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Research Article

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BER and PAPR Analysis of OFDM and SC-FDMA for Different Fading Channels

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Abstract-

Wireless communication is known as the future trends that are used to communicate between transmitter and receiver. Modulation has been done after generation of the signal in each multiple sub carriers to send it over the channel. OFDM, SC-FDMA and other modulation schemes are used and reviewed. Earlier OFDM method was used but it has various disadvantages like it is sensitive to Doppler shift and frequency synchronization problems. It has high peak to average power ratio (PAPR), requiring linear transmitter circuitry, which suffers from poor power efficiency .In OFDM method there is loss of efficiency due to which SC-FDMA has been used. In this paper, simulations have been performed using different fading channels by evaluating PAPR on the signal. Results show performance of individual fading channels through different modulation schemes.

Keywords- OFDM, SC-FDMA, PAPR ratio, Fading channels, Wireless Communication, Fading types.

I. INTRODUCTION

OFDM has been used for downlink communication in wireless networks referred as orthogonal frequency division multiplexing. These channels can be easily adopted by the difficult channel conditions. As a result there is no requirement for complex time domain equalization. OFDM is one of the most attractive candidates for 4G wireless communication. It effectively prevents the multipath fading and increases the bandwidth efficiency. In order to provide the reliable transmission, it also increases the system capacity. It also provides improved spectral efficiency and works on the principle of FDM (Frequency Division Multiplexing) in a controlled manner. The function of OFDM is to split high rate data stream into lower rate data stream and transfer it over simultaneously number of subcarriers. These subcarriers get overlapped because the symbol duration increases for lower rate data stream. Due to this ISI (inter symbol interference) arises which can be avoided by inserting a guard interval between each OFDM symbol [1]. OFDM has several disadvantages but the major problem is high PAPR (peak to average power ratio). There are several techniques to reduce PAPR value. Demerits of OFDM give rise to SC-FDMA for communication or transmission. SC-FDMA replaces OFDM because it can be used for uplink communication in wireless networks. It has many useful properties like less PAPR, low sensitivity to carrier frequency offset etc. Thus SC-FDMA reduces the PAPR to much extent.

II. PROBLEM FORMULATION

PAPR (Peak-to-Average Power Ratio) is the one of the challenging issue in the multi carrier systems i.e. OFDM systems. PAPR should be reduced so that Performance of these systems can increase. In comparison with single carrier systems PAPR is high in multi carrier system. High PAPR reduces the efficiency of the Power amplifier (Transmitter) [2]. PAPR effects on the transmitted signal in large quantity as low PAPR can make the power amplifier efficient in terms of work whereas high PAPR works opposite. PAPR is the problem exists in OFDM system. The input symbol stream in case of IFFT should have a constant value of power spectrum. But the output of IFFT can result in a variable value and fluctuated wave or spikes [3].

The peak-to-average power ratio (PAPR) is the peak amplitude squared (giving the peak power) divided by the RMS value squared (giving the average power). It is the square of the crest factor as given in equation (1)

$$\mathbf{PAPR= |x|peak^2 / x_{rms}{}^2 = C^2} \tag{1}$$

When expressed in decibels, crest factor and PAPR are equivalent, due to the way decibels are calculated for power ratios vs. amplitude ratios. Crest factor and PAPR are therefore dimensionless quantities. While the crest factor is defined as a positive real number, in commercial products it is also commonly stated as the ratio of two whole numbers, e.g., 2:1. The PAPR is most used in signal processing applications [4]. As it is a power ratio, it is normally expressed in decibels (dB).The minimum possible crest factor is 1, 1:1 or 0 dB.

To reduce the PAPR, several techniques have been proposed such as clipping, coding , peak windowing, Tone Reservation and Tone Injection. But, most of these methods are unable to achieve simultaneously a large reduction in PAPR with low complexity, with low coding overhead, without performance degradation and without transmitter receiver symbol handshake[5,11].

