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PAPR Reduction on Adaptive Modulation Based MIMO OFDM System

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Abstract: *OFDM technology considered to be next generation mobile wireless communication technique against the multipath fading channel. OFDM is the effective method for the data transmission for fast speed communication. It has less complexity to implement and having distortion resistance.AlthoughOFDM having some PAPR problem which isthe major drawback for multicarrier transmission system which stimulus power inefficiency for RF section of the transmitter. It has larger no of subcarrier which are independent in nature, because of that its amplitude having highest peak value. In this paper Companding technique is used for reducing PAPR of OFDM system.*

Keywords: *Companding, Orthogonal Frequency Division Multiplexing (OFDM), Peak to Average Power Ratio (PAPR), Frequency Division Multiplexing (FDM), Multiple Input Multiple Output (MIMO), etc.*

I. Introduction

Wireless communication operations, such as long-range communications that are impossible or impractical to implement with the use of wires. In the term is commonly used in the telecommunications industry to refer to telecommunications systems which use some form of energy (radio waves, acoustic energy, etc.) to transfer information without the use of wires. Information is transferred in this manner over both short and long distances communication.

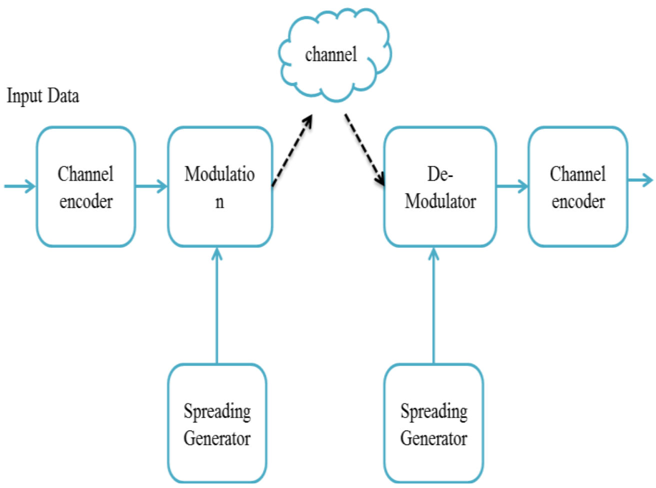

Fig: 1 Communication network

4th generation of wireless communication mainly introduce by a technology known as OFDM technique. The FDM is the main principle of OFDM with a systematic controlled order with improved efficiency of spectral and multipath delay. OFDM is a type of multi carriertransmission method in which a single data signal is divided into multiple data signal, after that these data signal is modulated with subcarrier orthogonal signal and makes a great reeducation in its symbol rate. Its orthagonality between the signals are maintained using time-dispersive channel, therefore whenever increase consistent OFDM signal its resultant signal get larger peak and rest time it remain low. Therefore OFDM experience a higher PAPR problem.

The main advantage of OFDM signal is that it used inverse Fast Fourier Transformation (IFFT) and Fast Fourier Transformation (FFT) for modulation and demodulation. When a fixed transmission technique used in OFDM subcarrier controls its error probability with a higher attenuation and poor performance. However, OFDM techniques use the spectrum more effectively by spacing the channels much closer together. To achieved this arrangement all the carriers keep orthogonal to one another, preventing interference between the closely spaces carrier

The OFDM technique mathematically express as

$$x(t) = \frac{1}{\sqrt{N}}\sum_{k=0}^{N-1} X_k e^{j2\pi k f_0 t}, \quad 0 \le t \le T \quad (1)$$

Where Xk (k=0,1,……N-1) is input data symbol, T is symbol period, N is no. of subcarriers, f0 frequency spacing.

II. Multiple Input Multiple Output

MIMO is an intelligent antenna technology. It has main awareness in wireless communications; because it providesnotable increases in data throughput and signal link range without increasing bandwidth or transmitted power. It reaches this goal by expandingthe total transmits power over the antennas to achieve an array gain that improves the spectral efficiency and signal link responsible to reduced fading.

