power consumptions.



The BER performance is further improved by adaptive clipping the OFDM signal with higher data rate and lower power consumptions. The performance of OFDM system is simulated by using clipping and SLM scheme with ML decoder .In this work, two schemes are proposed to address the PAPR in OFDM system. Using this method, no side information is required to retrieve the signal at receiver side which increase the bandwidth efficiency. Due to these methods the reduction in peak power is done at low complexity. Various methods for PAPR reduction are envisaged but each method has its limitation. The high peak amplitude effects the system performance which can be managed by these technique and improve the BER performance. The efficient PAPR is achieved by combination of both the schemes up to 80% reduction is done with 1024 number of subcarrier.



Bit error rate BER is a parameter which gives an excellent indication of the performance of wireless channel. When data is transmitted over a channel, there is a possibility of errors being introduced into the system. The integrity of the system may be compromised if errors are introduced into the data. As a result, it is necessary for the performance of the system,bit error rate, BER, provides an ideal way in which this can be achieved [4]. The bit error rate or bit error ratio (BER) is the rate at which errors occur intransmission system. The definition of bit error rate can be translated into a simple formula Bit Error Rate assesses the full end to end performance of a system including the transmitter, receiver and the channel between the two. Main reason for the degradation of a data transmitted through channel is noise and changes to the propagation path of radio signal. Signal to noise ratios (SNR) is parameter that is more associated with radio links and radio communications systems[5,6]. SNR can also define BER in terms of the probability of error. BER and SNR are excellent in the proposed system compare other systems. PAPR is more in rician channel compare to AWGN Channel.

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