Performance Analysis Of OFDM System Using Different Types Of Modulation Techniques Under Different Fading Channels And Reducing PAPR Of An OFDM System By Clipping Method

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Abstract

Higher data rates connectivity with strong link reliability is the important requirements of today's wire- less communication systems user. This is the driving force for the future mobile broadband networks (4th Generation (4G)). Multiple Input Multiple Output-Orthogonal Frequency Division Multiplexing (MIMO-OFDM) systems accomplish such require- ments. This project deals with performance analysis of different modulation schemes such as BPSK, M-ary QAM and QPSK for OFDM system in MATLAB. BER for BPSK, QAM and QPSK for single channel OFDM system are derived. Comparisons of simulated and theoretically calculated BER are presented using MATLAB simulation for both AWGN and Rayleigh channel. A method to reduce Peak to average power ratio (PAPR) is also presented.

Keywords: Fading, Orthogonality, Interference, PAPR

I. INTRODUCTION

Now a day it is necessary to judge the performance evaluation of wireless gadgets by thinking about transmission characteristics, wireless channel parameters and gadget structure. In wireless channels, many models are planned and investigated to calculate BER. The signal is obtained and encrypted by using many other forms of the received signal. Hence, we have a tendency to think about multilink receiver structure. Wireless communication is one in every of the premier dynamic regions of innovation advancement and has turned into a perpetually crucial and recognized a piece of day by day life. Simulation of wireless channels accurately is extremely vital for the planning and performance analysis Communications Field. A critical issue is in wireless application improvement is that the decision of attenuation models .A relative investigation of BPSK ,QPSK and QAM will likewise give learning base which serves to application advancement in genuine world.

In wireless communication technology the main purpose is to afford high quality of data. Orthogonal frequency division multiplexing (OFDM) has turn out to be a more popular technique for transmission of signals over wireless channels.

In OFDM, signals are transmitted in sub carriers of various sub channels which are parallel. The frequency of sub-channel are so selected in such a manner that they are orthogonal to each other and therefore it avoids interfere carrier interference. This concept makes it doable to transmit the data in overlapping frequency and therefore reduces the bandwidth requirement considerably. OFDM is gainful in numerous perspectives, for example low computational multifaceted nature, recurrence particular blurring, and simple to execution utilizing IFFT/FFT. In wireless communication systems frameworks the information bits are transmitted in radio space, channels are normally multipath blurring channels, which cause which causes inter symbol interference (ISI in the received signal. ISI is unwanted and it builds bit error rate. ISI causes due to multi- path proliferation and band constrained channels. To wipe out ISI from the flag, solid equalizers are utilized, which requires channel impulse response (CIR). Equalizer remunerate the inter symbol interference means it works such that BER ought to be low and SNR ought to be high. Leveling methods have significance to outline of high information rate remote frame- works. The majority of the remote collectors are outfitted with the equalizer which gives great outcome. The nature of remote correspondence relies on the three parameters i.e. rate, range and unwavering quality of transmission. These parameters are connected with each other. Concurrent change in each of the three parameters can be refined with the assistance of new strategy called MIMO helped OFDM framework. Presently a days combination of OFDM procedure with MIMO framework has been a region of fascinating in the field of expansive band remote correspondence. MIMO is a recurrence particular procedure. OFDM can be utilized to change over such a recurrence particular channel into set of parallel recurrence level sub channels. MIMO-OFDM framework can accomplish solid high information rate transmission over wide band remote channel l [12]. BPSK modulation technique is used in MIMO-OFDM system to evaluate the BER performance. W(n) i.i.d. additive white Gaussian noise sample and X (n)is the discrete time channel impulse response (CIR). At the recipient, right off the bat serial to parallel change happens and cyclic prefix evacuated. In the wake of expelling the CP, the got tests are sent to a quick Fourier change (FFT) square to de-multiplex the multi-transporter signals.

