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Research paper



Performance analysis of paper, BER and snr of OFDM for different modulation techniques: a survey

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Abstract

The subcarriers must be kept orthogonal to each other, which are called as an Orthogonal Frequency Division Multiplexing to achieve a better performance by using multi carrier modulation. But an injury to reputation of an OFDM method is of its enormous Peak power ratio. This paper is purely based on performance analysis of PAPR, BER and SNR by using different modulation techniques and different schemes

Keywords: *OFDM; PAPR; SNR and BER.*

1. Introduction

Orthogonal Frequency Division Multiplexing is a multi carrier modulation mode which is particularly well appropriated for the transmission of a signal over a dispersion medium or it can be defined as a distinguished form of multi carrier transmission where in subcarriers are orthogonal to one another. In OFDM, data is transformed concurrently by way of various bands. Several benefits or advantages are offered by OFDM through single frequency transmission like huge spectral efficiency, strong enough to fading the channel, immunity to impulse noise, capacity to manage frequency selective fading, sensitive to the small carrier frequency offsets and displays high peak to average power ratio. OFDM uses small guard interval and an action is taken to reduce or prevent the problem of Inter Symbol Interference. Hence instead of complex adaptive channel equalization, simple channel equalization is needed. Orthogonal frequency division multiplexing signal has a typical dispute which is its immense peak power ratio. During the signal transmission and reception, an effective dimension of power amplifiers and D/A converter required is tremendous. This is the drawback of the high PAPR. Because of this result, with the reduced efficiency, the total cost of the transceiver increases. OFDM is the technique of multi carrier transmission where a single set of data is transformed over a number of subcarriers. Multipath propagation is an advantage of OFD, which will scale down the fading effect. The total transmission bandwidth is splitted into a number of orthogonal subcarriers which causes to reduce inter symbol interference, absorption of power and increases the system's contents and efficiency. These are the main ideas of OFDM. An efficiency of the system is reduced because of peak to average power ratio, which is one of the disadvantages of OFDM.

BER is the probability of any given bit being in error. In digital information transmission system, several types of modulation techniques such as BPSK and QAM are used. Over a communication channel, bit error rate can be demarcated as the number of received bits of a data stream which could be affected because of noise, intercession and distortion or errors of bit synchronization. By using Forward Error Correcting codes schemes, this survey is focused mainly on the performance comparison of OFDM–BPSK and QAM system. Normally FEC codes are used to encode the data stream which can pass through communication channels that looks like AWGN channel. By using Selected Mapping (SLM) technique significant gains can be accomplished whereas the complexity remains quite moderate. OFDM is one of the common techniques of multicarrier modulation which is used to transmit signals in diverse environments over wireless channels. High rate data stream is divided in to parallel lower data rate by OFDM and therefore drawn out the duration of the symbol, which helps in eliminating an Inter Symbol Interference. The sub channels will overlap with one another in OFDM system to a great extent that leads to cut down us age of bandwidth. Inter Carrier Interference is also diminished since the sub carriers are orthogonal to one another. OFDM is an innovative multi carrier modulation technique which is adapted to more wireless standards like IEEE802.11a and HiperLAN2. OFDM approach is being extensively used in the wireless communication system due to transmission of high speed data and performance combating in the frequency selective fading channel.

The remaining of the survey is constructed as mentioned below. Section I includes Introduction. Section II discusses the purpose of the survey. Section III characterizes blocks involved in OFDM communication system in detail, Section IV includes simulation or experimental results and analysis of different modulation schemes and techniques, Section V concludes with OFDM issues.

2. Purpose of the paper

OFDM has many advantages such as allowing subcarriers to overlap without any guard band which results in limited wastage of bandwidth without causing Inter Carrier Interference. Large

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data rates which are delivered through multiple carriers results to reduce symbol rate which is unaffected to Inter Symbol Interference that allows bigger data rate when compared to Frequency Division Multiplexing (FDM) and simple guard intervals will develop the system more powerful to the multipath reactions and so on. However, OFDM has some of the major drawbacks to be implemented practically by using MATLAB/Labview. Some of them are bit error rate, peak to average ratio and signal to noise ratio. In this survey paper, all these parameters are discussed and compared with various techniques and different modulation schemes available in the literature.

