PERFORMANCE ENHANCEMENT OF MIMO OFDM BY PAPR REDUCTION

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Abstract: Multiple Input Multiple Output (MIMO) technology is currently playing a vital role in fourth-generation wireless communication. There is a need to improve the performance for the utilization of this technology in the next generation communication system. Peak to average power ratio (PAPR) is one of the foremost challenges to improve the performance of mimo-ofdm systems. Here In this paper, we propose a method to improve the performance of the system using an interleaving technique to reduce PAPR .

Index Terms **- MIMO, OFDM, PAPR, Interleaving, BER.**

I. INTRODUCTION

The world of mobile communication has emerged as one of the biggest need and the most essential part of our daily life. Current scenario of communication world shows that we are now moving towards a digital world, where each and everything will be connected to each other digitally. Smart home automation, smart phone, smart television, and smart refrigerators are the suitable examples of digitally connected world. All these can be operated anytime anywhere by their users. The significant challenge encountered now days by imminent wireless communications systems is to make available high data rate wireless access at high quality of service (QOS). Combined with the facts that spectrum is a limited resource and propagation conditions are unfriendly due to fading and interference from other users, this requirement calls for means to radically increase spectral efficiency and improve link reliability. Figure 1shows a bar graph based on report on IMT traffic estimates for the years 2020 to2030 published by Radio communication sector of International Telecommunication Union. This report clearly shows that in the world of wireless mobile communication global mobile traffic will increase exponentially in upcoming years [1].

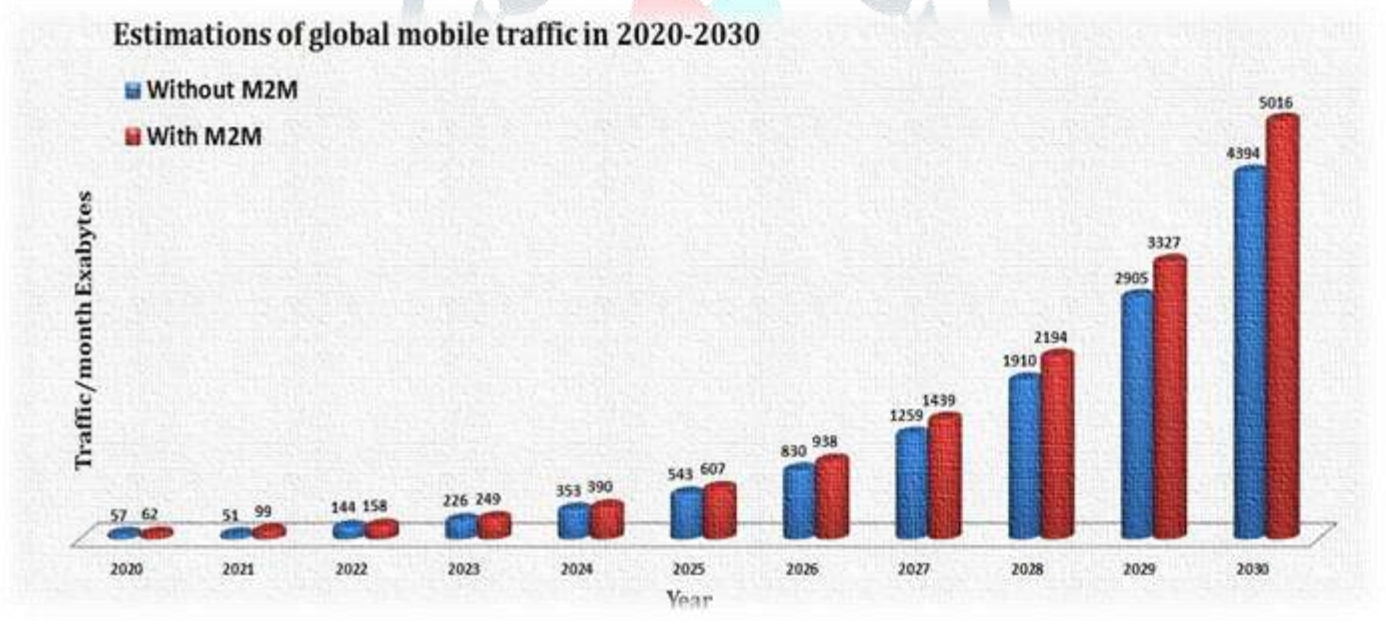

Figure 1: Mobile traffic estimation for 2020 to 2030

To achieve improved spectral efficiency and data link reliability, recently many prominent companies in the field of wireless communication like Nokia, ZTE, Samsung, and Huawei have focused their research towards MIMO-OFDM (Multiple Input Multiple Output- Orthogonal frequency division Multiplexing) systems. This technology has gained significant attentions from these companies and the active academicians and researchers. As name suggests MIMO system is a system integrated with multiple antennas at the transmitter and receiver end besides this the receiver supposedly allows linear growth of the link capacity. The capacity is proportional to the rank of MIMO channel. While high spectral efficiency can be obtained through spatial multiplexing, many other MIMO systems benefits such as improved signal quality and coverage can be achieved via spatial diversity, beam forming space time coding and interface cancellation. [2]