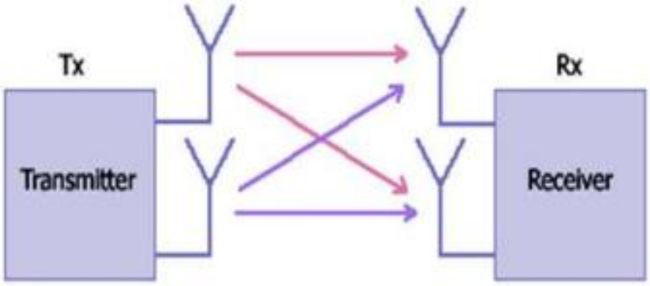

Fig: 2 MIMO 2 Transmitter and 2 Receiver antenna

MIMO technique based on the natural radio wave event known as multipath. Using this multipath, transmitted information jump off to the walls, ceilings, and other objects, for the receiving antenna multiple times with different angles .MIMO can be divided into following three main categories:

Recoding: Precoding is a type of multi-stream beam forming which occur at the transmitter end with a spatial manner. In the single stream beam forming the same signal is transmitted from the each of transmitter to get maximum power gain at receiver input end. Recoding techniques requires information of channel state at the transmitter and the receiver end.

Spatial Multiplexing: This multiplexing requires configuration information of MIMO antenna as it split the high rate signal into multiple low rate streams and this stream signal is transmitter to different transmit antenna with same frequency. At receiver end this stream signal are separated by parallel channel. This technique is very powerful for high signal to noise ratio (SNR) with increasing channel capacity. This technique can be work without knowing information of channel state at transmitter and receiver end.

Diversity coding: Diversity coding used a single stream with coded signal used for transmission these using coded techniques known as space-time coding. The signal is emitted follow the full or near orthogonal coding from each of the transmit antennas .This coding doesn't require any channel information. Sometime diversity coding can be used as combine with spatial multiplexing when some channel information is available at the transmitter end.

III. Literature Review

The many researchers have been done significant work in the field of PAPR reduction technique problem some of the work is described in this paper.

Sohail, et.al, [1], Propose a algorithm using Block wise bit loading on adaptive OFDMtransmission system, uses subcarrier signal on attenuated individually under the selection of frequency and fast fading channel. The performance of channel may be highly fluctuating across the subcarriers and with some variation from symbol to symbol.

J.Faezah, et.al, [2], investigated the performance of OFDM system for encoded adaptive modulation using two modulation technique quadrature amplitude modulation (QAM) and phase shift keying (PSK). Then for enhance of system, we added convolution coding to OFDM system. The added coding made significant results with an improvement in bit error rate (BER) and throughput for representing the advantage of the adaptive modulation schemes to fixed transmission scheme.

P.Kothai, et.al, [3], investigated the performance of OFDM system for un-coded adaptive modulation using quadrature amplitude modulation (QAM) and phase shift keying (PSK). Convolution coding apply to OFDM system for obtained improvements in terms of bit error rate (BER) and throughput the adaptive modulation compared to fixed transmission methods.

M.I.Rahman, et.al, [4], proposed an adaptive OFDM system with changeable pilot spacing. The results showed that a significant improvement in the bit error rate (BER) performance is achieved with immolate a small value of the total throughput of the system. A work is done on several strategies on bit and power allocation for multi-antenna assisted OFDM systems

IV. Working of Adaptive Modulation

Adaptive modulation worked in the two types of adaptation modes. The first one is adaptive modulation without transmission blocking and the second one is adaptive modulation with transmission blocking. In adaptive modulation without transmission blocking, data will be constantly transmitted in this mode even channel is in deep fades. If the channel quality is very bad, a robust modulation mode will be used and when the channel quality is good a spectrally efficient modulation will be used. Adaptive modulation with transmission blocking, transmission will be disabled when the channel is in deep fade. This mode is introduced because the signal quality is too bad to guarantee a required transmission. Data will be transmitted if the channel quality improved.