3. OFDM system

OFDM is a form of digital modulation where the signal is split into various narrow band channels at several frequencies. Fast Fourier Transform (FFT) and Inverse Fast Fourier Transform (IFFT) are two fourier transforms which are used to modulate and demodulate the OFDM individual sub carriers and transfer the spectrum of the signal into time domain through the channel and FFT is used in the receiver side for retrieving the data symbols in serial arrangement. The Cyclic Prefix (CP) is used here in order to prevent inter symbol interference and Guard Interval (GI) is used to eliminate ISI in OFDM system. Linear convolution channel is converted into a circular convolution channel CP. CP restores an orthogonality at the receiver. The transmitted signal is kept periodic by CP. Here CP is applied to bypass ICI. Interleaving is applied which is a vital concept here. The data symbols may be affected by radio channel that are transported on more than one subcarriers that leads to bit errors. The purpose of adding GI is to provide immunity or resistance to propagation delay, echoes and reflections for which digital data is very much delicate. In GI, CP is used for opposing an Inter Carrier Interference inside the OFDM structure. The Cyclic Prefix is the replica of last symbols of the samples placed which makes the signals to appear as periodic in the receiver end which is presented in figure below. The Cyclic prefix is removed before demodulating the OFDM signal by exploiting the structure imposed by making use of cyclic prefix. Synchronization of the symbol could be accomplished.

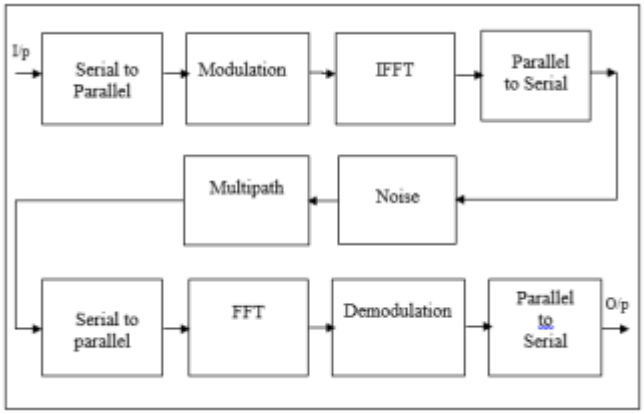


Fig. 1: Block Diagram of OFDM System.

It can be possible to make use of Discrete Fourier Transform (DFT) and an Inverse Discrete Fourier Transform (IDFT) due to the orthogonality of the carrier for modulation and demodulation of the signal. Different modulation schemes like 16-QAM, 64-QAM could be applied to achieve high spectral efficiency. Fundamentally, the work here deals with OFDM system's performance under Rayleigh, AWGN and Rician fading atmosphere. Although the total channel is the frequency selective channel, the channel experienced by each of the subcarrier is a flat fading channel, with each of the sub carriers experiencing an independent Rayleigh fading in an OFDM system. As we all know that the orthogonality is an eminent property for an OFDM system, the synchronization should be extremely good in time domain and frequency domain. We are going to experience Inter Carrier Interference when the orthogonality is lost. It will be responsible to add or insert disturbance from one subcarrier to another. There is one more reason for Inter Carrier Interference to appear in OFDM system. If the guard time is added with no transmission then this will create problem to two FFT's. i.e. IFFT and FFT that produces Inter Carrier Interference. A delayed version of one subcarrier can be interfered with another subcarrier in the next symbol period which could be avoided by enhancing the symbol into guard period that anticipates it and this is said to be called as CP.

4. Experimental results

Renhui Xu et al., [1] proposed a unitary precoder to put an end to spectral leakage of the Out Of Sub Band (OOSB) and to make the peak average power smaller in amount on Discrete Fourier transform based OFDM access uplink signal. And PAPR of the OFDM signal is given by maximum power to average power ratio. i.e.

$$\text{PAPR} = \frac{\text{Ppeak}}{\text{Paverage}} = \frac{\max[|x_n|^2]}{E[|x_n|^2]} \quad (1)$$

Where

x_n= An OFDM signal after IFFT.

E [.] = Expectation operator, it is an average power. Here the optimum precoder method is developed and this method consists of two steps. They are: Firstly eigen value decomposition is used to outline a precoder by curtailing the power radiation of an out of sub band and make a hunt for the excellent permutation of the columns in order to diminish PAPR sufficiently.
Along with this, an iterative decoding algorithm is designed to progress the achievement of the system on Bit Error Rate (BER). Evaluation can be done on the basis of improving the performance of the proposed method in connection with probability of reduction of PAPR successfully which is shown in figure 2 and simulations/Labview can be employed to figure out the BER performance of the proposed method. The number of iterations will play vital character in an iterative decoding.