Orthogonal frequency-division multiplexing (OFDM) is a key broadband wireless technology which supports data rates in excess of 100Mbps which was crucial in 4th generation broadband wireless communication system and communication networks. OFDM is a basis not only for cellular standards but also for LAN standards like 802.11/a/g/n standards. In OFDM data beam is fragmented into multiple parallel data lines. These data lines, then transmitted on distinct subcarriers with lower data rate than that of original data stream. It is a transmission method to achieve high data rate over wireless links in multipath environments. [3]

Advancement over these technologies was achieved through merging MIMO technology with OFDM technique. MIMO-OFDM system converts a mimo frequency selective channel in time domain into a group of parallel mimo flat fading channel. A mimo frequency selective channel produces an Inter symbol Interference (ISI). To remove this ISI, system needs an equalizer. Thus, by converting mimo frequency selective channel into flat fading channel, mimo-ofdm eliminates the requirement of equalizer and hence this technology simplifies the baseband receiver processing. The forward error correction (FEC) mechanism plays an important role in the performance of MIMO-OFDM systems. One aspect of the MIMO-OFDM system that has not been investigated adequately is the use of different antenna configurations. MIMO-OFDM provides considerable improvement in reliability and improved latency. This paper studies about the performance measure of a MIMO-OFDM system and suggest an improvement to reduce peak to average power ratio (PAPR) and bit error rate (BER) with comparative study. [4]

II. SYSTEM DESIGN

Before analyzing the improved designs of MIMO-OFDM system, we first concisely explain the system model for MIMO-OFDM transmission system.

A. TRANSMISSION SYSTEM MODEL

For reliable, secured, fast and efficient transmission of the data basically three parameter of any wireless system should be good. These three parameters are transmission rate of data, transmission range of the system and data reliability. Initially it was difficult to manage all three parameters simultaneously, as if we focus on any two parameters, quality of third parameter decreases concurrently. This flaw was uprooted with the implementation of MIMO-OFDM technology. So for the wireless transmission system which is currently being used for large data transmission, MIMO-OFDM became important technology.