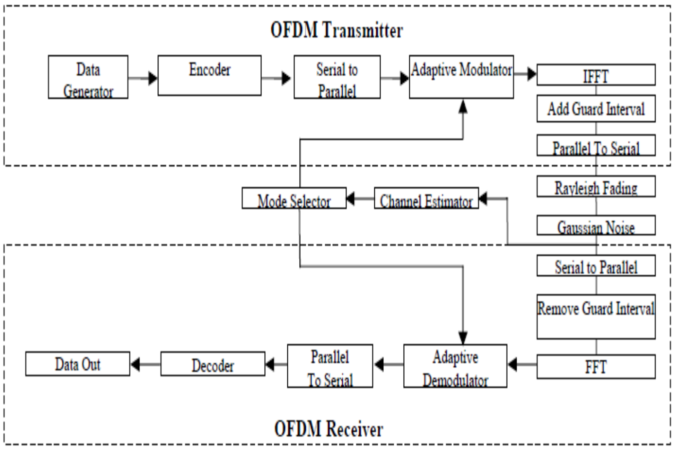

Fig: 3 OFDM transceiver with AMC

V. Companding Algorithm

μ-Law Companding

μ −Law is a simple but effective companding technique to reduce the peak-to-average power ratio of orthogonal frequency-division multiplexing signal. The idea comes from the use of companding in speech processing. Since orthogonal frequency-division multiplexing signal is similar to speech signal in the sense that large signals only occur very infrequently, the same companding technique might be used to improve OFDM transmission performance.

The incoming bit stream is packed into x bits per symbol to form a complex number S_k where x is determined by the QAM signal constellation. For a real sequence output at the IDFT, the complex input to the IDFT has Hermitian symmetry and is constrained as follows

$S_{N-K} = S_k$ (1)

Where k=0, 1, 2……… (N/2)-1, and S(0)=0.

Suppose N is even and $S_k = a_k - jb_k$

$$S(n) = \frac{1}{\sqrt{N}} \sum_{k=1}^{\frac{N}{2}-1} \left(a_k \cos\frac{2\pi kn}{N} + b_k \sin\frac{2\pi kn}{N} \right) \quad (2)$$

$$n = 0, 1, 2 \dots\dots\dots\dots\dots\dots\dots, N-1$$

The μ law companding technique can be then introduced. The samples of OFDM signal s(n) are companded before it is converted into analog waveform. The signal after companding is given by

$$S_c(n) = \frac{A \operatorname{sgn}(s(n)) \ln\left[1+\mu\left|\frac{s(n)}{A}\right|\right]}{\ln(1+\mu)} \quad (3)$$

'A' is normalization constant, after D/A conversion the signal transmitted through channel. At the receiver end, received signal first converted into digital form, the sampling result is

$s(n) = S_c(n) + q(n) + w(n)$

Where q is analog to digital conversion error and w is AWGN channel factor. The expanded signal can be approximated as:

$$S'(n) \approx s(n) + \frac{[q(n) + w(n)]AB}{\mu} + S(n)[q(n) + w(n)]B$$

VI. Peak-To-Average Power Ratio

Theoretically, large peaks in OFDM system can be expressed as Peak-to-Average Power Ratio (PAPR), or referred to as PAPR (Peak-to-Average Power Ratio), in some literatures, also written as PAR. It is usually defined as:

$$\mathrm{PAPR} = \frac{P_{peak}}{P_{average}} 10\log_{10} \frac{\max[|x_n|^2]}{E[|x_n|^2]} \qquad (4)$$

Where P_{peak} represents peak output power, and $P_{average}$ means average output power. E[·] denotes the expected value, xn represents the transmitted OFDM signals which are obtained by taking IFFT (Inverse Fast Fourier Transform) operation on modulated input symbols $X_{k,}$ Mathematically, x_n is expressed as:

$$x_n = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k W_N^{nk}$$

PAPR depends on modulation schemes, oversampling factor and number of subcarriers. There are different kinds of PAPR reduction Schemes. They are:
Distortion Schemes (Clipping and Filtering)
2. Scrambling Schemes
3. Coding Schemes

VII. Simulation Results

Simulation has been done for different number of carriers using MATLAB. In the theoretical and simulated CCDFs of OFDM signals. The PAPR values for different number of carriers are obtained for theoretical as well as simulation perspectives.