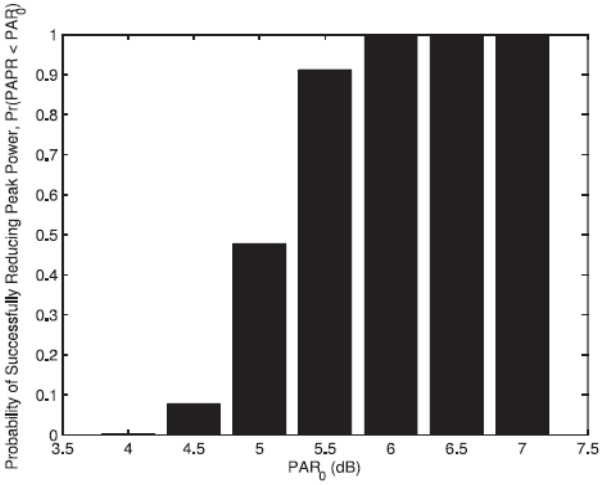


Fig. 2: Probability of Reducing the PAPR by Using Proposed Method.

By increasing, the number of iterations the bit error probability is decreased as shown in figure 3 where the performance of BER is calculated through Channel B. Channel B is one among two multipath fading channels that are generated by Jakes model. Without declining the spectral leakage suppression efficiency, the PAPR of OFDM blocks can be deminished with large probability by permutating the columns of precoder matrix. Further, in order to accomplish an adequate performance of the system's BER an iterative decoding algorithm will make use of the frequency diversity.

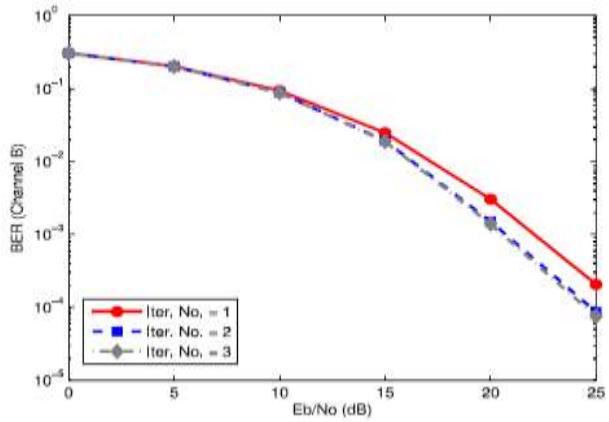


Fig. 3: Performance of BER versus Number of Iteration in the Iterative Detection of Proposed Precoder.

Lin Yang et al., [2] proposed that the iterative clipping and filtering methods to eliminate out of band interference and to abolish the continued growth of the peak power. But bit error rate performance will be deteriorated an iterative process. So to restore an iterative clipping noise, a semi-analytic pattern is proposed based on compressed sensing. For 16 QAM OFDM in AWGN channel, comparison amidst the semi-analytic and simulation results are shown in figure 4 when number of iterations L = 8. It can be observed from the figure 4 that the pleasant adjustment with the BER simulation results will be demonstrated by semi-analytic BER results which in turn will allow improving the BER performance of the Iterative Clipping and Filtering system which is based on clipping model.
Clipping ratio $\gamma$is defined as,

$$\gamma = \frac{A_{max}2}{E[|x_n|^2]} \tag{2}$$

Where A_{max} is the clipping level, E[·] represents an expectation. x_n= Time domain OFDM symbol (n = 0, 1, . . . , JN − 1) and

$$x_n = \frac{1}{\sqrt{JN}} \sum_{K=0}^{JN-1} X_k e^{j\frac{2\pi kn}{JN}} \tag{3}$$

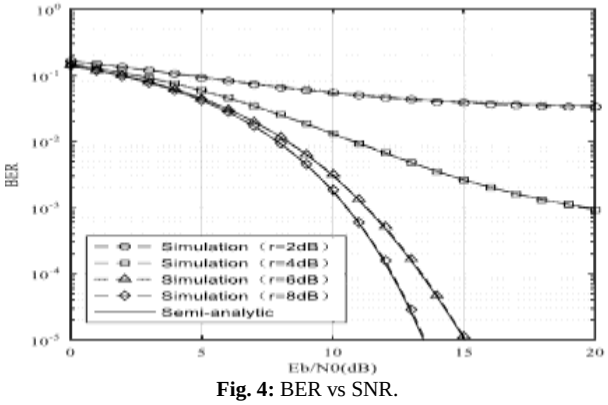


Fig. 4: BER vs SNR.

Out of band distortion can be eliminated by filtering the clipped OFDM signal. But this leads to regrowth of the peak. Hence to achieve a better PAPR ICF is used. In figure 5 it is observed that by increasing the number of iterations L, ICF approach can substantially diminish PAPR of OFDM signal.