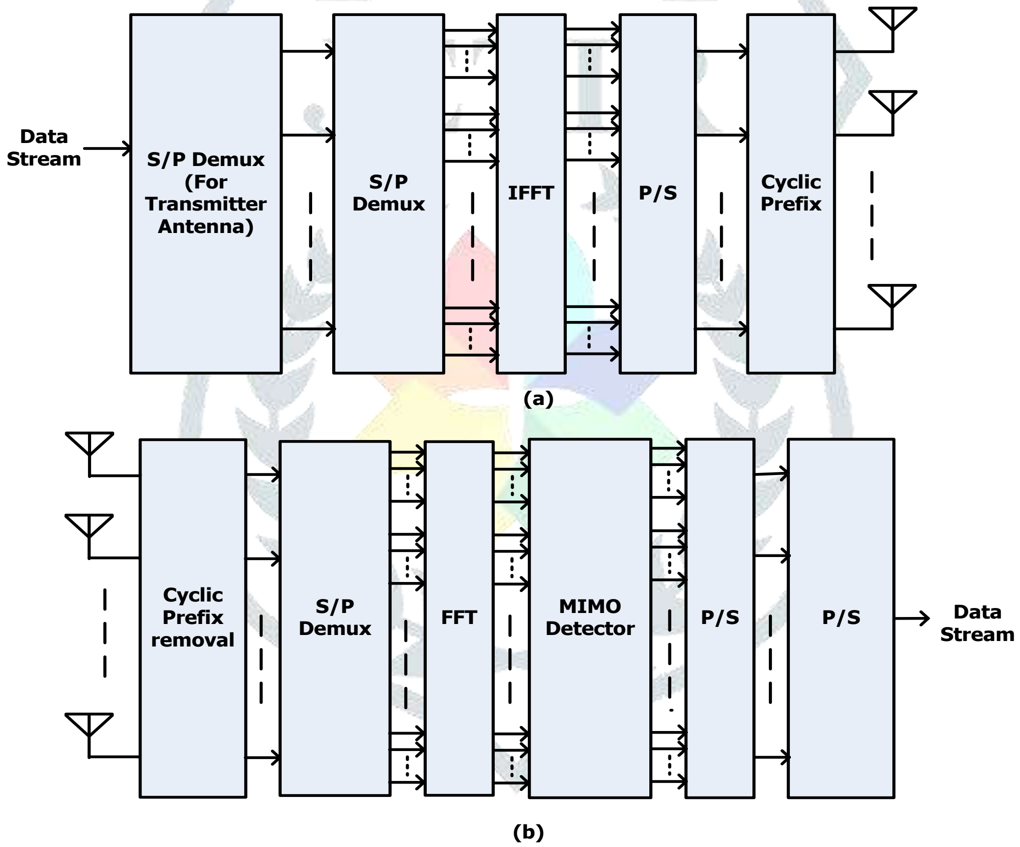

Figure 2: Block diagram of MIMO-OFDM

Figure 2 shows block diagram representation of process of MIMO-OFDM transmission. It combines two different technologies i.e. MIMO and OFDM to attain improved throughput. Concurrently at the receiver, this combination makes receive processing easier. In this process multiple flat fading channels are created from single channel. By converting a channel in a set of parallel flat fading channel mimo-ofdm considerably shortens the processing at baseband receiver.

MIMO OFDM technology became prominent technology in the world of wireless communication. Besides this, With the passage of time traffic in wireless mobile communication world has been increased significantly and thus we have to look for the improvement in the current technology. This improvement may be in terms of low peak to average power ratio (PAPR), improved bit error rate and inter cell interference (ICI). This paper proposes advancement in PAPR reduction technique.

B. PEAK-AVERAGE POWER RATIO (PAPR)

In MIMO OFDM systems there are multiple antennas at the transmitter end as well as receiver end. For each antenna PAPR is calculated individually. Thus calculation of PAPR for each antenna is very similar to SISO system. In MIMO OFDM peak power values in time domain may be high due to the large number of subcarriers. PAPR is determined by the ratio of peak power to its average power and given as

$$\text{Peak to average power ratio (PAPR)} = 10 \log\left\{\frac{P_{Peak}}{P_{avg}}\right\} \text{ dB}$$

As composite baseband signal is express over time interval, and mathematically, PAPR is given by

$$\text{PAPR} = 10 \log\left\{\frac{max\ |s(t)|^2}{E\ |s(t)|^2}\right\} \text{ dB}$$

Here max $|s\ (t)\ |^2$ is maximum signal power and E $|s(t)|^2$ is the average signal power. Average signal power of system is thus calculated by

$$E = \frac{\text{Sum of the magnitude of all OFDM symbol}}{\text{No. of OFDM symbols (N)}}$$

The performance of PAPR is frequently expressed in Complementary Cumulative Distribution Function (CCDF) which described as the probability of exceeded PAPR in a certain PAPR threshold, γ. CCDF of OFDM system can be given as

$$\text{CCDF}(\gamma) = \Pr\{\text{PAPR} > \gamma\} = 1 - (1 - e^{-}\gamma)^N$$

C. BER (Bit Error Rate)

To characterize the performance of data channels BER becomes an essential parameter. While transmitting the data from source to destination over the wired or wireless link, important point to consider is how many bits get affected in the data stream which produces errors at remote end. While transmitting data through data link it is very much possible that errors may occur into the system. If it happens then the reliability of the system may be compromised. Therefore Bit error rate provides an ideal way to assess the performance of system. Bit error rate is simply the rate in a transmission system at which errors occur. Bit error rate can be expressed as

$$\text{BER} = \frac{\text{Error bits occured in the data stream}}{\text{Total number of bits in data stream}}$$

If the transmission channel between transmitter and receiver end is good enough and the signal strength over the noise is much high (if signal to noise ratio is high) then the bit error rate will be very small. [8]

D. Proposed improvements

A proposed improved interleaving technique is demonstrated in Figure 3. In this technique Orthogonal Genetic Algorithm (OGA optimization algorithm) is used to obtain the interleaving patterns. The generated Interleavers are mapped with original OFDM frame and generate the permuted data block. IDFT operations is used to compute the PAPR of permuted data.Now for the transmission data block is chosen such that it should have lowest PAPR. Therefore at the transmitter designed interleaver is abridged by generation of interleaving pattern using optimization technique. The description of the optimization problem is to catch the finest interleaving pattern from the pair of vectors containing subcarrier index which is represented by M and the random vector corresponds with interleaving pattern. Best Interleaving pattern is separately applied to the M_t parallel OFDM frames to produce the preeminent permutated frame which results in least possible PAPR for transmission. [9]