Table. 1. Simulation Parameter

.N	Parameter	Specification value
1.	Modulation technique	BPSK, QPSK,QAM-8
2.	SNR range	0-30
3.	MIMO encoding scheme	STBC Alamouti
4.	Channel Model	Rayleigh
5.	No. of transmitter antenna	2
6.	No. of receiver antenna	2
7.	Channel coding	Convolution code
8.	Equalizer	Zero forcing

The parameter of simulation are given as follows

Performance parameter: BER, spectral efficiency and CCDF with SNR and PAPR respectively.
BER threshold for Adaptive Modulation scheme : 10-2
The various results are obtained after the simulation. The results are given as follows,

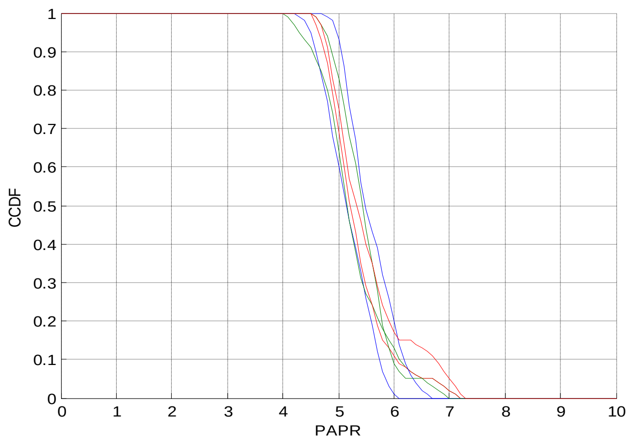

Fig: 4 Shown Peak Average Power Ratio v/s CCDF with AMC water filling without AMC water filling

This graph shown that Peak Average Power Ratio (PAPR) is increase in AMC with water filling as compare to i AMC without water filling.

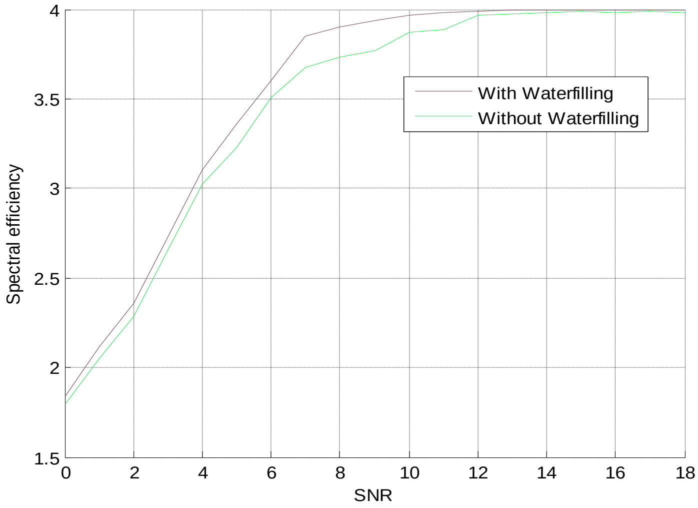

Fig: 5 Shown Spectral efficiency v/s SNR

In this graph shown that Spectral efficiency is increase in Adaptive Modulation Coding with water filling as compare to i AMC without water filling.