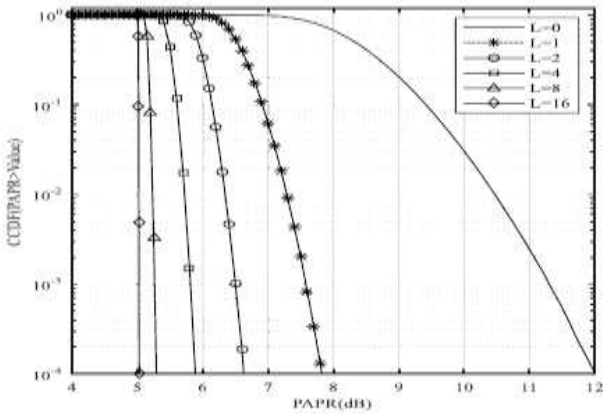


Fig. 5: Distribution of PAPR of an OFDM Signal with ICF.

Chirawat Kotchasarn [3] focuses on the analysis of expression of BER of the correlated MC-CDMA system over $\alpha - \mu$ fading channel. And he has performed the Signal to Noise Ratio of the system where SNR is given by the meaningful information to the noise signal or unwanted signal ratio. i.e.

$$\text{SNR} = \frac{P_{signal}}{P_{noise}} \tag{4}$$

Where P = average power.SNR should be calculated at similar points in a system within the similar bandwidth of system. SNR can be obtained by calculating the following formula if the signal and the noises are measured across the same impedance. i.e.,

$$\text{SNR} = \frac{P_{signal}}{P_{noise}} = \left(\frac{A_{signal}}{A_{noise}}\right)^2 \tag{5}$$

Where A is the amplitude of the root mean square value. SNR in decibel is defined as

$$\text{SNR}_{dB} = 10\log_{10}\frac{P_{signal}}{P_{noise}} \tag{6}$$

= Psignal,db- Pnoise,db

which can be written identically by using an amplitude ratio as

$$\text{SNRdB} = 10\log10\left(\frac{A_{signal}}{A_{noise}}\right)^2$$

$$= 20\log10\left(\frac{A_{signal}}{A_{noise}}\right) \tag{7}$$

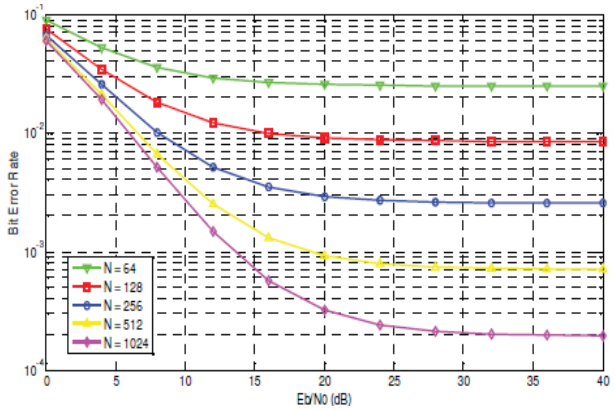


Fig. 6: BER for MC-CDMA over $\alpha = 2, \mu = 1$ Channel.

And the BER expression is calculated by using Moment Generating Function (MGF) technique. Also he has noticed that the more the number of subcarriers the better is the performance of BER which is shown in figure 6. In figure 7 the performance of the system in terms of BER for $\boldsymbol{\alpha}$ =2 and $\boldsymbol{\mu}$=1 with number of users equal to 25 for different number of subcarriers N = 64, 128, 256,

512 and 1024. And can be noticed that, more the subcarriers the better is the performance of BER.

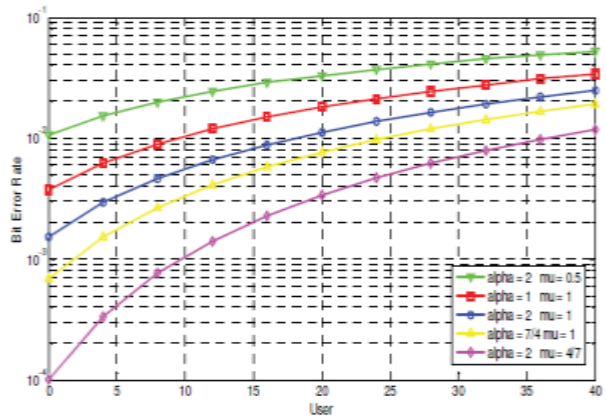


Fig. 7: BER for MC-CDMA over Different Channels.

In figure 7, he has shown the BER of the system for the different values of α & μ over correlated fading channels. i.e. for $\alpha = 2$ & $\mu = 0.5$ the system is called as one-sided Gaussian channel. While for $\alpha = 2$ &μ =1 the system is said to be known as Rayleigh fading channel and finally for $\alpha = 2$ & $\mu = 4/7$, this system is known as Nakagami fading channel.