II. Literature Survey

In the proposed scheme [1] proposes two enhanced OFDM-IM schemes designed to attain higher spectral efficiency and diversity gain, respectively. It give the I- and Q-dimensions together for index modulation, providing transmission of more index modulation bits in each subcarrier group revealed by both theoretical analyses and simulations, which enable low-complexity discovery and show superior error rate performance over the existing OFDM schemes.

In this paper [2]It describes the MIMO-OFDM system performance over the Rayleigh blurring channel which is one of the well-liked technique for mobile communication and performance using ASTC encoder is deliberate and simulation results are carried out for various transmitters, and also the performance of system is evaluated by calculating the chance of BER are studied.

]In this propsed paper [3] They explain inter carrier interference (ICI) lessening; high reliability; and better performance in multipath fading. The main result to be considered at receiver is fading things which must be controlled at receiver using equalization technique.

In this paper [4] It describes the effectiveness of OFDM and assesses its suitability as a modulation technique in wireless communications. Several of the main factors affecting the performance of a typical OFDM system are considered and they include multipath delay spread, channel noise, distortion (clipping), and timing requirements. The core processing block and performance analysis of the system is modeled using Matlab.

In this paper [6]It describes about the benefit of OFDM and the drawback of it and method to beat or to reduce the problems of OFDM, few techniques e.g. SLM, PTS, Clipping, Coding, Pre-coding etc are discussed. [10]

This paper [7] It develops an analytical structure intended to examine the link level performance of rate adaptation in a time-varying channel for MIMO OFDM systems. The paper address outmoded CSI impact due to feedback delay and derived new threshold for SNR, results are compared with the simulation results.

In this paper [8] It describes about the PAPR in the OFDM system ,its effect and provides some techniques which can be used to reduce the PAPR according to the requirement.

sectionMethodology

1) Study the basics of MIMO-OFDM
2) Analyze the performance of different modulation schemes of OFDM and plot the relevant graphs using MATLAB tool and comparing with different guard Intervals in different fading channels.
3) Reducing PAPR by using one of the signal Distortion method i.e, Clipping method

III. Modulation

Modulation is the method of fluctuating one or more properties of a intervallic waveform called the carrier signal, with a modulating signal that ordinarily contains data that has to be transmitted. This modification is termed as modulation, and the transmitted signal is called as modulated signal. At the receiver part the original signal is recovered this method or process is called as demodulation . Modulation systems are relied upon to have three positive properties they are

- Good Bit Error Rate Performance: Modulation plans ought to accomplish low piece mistake rate within the sight of blurring, Doppler spread, interference and thermal noise.
- Power Efficiency:Power restriction is one of the basic outline challenges in compact and portable applications. Nonlinear enhancers are generally used to build control productivity/efficiency. Be that as it may, nonlinearity may corrupt the bit mistake rate execution of some balance plans.
- Spectral Efficiency: The modulated signals power spectral density ought to have a thin main lobe and quick roll-off of side lobes. Spectral efficiency is calculated in units of bit /sec/Hz.

A. OFDM General Block Diagram

OFDM is multiplexing scheme that divide input data brook became more narrowband data channel to divide the bandwidth accessible. Narrowband channel is called subcarrier which transmit phase or amplitude modulated data signal. Different with Frequency Division Multiplexing (FDM), OFDM have subcarrier that orthogonality. This orthogonality can reduce inteference between subcarrier and increase spectrum efficiency utilization. OFDM receiver require frequency synchonization to combat Inter-Carrier Interference (ICI).This inteference occurs caused by Doppler shift due the mobile device movement and multipath channel.

- Data bits stream are splitted from serial to parallel and each subcarrier is modulated using phase or amplitude modulation. Modulation prosses is called as symbol mapping.
- The each subcarrier is modulated separately or individually and carried through OFDM channel
- All subcarrier contains the complex signal due to use of IFFT module
- Parallel data bits are converted to serial and are separated int real and complex part respectively are processed on Digital to Analog Converter (DAC). Both analog signal are multiplied by radio frequency with shift its phase 90 degree and summing both. This signal will transmit over antenna. The below figure shows the diagram of OFDM system.
- The receiver will receive real and imaginery signal separately and they are processed by LPF to eliminate mirrored frequencies. Then, they are quantized by Analog to Digital Converter (ADC) block and the signal is calculated by Fast Fourier Transform (FFT) module.