III. FADING CHANNELS

In wireless communication fading is derived as a problem that can affect the signal over the media. Fading can vary according to time, geographical position or radio frequency, also modelled as random process. A fading channel is a communication channel that faces fading issue. Fading can occur in communication channel due to the multipath propagation also known as multipath induced fading or can be due to shadowing also known as shadow fading. In the environment reflectors are available that create multiple paths for the transmitter and receiver on which transmitted signal can traverse [6]. Consequently, receiver can see the path of transmitted signal, each traversing a different path.

Fading has been divided into two types named as large scale fading and small scale fading. Small scale fading is further subdivided into slow fading, fast fading and selective fading.

These divisions have been done on the basis of magnitude and phase change imposed by the channel on the signal changes. Another term known as coherence time is the measurement of the minimum time taken by the magnitude change or phase change to become in uncorrelated from previously defined value.

A. Small scale fading

1) Slow fading

The occurrence of this fading is due to the large coherence time of the channel relative to the delay constraint of the channel.

2) Fast fading

The occurrence of this fading is due to the small coherence time of the channel relative to the delay constraint of the channel.

3) Selective Fading

It occurs due to the partial cancellation of radio signal by itself which means that when signal arrives from two paths so one of them is changing due to lengthening or shortening. It is also referred as frequency selective fading. Selective fading is a fading which constantly changed due to the cyclic disturbance sweeping through the received audio [7].

B. Fading Models

Due to these Electromagnetic propagation mechanisms, radio propagation can be roughly described by three nearly independent phenomenons such as path loss, shadow fading, multipath fading.

There are different fading models available which are different in terms of delay, gain and phase shift [5]. Some of them are:

a) Nakagami fading
b) Log normal shadow fading
c) Rayleigh fading
d) Rician fading
e) Weibull fading
f) Rayleigh fading

Multipath fading (fast fading) in wireless communication systems can be described by Rayleigh and Rician fading channels described below [8]:

1) Rayleigh fading channel model

Due to the development of the urban area, object in the environment may scatter the radio signals before it arrives at the receiver. In Rayleigh fading channel no dominant propagation along a Line of Sight between the transmitter and receiver [9].

To evaluate the channel, R has taken as random variable consist probability distribution. Rayleigh distribution can acquire through taking two independent and identically distributed zero mean Gaussian random variable. These variables can be real and imaginary parts of the complex numbers soon after magnitude will be taken. The characteristics equation for Rayleigh distribution channel is given in equ. (2)

$$PR(r) = 2r\,\Omega * \exp(-r^{2}\,\Omega) \tag{2}$$

$$\text{Where } \Omega = E(R^{2})$$

2) Rician fading channel model

Rician fading model can be defined as Rayleigh fading model but the difference lies at the dominant component. In the Rician fading channel model there is a strong dominant component present which is a non fading signal commonly known as line of sight component.

Rician fading happens by cancellation of radio signal by itself. Signal reached at the destination part through several paths where at least one of them has changed due to lightning or shortening. Accordingly, this fading occurs when one of paths having stronger line of sight than others. [10]

Rician fading can be explained via Rician distribution. Thus, path can be written as in terms of transmitter signal:

$$\mathbf{S\ (t) = \Sigma^{N-1}_{i=1}\, a_i \cos(\omega_c\, t + \omega_{di}\, t + \omega_i) + K_d \cos(\omega_c\, t + \omega_d\, t)} \tag{3}$$

K_d defines strength of the direct component, ω_d defines Doppler shift of the line of sight path and Doppler shifts along the indirect paths defines through the variable ω_{di}.

IV. METHODOLOGY

This paper describes the STBC code that has been applied on the signal before sending to the receiver and SC-FDMA instead of OFDM to reduce the PAPR problem. The methodology of the proposed work is shown in figure 1.