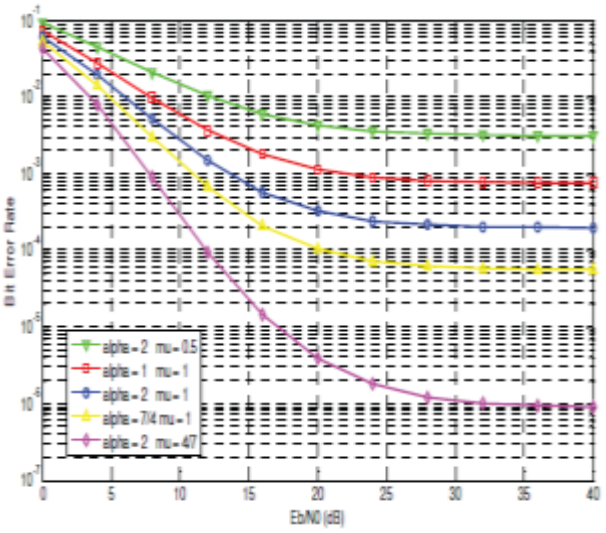


Fig. 8: Shows the BER of the System for MC-CDMA over Different Channels with SNR = 10db and the Subcarriers of 128.

Figure 8: BER for MC-CDMA over different channels at Eb/N0=10db and subcarriers=128

Yen-Ching Liu et al., [4] investigates that the reduction of the Peak average power can be done by using bit flipping method where bit flip is same as bit manipulation, which is processing individual bits within a byte. The degradation of BER can be relieved by using coding technique called Error Correction Coding (ECC).

Forward Error Correction (FEC) code is the other name of ECC where ECC is the process of adding repetitious data to a message, such that it could be recaptured by receiver even when the number of errors was presented either during the transmission process or on storage. Performance of PAPR of an OFDM system may be calculated with the help of the Complementary Cumulative Distribution Function of an OFDM signal as follows:

$$\text{CCDF}\{PAPR(\hat{s})\} = \text{Prob}\{PAPR(\hat{s}) > \varepsilon\}$$

Meaning that probability of the OFDM signal $(\widehat{s})$ $PAPR$ outstrips the given threshold ε. Bit flipping method is based on Clipping Based and Selective Mapping Based Bit-Flipping methods. These two methods are combined with Active Constellation Extension (ACE) to achieve more the reduction in PAPR. Experimental results show that the proposed designs i.e., CBBF and SLMBBF can achieve adequate reduction of PAPR with very lesser degradation of the BER in most of the cases. Figure 9 illustrates the graph of BER Vs SNR.

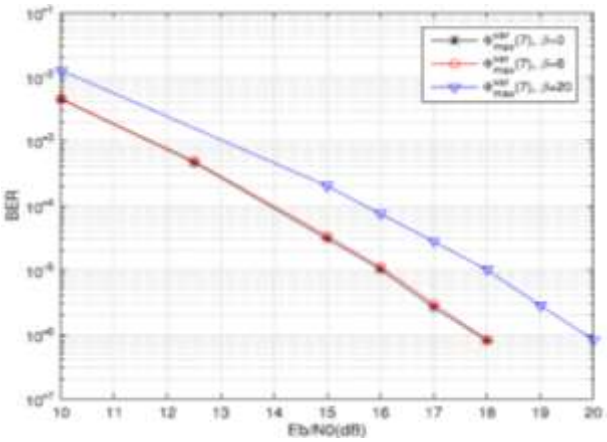


Fig. 9: Graph of BER Vs SNR. Q=2, R = 0.5, $\emptyset_{max}^{var}(7)$, 6 Path Fading Channel.

Fang Yang et al., [5] proposed the clipping noise elimination schemes to mitigate clipping noise that is based on Compressed Sensing (CS) which is responsible for the cause of out of band radiation and increased or addition of Bit Error Rate in OFDM systems. Conventional clipping noise elimination approaches are outperformed by this proposed method in the aspects of both the accuracy and robustness which is verified by both theoretical analysis and numerical simulation. Here, a compressed sensing based approach is investigated to remove the clipping noise in the OFDM systems. PAPR is given by the maximum peak power to the average power ratio of an OFDM signal for discrete time domain signal, and it is given by,

$$PAPR_x = \frac{max_{0\le n<N}|x_n|^2}{E[|x_n|^2]} \tag{8}$$

where E{ · } represents the expectation operation.

$$x_n = \frac{1}{N}\sum_{K=0}^{N-1} X_k e^{j\frac{2\pi kn}{N}} \quad 0 \le n < N \tag{9}$$

x_n= time domain OFDM symbol.