- Demodulation of data will be done according to the type of modulation used. Parallel data stream is converted into data serial to obtain the desired data. Due to multipath propagation received signal will be received many times ,specially in urban environment or mobile device are moving high speed. Line of sight and multipath signal have difference arrival time. It is called delay spread which can cause Inter Symbol Inteference (ISI).

OFDM scheme proposes to lessen of ISI effect provided that can conserve orthogonality. Orthogonality OFDM subcarrier can be achieved with addition of guard time (guard interval). The OFDM guard time can be do by insert zero padding (ZP) or cyclic prefix (CP). CP is to expand the OFDM symbol by copying the last samples of the OFDM symbol into its front. CP is introduced before the OFDM symbol. Let TG denote the length of CP and Tsub denote the duration of OFDM symbol without guard time. So, the extended OFDM symbols now have the duration of $T_{sym} = T_{sub} + T_G$. Guard time is selected longer than multipath delay so as not to cause inteference with the next OFDM symbol. The other advantage of CP is combating Inter Carrier Inteference (ICI) which is crosstalk between subcarriers. detailed description abput guard interval is discussed in below sectio. OFDM system needs synchronization in the receiver side to find the beginning of each symbols corectly. Synchronization parameters include finding the right time delay, frequency deviation and phase shift of each symbols in the subcarrier. These parameters can be determined with addition redundancy in some of the subcarriers which transsmitted. The redundancy is called pilot symbol or preamble. The parameters are known by looking pilot signal from data received and will be calculated for synchronization and channel estimation process. The density of pilots detemine quality of synchronization but decrease of data rate transmission.

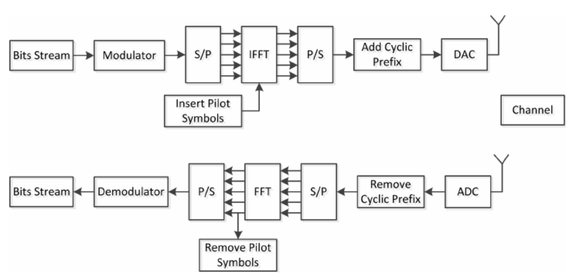

Fig. 1. OFDM Block Diagram

B. OFDM Modulation and Demodulation

OFDM transmitter maps the message bits into a succession of PSK or QAM images which will be along these lines changed over into N parallel streams. Every one of N images from serial-to-parallel (S/P) change is done by the diverse subcarrier .Let

$$\{X_l\,[k]\}$$

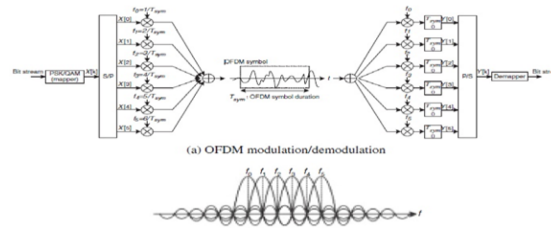

Fig. 2. Realization of subcarrier Orthogonality and Illustrative block diagram of OFDM modulation and demodulation

mean the lth transmit image at the kth subcarrier, l=0,1,2 . .., k=0,1,2 .. . .. N-1 . Because of the S/P change, the term of transmission time for N images is reached out to NTs, which shapes a solitary OFDM image with a length of Tsym Due to the S/P conversion, the duration of transmission time for N symbols is extended to NTs, which forms a single OFDM symbol with a length of Tsym. Let denote the lth OFDM signal at the kth subcarrier, which is given as

$$\Psi_{l,k}(t) = \{e^{j2\Pi\, f_k(t-l\,T_{sym})}, 0 < t < T_{sym}\}$$

Then the passband and baseband OFDM signals in the continuous-time domain can be expressed respectively as

$$X_l(t) = \mathrm{Re}\{\frac{1}{T_{Sym}} \sum_{l=0}^{\infty} \{\sum_{k=0}^{N-1} X_l[k]\, \Psi_{l,k}(t)$$

and

$$X_l(t) = \sum_{l=0}^{\infty} \sum_{k=0}^{N-1} X_l(k)\, e^{j2\Pi\, f_k(t-l\,T_{sym})}$$