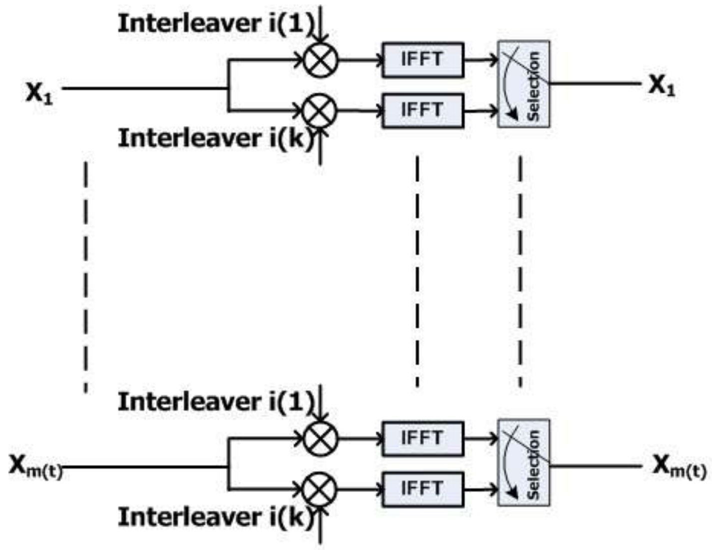

Figure 3: Proposed Interleaving Technique

E. Result and Discussion

In the process of interleaving complementary cumulative distribution function (CCDF) of PAPR analyzed for different number of antennas at transmitter which is shown in figure 4. From this analysis it is clearly visible that the value of PAPR is lesser for the greater number of transmitting antennas. As compared to the conventional method, proposed interleaving method results in lesser value of PAPR. For the transmitted OFDM symbols PAPR is measured only at the transmitter. If the number of transmitting antenna increases then the number of bits transmitted through each antenna get reduced. Therefore system produces low value of PAPR as the less number of bits which are to be transmitted exhibits minimized value of PAPR.

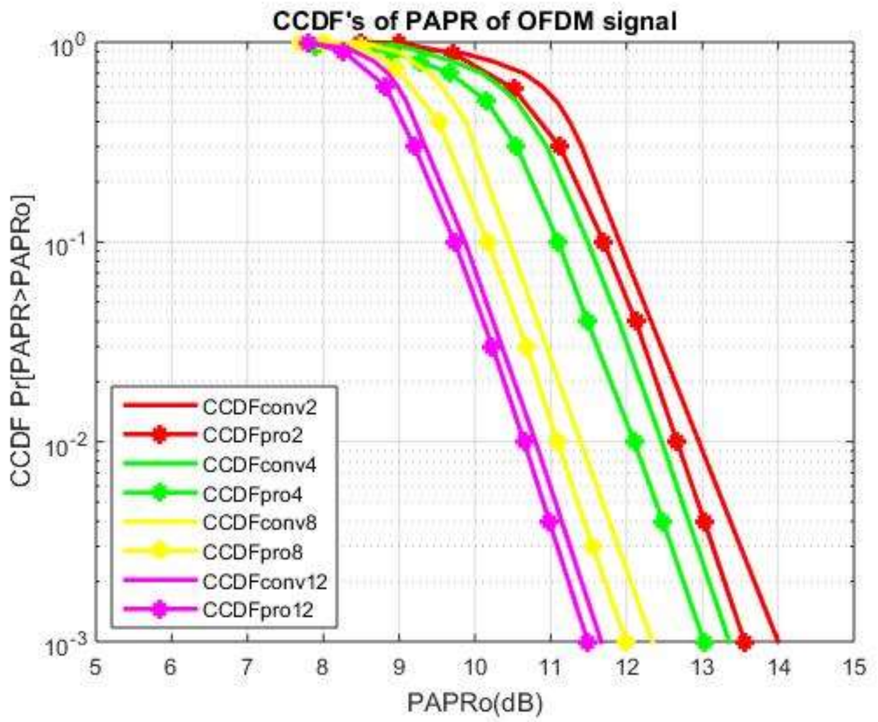

Figure 4: CCDF of the PAPR for different number of transmit antennas

Result of proposed method shows that in previous technique values of PAPR vary from 11.7 dB to 14 dB when the value of CCDF is 10^{-3}, using the number of antennas increases from 2 to 12. With the same conditions proposed method results in the form of minimized PAPR of 11.5 to 13.6 dB for the same CCDF value of 10^{-3}, using same number of antennas from 2 to 12.