This research work focuses to get the highly effective BER performance and to reduce peak to average power ratio by using companding scheme along with two nonlinear companding levels. Nazar Ali et al., [6] explained μ-law companding scheme is used for the reduction of PAPR. Many techniques such as clipping & filtering and coding have been suggested to scale down PAPR of the system. There's one more approach called Hyperbolic Tangent (HT) operation to decrease PAPR. For an output of μ-law companding algorithm D(x) and decompanding algorithm D(r), mathematical expressions are given respectively as,

$$D(x) = \frac{v}{log(1+\mu)}\log\left(1+\frac{\mu}{v}|x|\right)sgn(x) \tag{10}$$

$$\bar{D}(r) = \frac{v}{\mu}\left(e^{\frac{|r|log(1+\mu)}{v}} - 1\right) \tag{11}$$

Where x = baseband OFDM signal. r = received signal. v, maximum amplitude of signal x. μ, the companding level and sign(.), the signum function. Figure 10 (a) and (b) shows the graphs of PAPR Vs μ and BER Vs μ.

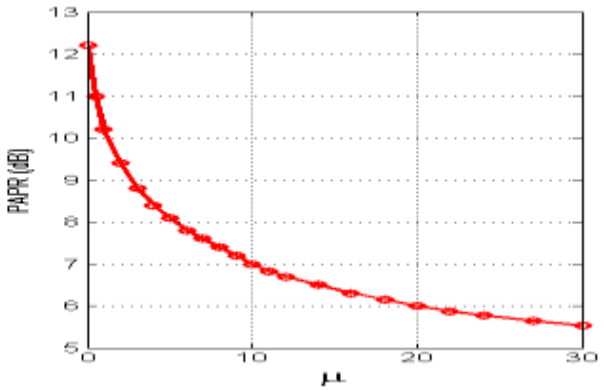


Fig. 10: a): PAPR Vsμ.

And as the value of $\boldsymbol{\mu}$ increases it shows the concession between decreasing of PAPR and increasing of BER. When compared to μ-law companding technique, Error Vector Magnitude (EVM) is better to achieve a good reduction of PAPR with an endurable increase either in BER or SNR.

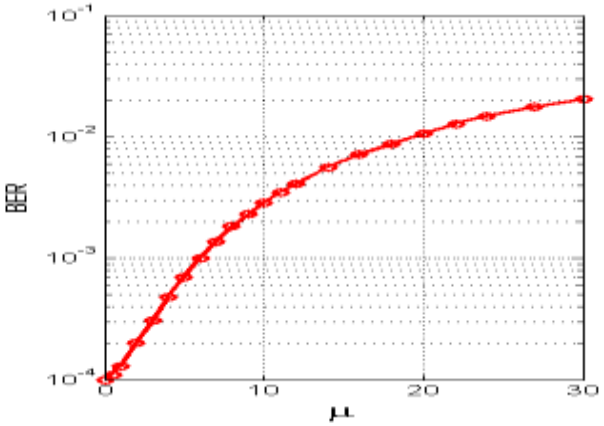


Fig. 10: B): BER Vs μ.

In [7], Georges Kaddoum presents a Multiuser OFDM based Chaos Shift Keying modulation (MU OFDM-DCSK). Here in time domain, the spreading process is implemented over multi carrier frequencies in this system. This system desires in boosting the spectral and energy efficiencies by granting transmission of multiple access their by diminishing the complication by making use of Inverse Fast Fourier Transform/Fast Fourier Transform applications rather than parallel matched filters. MU OFDM-DCSK performance is evaluated and demonstrated in fig. 11 in multipath Rayleigh fading channels for M = 49 bits per user as the range of FFT N_t = 128 and for different values of spreading factor i.e.,β = 12 and β = 120.

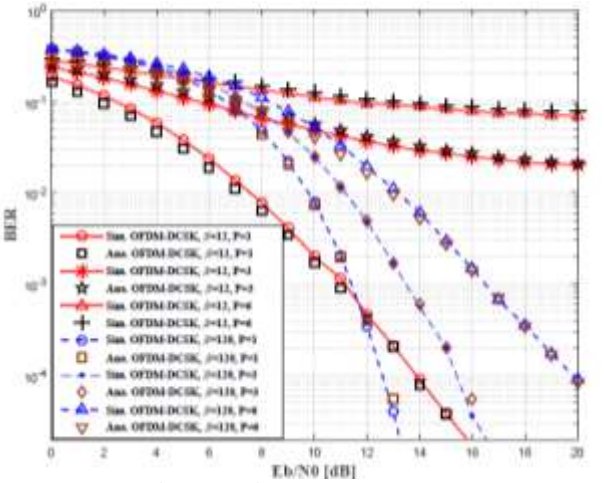


Fig. 11: Performance of MU OFDM DCSK W.R.T BER.