The continuous-time baseband OFDM signal in Equation can be sampled at t = lTsym + nTs with Ts =Tsym/N and fk= k/Tsym to yield the corresponding discrete-time OFDM symbol as

$$X_l[n] = \sum_{k=0}^{N-1} X_l(k)\, e^{j2\Pi kn/N}$$

The transmitted signal Xl [k] can be remade by the orthogonality among the subcarriers where the impacts of channel and noise are not considered. Give [yl(n)] a chance to be the example estimations of the got OFDM symbol yl(t) at t=lTsym+nTs. At that point, the combination in the balance procedure can be spoken to in the discrete time as takes after

$$Y_l[k] = \frac{1}{N} \sum_{n=0}^{N-1} \sum_{i=0}^{N-1} X_l[i]\, e^{j2\Pi(i-k)n/N} = X_l[k]$$

C. OFDM Guard Interval

The OFDM guard interval can be inserted in two different ways. One is the zero padding (ZP) that pads the guard interval with zeros.The other is the cyclic extension of the OFDM symbol(for some continuity) with CP (cyclic prefix) or CS (cyclic suffix).

- CP is to extend the OFDM symbol by copying the last samples of the OFDM symbol into its front. Let TG denote the length of CP in terms of samples. Then, the extended OFDM symbols now have the duration of $T_{sym} = T_{sub} + T_G$

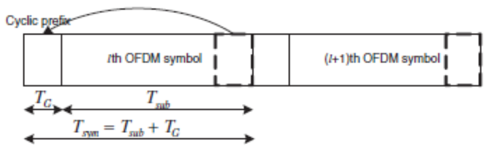

Fig. 3. OFDM symbol with CP

- CS is also a cyclic extension of the OFDM system. It is different from CP only in that CS is the copy of the head part of an effective OFDM symbol, and it is inserted at the end of the symbol. CS is used to prevent the interference between upstream and downstream, and is also used as the guard interval for frequency hopping or RF convergence, and so on.

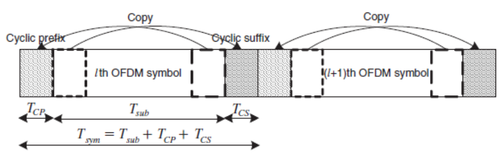

Fig. 4. OFDM symbol with both CP and CS

- We may insert zero into the guard interval. This particular approach is called as ZP adopted by multiband-OFDM (MB-OFDM) in an Ultra Wide-band (UWB) system. Since the ZP is filled with zeros, the actual length of an OFDM symbol containing ZP is shorter than that of an OFDM symbol containing CP or CS and accordingly, the length of a rectangular window for transmission is also shorter, so that the corresponding sinc-type spectrum may be wider.

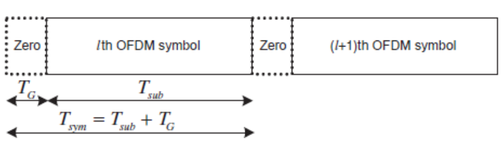

Fig. 5. OFDM symbol with ZP

D. BER of OFDM System

The analytical BER expressions for M-ary QAM signaling in AWGN and Rayleigh channels are respectively given as

$$p_e = \frac{2(M-1)}{M\log_2 M} Q\left(\sqrt{\frac{6\,E_b}{N_0}\frac{\log_2 M}{M^2-1}}\right)$$

for AWGN channel

$$p_e = \frac{M-1}{M\log_2 M}\left(1 - \sqrt{\frac{3\mathrm{g}\log_2 M / M^2 - 1}{3\mathrm{g}\log_2 M \Big/ (M^2-1) + 1}}\right)$$

for Rayleigh fading Channel where g and M denote Eb=N0 and the modulation order, respectively while Q(.) is the standard Q-function defined as