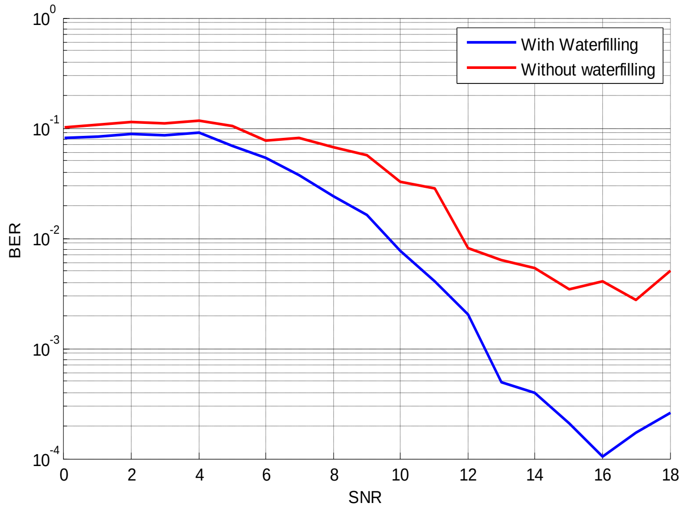

Fig: 6 Shown BER v/s SNR

In this graph shown that BER is reducing in AMC with water filling as compare to AMC without water filling.

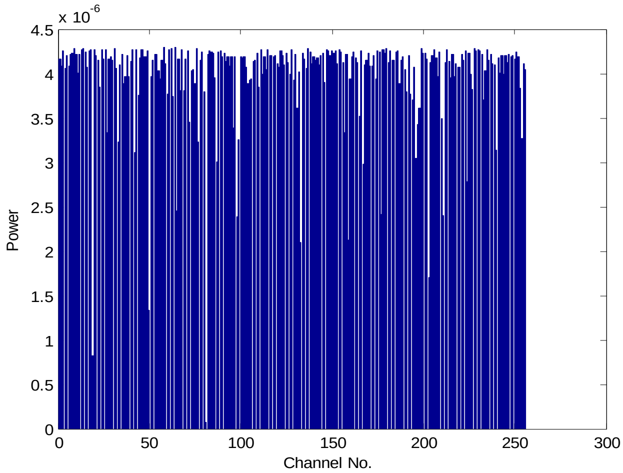

Fig: 7 Shown Power v/s Channel

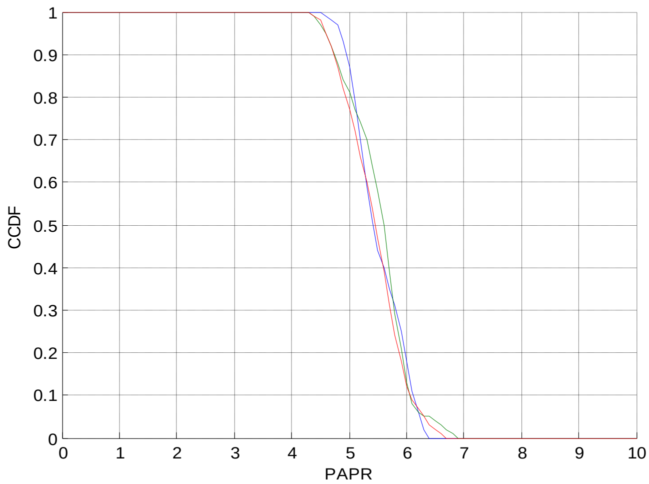

Fig: 8 Shown Peak Average Power Ratio v/s CCDF with AMC water filling without AMC water filling.

This graph shown that Peak Average Power Ratio (PAPR) is increase in AMC with water filling as compare to i AMC without water filling

VIII. Conclusion

In this paper, the effect of the wireless channel on BERand PAPR has been reported. There significant improvement in BER (.9approx) has noticed and given in result section. Due to the process of water filling uneven power distributed to different channel at transmitter side which is cause the increase in PAPR value. Which is again compensating through the companding technique? Still there is degradation in PAPR (0.5 at SNR0db) Observe as compare to without applying water filling .In future these work may explored with the use of optimization technique for optimum companding and water filling technique for performance enhancement of OFDM System

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