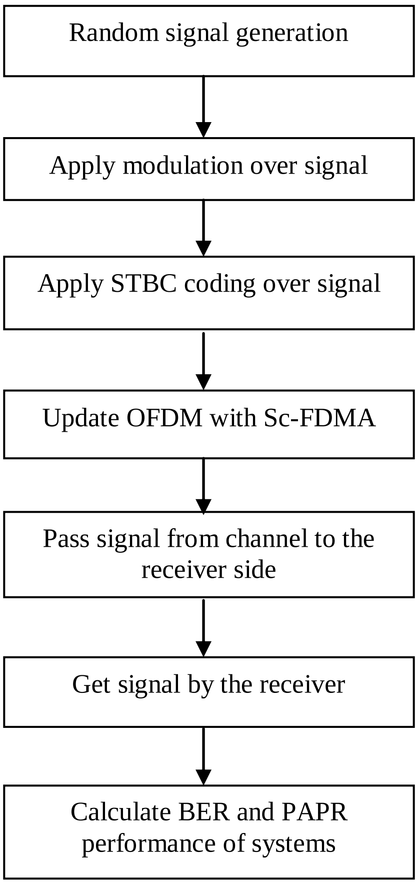

Fig. 1. Flow diagram of the proposed technique to enhance the performance of the system.

V. RESULTS AND DISCUSSIONS

This section describes the results that have been evaluated on the signal by taking different fading channels. Bit error rate and PAPR ratio values are computed through several modulation techniques.

Figure 2 represents the comparison graph of BER of SC-FDMA with 16-QAM using two different fading channels Rayleigh channel and Rician channel. The simulated graph shows that Rician channel gives the best result for PAPR.

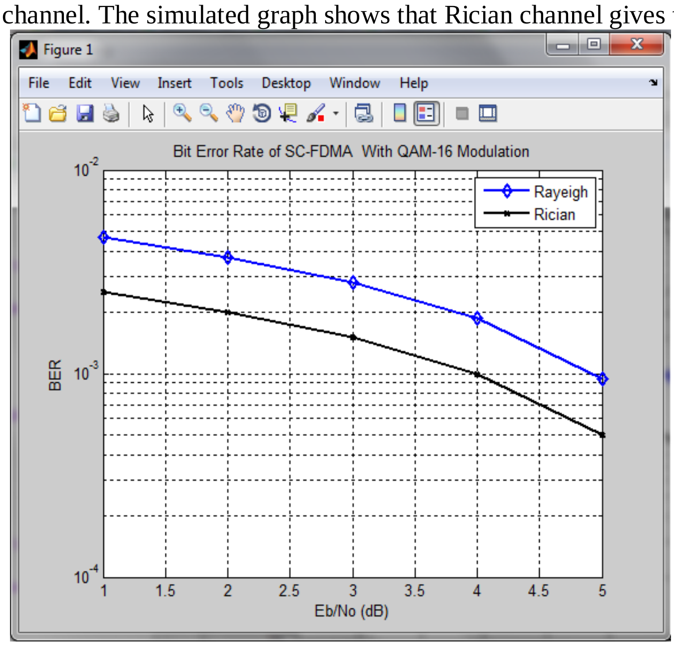

Fig 2: BER comparison of SC-FDMA with 16-QAM using Rayleigh and Rician channels

Figure 3 represents the comparison graph of BER of SC-FDMA with 32-QAM using Rayleigh and Rician channels. The graph shows that there is similarity between the previous graph as 16-QAM. There is not as much difference between 16-QAM and 32-QAM graphs using these two channels. But with Rician channel Bit error rate improves as compare to Rayleigh channel. From these two simulation results of BER for different channels, it is concluded that Rician channel gives the best suited results for bit error rate.

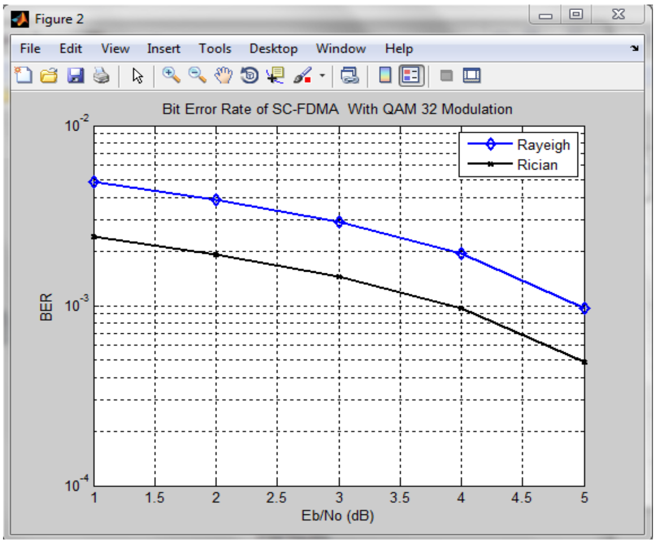

Fig 3: BER comparison of SC-FDMA with 32-QAM using Rayleigh and Rician channels.