$$Q = \frac{1}{2\Pi}\int_x^{\infty} e^{-t^2/2} dt$$

IV. PAPR REDUCTION

The Tx signals in an OFDM system can have high peak values in the time domain since numerous subcarrier components are added via an IFFT operation. Therefore, OFDM systems are known to have a high PAPR (Peak-to-Average Power Ratio), compared with single-carrier systems. In fact, the high PAPR is one of the most disadvantageous aspect in the OFDM system, as it decreases the SQNR (Signal-to-Quantization Noise Ratio) of ADC (Analog-to-Digital Converter) and DAC (Digital-to-Analog Converter) although degrading the effectiveness of the power amplifier in the Tx. The PAPR difficulty is more important in the uplink since the competence of power amplifier is critical due to the restricted battery power in a mobile terminal.

V. WHAT IS PAPR

PAPR is the ratio between the maximum power and the average power of the complex passband signal s(t) that is,

$$\mathrm{PAPR}\bar{\mathrm{S}}(\mathrm{t}) = \frac{\max|s(t)|^2}{E\{|s(t)|\}^2}$$

The above power characteristics can also be described in terms of their magnitudes (not power) by defining the crest factor (CF) as Passband condition:

$$CF = \sqrt{PAPR}$$

In the PSK/OFDM framework with N sub bearers, the most extreme power happens when the majority of the N subcarrier parts happen to be included with indistinguishable stages. Accepting that $E\{|s(t)|\}^2$=1,it brings about PAPR is N that is, the most extreme power proportionate to N times the normal power.We take note of that more PAPR is normal for M-QAM with M greater than 4 than M-ary PSK. In the interim, the likelihood of the event of the greatest power flag diminishes as N increments. At the end of the day, the to N biggest PAPR infrequently happens. We are regularly intrigued by finding the likelihood that the signal control is out of the direct scope of the HPA. Towards this end, we initially think about the dissemination of yield signals for IFFT in the OFDM framework. While the info signs of N-point IFFT have the autonomous and limited sizes which are consistently circulated for QPSK and QAM, we can expect that the genuine and fanciful parts of the time-area complex OFDM flag s(t)(after IFFT at the transmitter) have asymptotically Gaussian dispersions for an adequately expansive number of subcarriers by as far as possible hypothesis. At that point the plentifulness of the OFDM flag S(t) takes after a Rayleigh dissemination.

A. Clipping and Filtering

TThe section approach is the easiest PAPR diminishment plot, which restrains the greatest of transmit flag to a pre-determined level.The beneath demonstrates a square chart of a PAPR lessening plan utilizing cutting and separating where L is the over examining component and N is the quantity of sub transporters. In this plan, the L-times over examined discrete-time flag $x^{|}(m)$ is created from the IFFT with N (L-1) zero-cushioning in the recurrence area and is then tweaked with bearer recurrenceand is then modulated with carrier frequency f_c to yield a pass band signal $x^p[m]$. Let $x_c^p[m]$ is the clipped version $x^p[m]$ given by

$$x_c^p[m] = \begin{cases} -A & x^p[m] \leq -A \\ x^p[m] & |x^p[m]| < A \\ A & x^p[m] \geq A \end{cases}$$

$$x_c^p[m] = \begin{cases} x^p[m] & \text{if } |x^p[m]| < A \\ \dfrac{x^p[m]}{|x^p[m]|} \cdot A & \text{otherwise} \end{cases}$$

where An is the pre-determined cutting level ,Note that above Equation can be connected to both baseband complex-esteemed flags and pass band genuine esteemed flags and to the pass band signals. Give us a chance to characterize the section proportion (CR) as the cut-out level standardized by the RMS

$$CR = \frac{A}{\sigma}$$

The below block diagram shows the PAPR reduction scheme using Clipping and Filtering

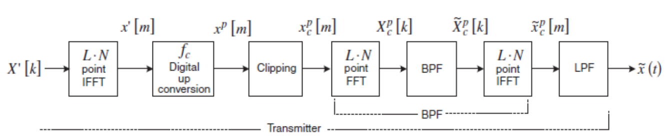

Fig. 6. Block diagram of a PAPR reduction scheme using clipping and filtering

It has been known that $\sigma = \sqrt{N}$ and $\sigma = \sqrt{\frac{N}{2}}$ in the baseband and pass band OFDM signals with N subcarriers, respectively.