And lastly, performance of the bit error rate is examined under multipath Rayleigh fading channels in the presence of multi user and AWGN interferences.Anas Tom et al., [8] explored the two major drawbacks where the OFDM system suffers inherently. They are: High power leakage of Out Of Band (OOB) and high peak power ratio. For the joint cut down of these two drawbacks, a novel resolution which is called as a suppressing alignment was introduced. A suppressing signal, generated by suppressing alignment, will reduce jointly power leakage of OOB and peak average power of OFDM-based systems. An elementary profit of suppressing alignment is it doesn't lower the spectral efficiency because it misuses hereditary redundancy in OFDM system which is granted by CP.

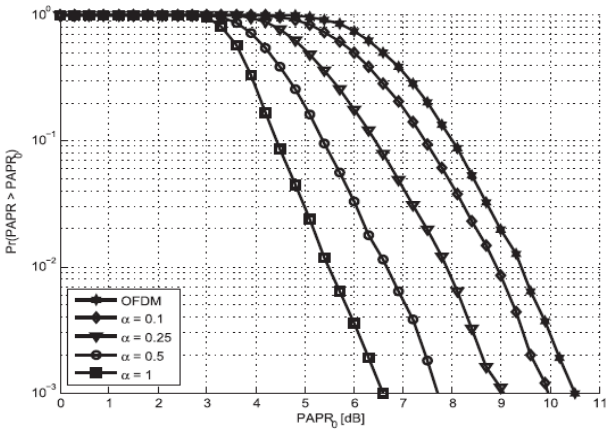


Fig. 12: Performance of PAPR for 4-QAM, $\lambda = 0.5$.

And the suppressing signal may be fabricated in this way that it doesn't organize noise to the information data which is available in OFDM symbol. Instead of using the wireless channel, suppressing signal is aligned at receiver end with CP which efficiently creates noise free transmission with the good accomplishment of the BER. An interesting or an excellent reduction of OOB power leakage and PAPR are shown through simulations. i.e. by using MATLAB/Labview. Figure 12 illustrates the performance of PAPR by using digital modulation technique like 4-QAM.
Figure 13 explains the performance of BER under Rayleigh multipath fading channel.

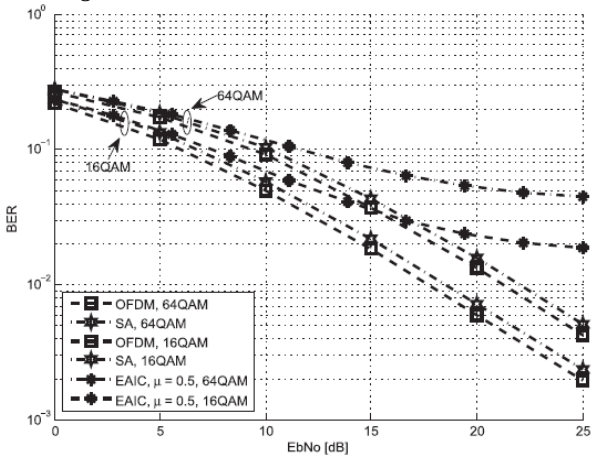


Fig. 13: BER Performance under Rayleigh Multipath Fading Channels, $\lambda = 0.5$ And α= 0.25.

Pooja K. S et al., [9] demonstrated that how well the detection and correction of errors are done by using FEC strategies in a communication system. By enhancing FEC strategies, performance of the BER will be improved or progressed. FEC contains encoder along with an interleaver. Interleaving is used for error correction in block codes to make them more impressive in a burst noise domain since digital communications are more prone to random burst errors. Here, evaluation and observation of the OFDM system is done with respect to BER performance.

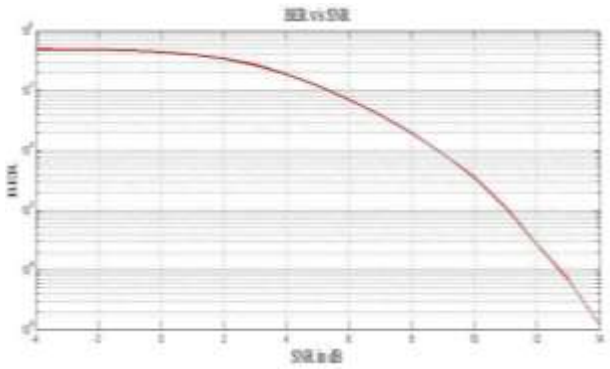


Fig. 14: A Graph of BER and SNR of OFDM System for16-QAM.