Figure 4 represents the comparison graph of PAPR of SC-FDMA with 16-QAM using Rayleigh and Rician channels. Graph indicates that PAPR is minimum for Rician channel.

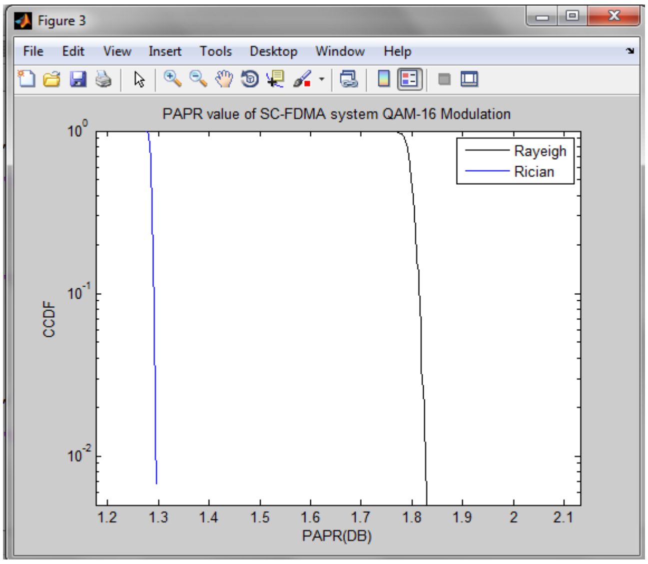

Fig 4: PAPR comparison of SC-FDMA with 16-QAM using Rayleigh and Rician channels

Figure 5 represents the comparison graph of SC-FDMA with 32-QAM using Rayleigh and Rician channels. The graph shows that there is a slight difference between the PAPR values which is not clearly seen as the graph is overlapping. So from this graph it is concluded that if we use the higher order modulation scheme then value of PAPR is difficult to calculate.

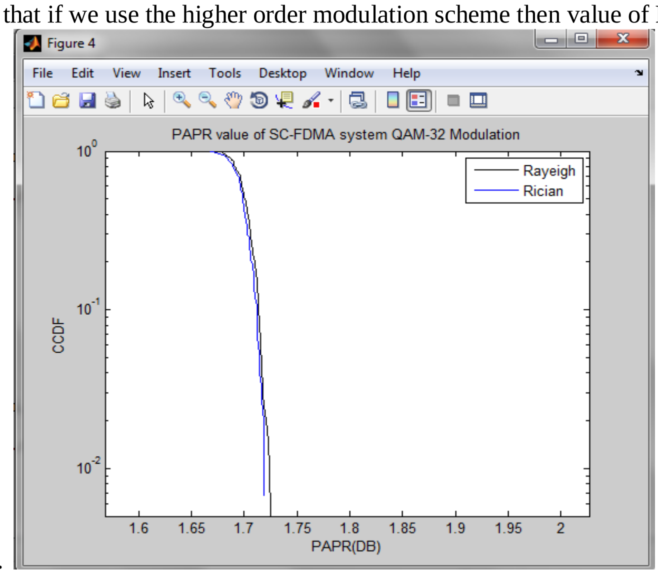

Fig 5: PAPR comparison of SC-FDMA with 32-QAM using Rayleigh and Rician channels.

VI. CONCLUSION AND FUTURE SCOPE

From the above explanation of the SC-FDMA systems and OFDM systems it can be stated that PAPR reduction is the critical task in both of them. As in the result section of the paper describes Rayleigh and Rician fading channels on which parameters are calculated where Rician fading channels provide less amount of PAPR in the signal.

For the future scope, PAPR value can be reduced more if applied Rician fading channel where line of sight component present. In future more modulation schemes can be used to enhance the performance as well as the quality of the signal. Supplementary fading channels can be proposed that can model real life wireless channel even better. Also in order to reduce the PAPR, some reduction techniques can also be used.

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