VI. Experimental Results

The below Fig(a) and (b) shows the simulated and theoretically calculated bit error rate plot for BPSK signalling in AWGN and Rayleigh OFDM channel respectively. It considers the BER performance for 10^4 symbols with each symbol consisting of 52 bits. Hence FFT size is also equal to 52. The BER obtained in AWGN channel is in the order of for SNR equal to 6 whereas the BER obtained in case of Rayleigh channel is in the order of 10^{-1} for the same SNR. The increased BER in Rayleigh compared to AWGN is due to more attenuation in the received signal caused by reflections from multipath channel. In both the case simulated BER approaches theoretical BER.

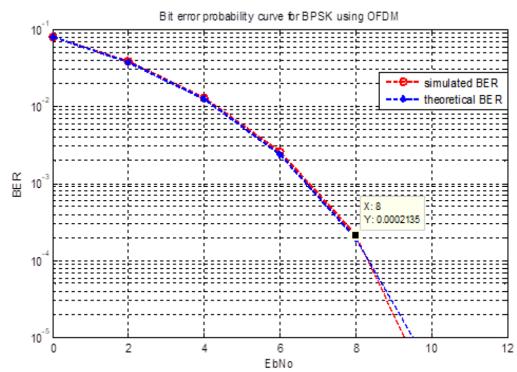

Fig. 7. BER for BPSK in AWGN channel

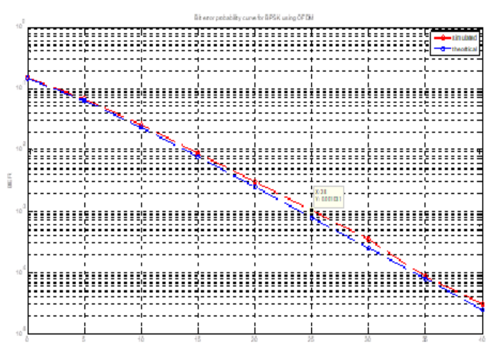

Fig. 8. BER for BPSK in Rayleigh channel

VII. BER for QAM

Figure shows the bit error rate plot for 16-QAM signalling in AWGN and Rayleigh OFDM channel. As seen from the graph 16-QAM outperforms in AWGN channel compared to Rayleigh channel. The BER for 16-QAM at high SNR (=10) is in the order of $10^{-1}$for Rayleigh channel whereas it is less than 10^{-4} for AWGN channel. The degradation in the BER is due to inter symbol interference (ISI) in the multipath Rayleigh channel that indicated the need to introduce ISI mitigation techniques such as clipping and increasing the guard interval. Later analysis was extended to find the best M-ary QAM suitable for OFDM in AWGN channel and the graph obtained is as shown below.

Fig. 9. BER for QAM in Rayleigh channel

Later analysis was extended to find the best M-ary QAM suitable for OFDM in AWGN channel and the graph obtained is as shown below. As seen in Figure, as the order of the M-ary QAM increases the BER worsen. This is due to more bits of information in each symbol which increases the probability of loss of information in the received signal.

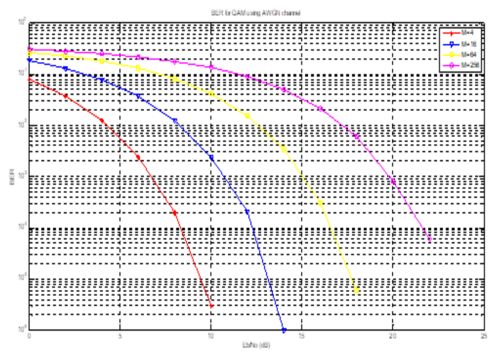

Fig. 10. BER for M-QAM in AWGN channel

VIII. BER FOR QPSK

Figure shows the bit error rate plot for QPSK signalling in AWGN and Rayleigh OFDM channel. As seen from the graph QPSK outperforms in AWGN channel compared to Rayleigh channel. The BER for QPSK at high SNR (=10) is in the order of 10^{-2} for Rayleigh channel whereas it is less than 10^{-4} for AWGN channel. To prevent ISI cyclic prefix of length 64 is used.