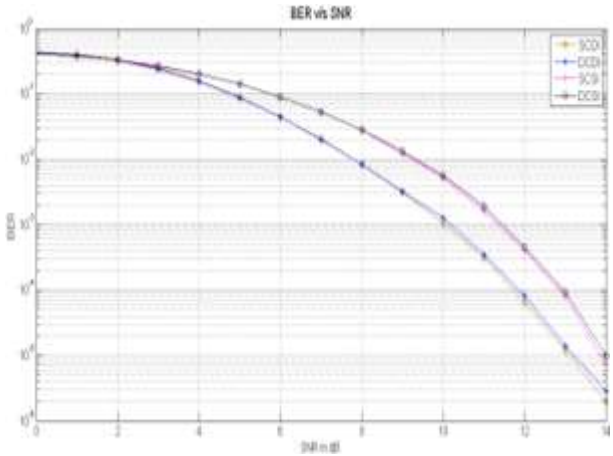


Fig. 15: Four Schemes for 16-QAM W.R.T BER Performance.

Figure 15: Four schemes for 16-QAM w.r.t BER performance
And also four FEC schemes are analyzed here. The design is implemented by using Simulink/Labview. The graphs are shown in figure 14 and 15.
In [10], Evaluation of SNR is implemented on fading channels lie AWGN, Rayleigh and Rician by Deepak K. Chy and Md. Khaliluzzaman in terms of constant bit error rate. When compared to AWGN and Rayleigh fading channels, Rician channel shows better performance. Probability density function of Rayleigh distribution is given by

$$f(x;\sigma)=\frac{x}{\sigma^2}e\frac{-x^2}{(2\sigma^2)},\ x\geq 0 \qquad (12)$$

Where σ is the scale parameter of the distribution.
Probability density function of the Rician distribution is given by

$$f(x\mid v,\sigma)=\frac{x}{\sigma^2}e\left(\frac{-x^2+v^2}{2\sigma^2}\right)I_o\left(\frac{xv}{\sigma^2}\right),\ 0\leq x<\sigma \qquad (13)$$

Where $I_0(z)$ is the modified Bessel function of the first kind with order zero.BER is inversely proportional to SNR. High BER causes increased loss of packets, increases the delay and their by decreases throughput of the system. Signal to noise ratio is typically used to figure out communication link quality and it is measured in decibels. The work presented by Deepak K. Chy and Md. Khaliluzzaman suggests that by using better techniques it mandatory to give outstanding and profitable services to customers. In figure 16 it can be absorbed that the value of SNR is rising with the higher value of M for the constant value of BER which is 10^{-3}.

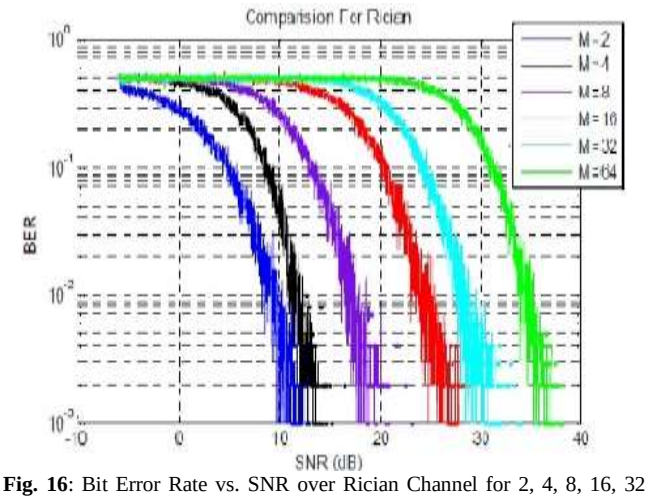


Fig. 16: Bit Error Rate vs. SNR over Rician Channel for 2, 4, 8, 16, 32 And 64 DPSK Modulations.

5. Conclusion

There are many digital modulation techniques to overcome generic problem like peak to average power ratio that are faced by the OFDM signals. Many researchers worked on various digital modulation schemes, various channels and other techniques to extract or to reduce BER performance degradation. This attempt is to choose simple and basic methods to improve the signal to noise ratio in a noisy channel at the cost of maximum data transmission capacity. Most of the literature explains the work done for the betterment of PAPR, BER and SNR by using different methods. This survey helps for Researchers work.

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