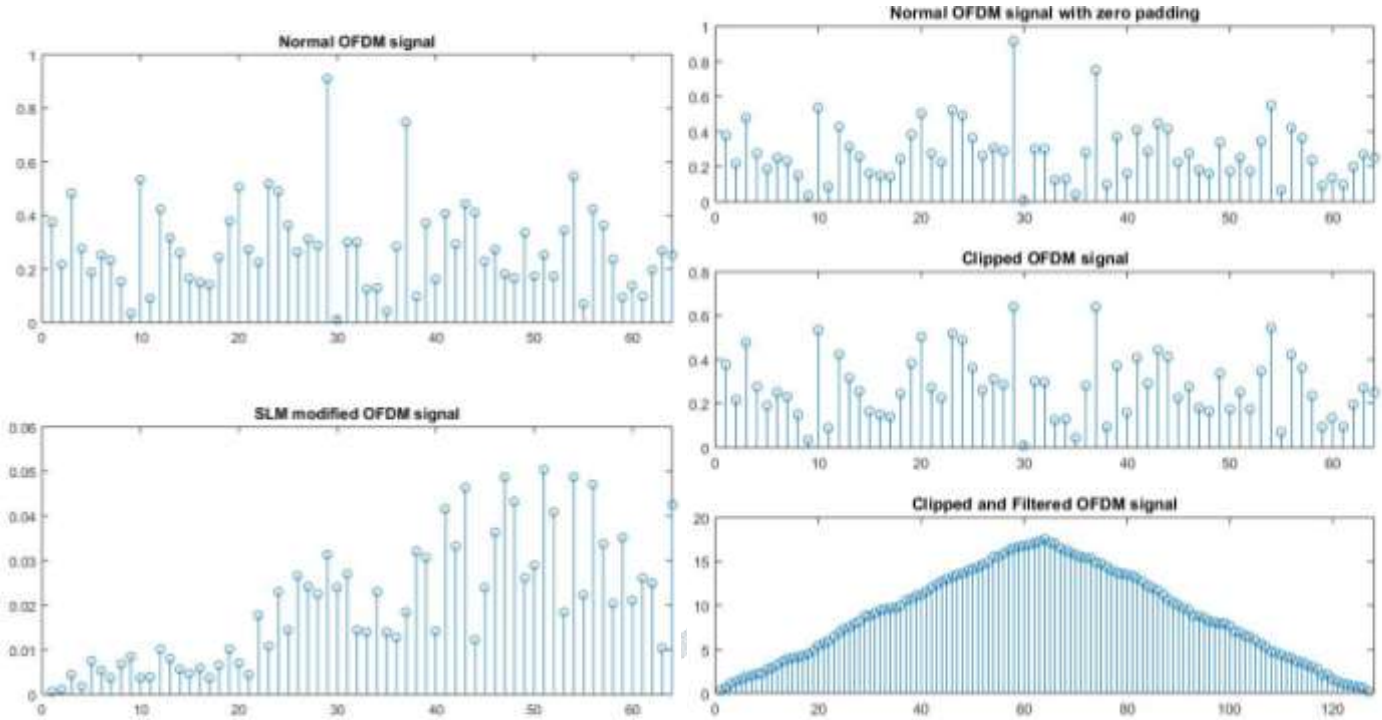

Figure 5: PAPR for different techniques

Figure 5 shows the study of PAPR values for Selected Mapping (SLM) technique and clipped and filtering technique. For 64 transmitting symbols with alphabet size of 8bits, PAPR value for SLM technique is 14.34 where as for the same parameters PAPR of clipped and filtering technique is 10.74. This result shows that clipped and filtering technique is more suitable to reduce PAPR.

I. Conclusion

In this paper, we suggested a PAPR reduction technique to improve the performance of MIMO-OFDM system. In this method we generated some possible PAPR outcomes at the transmitter before the transmission and selected the one that gives best suited result. Here we have used Orthogonal Genetic Algorithm to produce interleaving pattern. These patterns used to generate permuted data and finally using IDFT process PAPR is calculated for each data blocks. Now the data that have low PAPR is selected for the transmission. Hence the results that we have obtain are encouraging and indicate better performance.

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