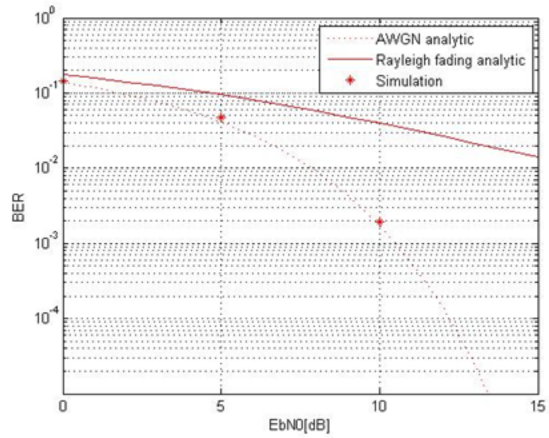

Fig. 11. BER for QPSK in AWGN channel

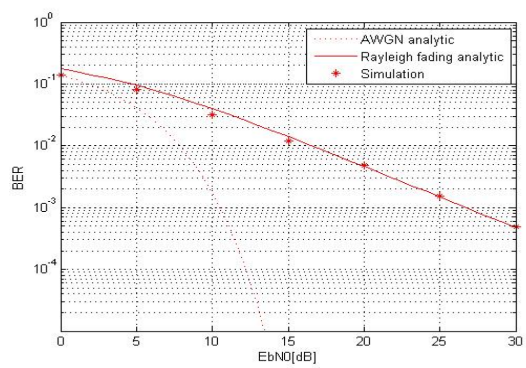

Fig. 12. BER for QPSK in Rayleigh channel

IX. PAPR REDUCTION

Figure (a) shows the CCDFs of crest factor (CF) for the clipped and filtered OFDM signals. Recall that the CCDF of CF can be considered as the distribution of PAPR since CF is the square root of PAPR. It can be seen from this figure that the PAPR of the OFDM signal decreases significantly after clipping and increases a little after filtering. Note that the smaller the clipping ratio (CR) is, the greater the PAPR reduction effect is. Figure (b) shows the BER performance when clipping and filtering technique is used. Here, C and CF denote the case with clipping only and the case with both clipping and filtering, respectively. It can be seen from this figure that the BER performance becomes worse as the CR decreases.

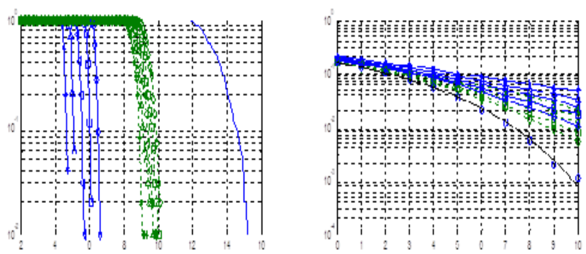

Fig. 13. PAPR reduction analysis

X. Conclusions

This paper deals performance analysis of different modulation schemes for OFDM system using MATLAB. Simulations are carried out for 10^4 symbols with each symbol consisting of 52 bits. The simulated BER is in good agreement with theoretically calculated BER. from the study it reveals ll modulation schemes (BPSK, QPSK, QAM) perform well (low BER) in AWGN channel compared to Rayleigh channel. This is due to reflection from multipath in Rayleigh channel.In M-ary QAM, as the order increases BER worsen. This is due to increase in number of bits per symbol which increases the probability of loss of information in the received signal. BPSK modulation scheme achieves lowest BER in the order of 10^-4 at SNR equal to 10dB compared to all other modulation schemes. So BPSK is more reliable.PAPR of OFDM scheme is reduced using clipping technique.

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