Investigations on PAPR and SER Performance Analysis of OFDMA and SCFDMA under Different Channels

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Abstract: Code Division Multiple Access (CDMA) and Orthogonal Frequency Division Multiplexing are two multicarrier regulatory systems that have improved due to the growing demand in quick communication (OFDM). A frequency division multiplexing (FDM) plot called orthogonal frequency division multiplexing is utilized as a sophisticated multi carrier regulation approach.

Due to its excellent spectrum efficiency and low data rate, the single carrier multiple access system (SC-FDMA) is a unique radio transmission technique that is now employed in long-term evolution (LTE) technology for uplink. When compared to OFDM, reduced peak-to-average power ratio (PAPR) and error rate technique. PAPR performance has been obtained using Matlab simulation. Techniques using variable numbers of subcarriers include SC-FDMA and OFDMA. Two various subcarrier assignment strategies have been proposed, distributed FDMA Localized FDMA and (DFDMA) (LFDMA). IFDMA, or interleaved FDMA, is a DFDMA special situation when DFT results have been distributed consistently and at the same distance. When comparing the SC-FDMA variants, we discover that Localized has a higher PAPR than interleaved (FDM). We also talk about the Performance of LFDMA and IFDMA's SER (Symbol Error Rate) and found that localized (FDMA) performs better in the SER than interleaved (IFDMA) method.

Keywords: CDMA, SC-FDMA, PAPR, OFDMA, IFDMA, SER.

1. INTRODUCTION

OFDM is an extraordinary type of multicarrier data carrier system used for information Exchange, which separates the whole frequency specific blurring channel into numerous orthogonal narrowband level blurring sub-channels, in which high-piece rate information stream is transmitted in equal over various lower information rate subcarriers in this way significantly lessening the ISI because of bigger image term. The key guideline of OFDM begins from the paper by Chang, and throughout the years various specialists have dealt with this method. Regardless of its calculated style, its utilization was at first restricted to military frameworks, for example, KINEPLEX, KATHRYN and ANDEFT because of its execution troubles. Weinstein and Ebert's proposition to utilize the Discrete Fourier Transform (DFT) to play out the subcarrier regulation with a solitary oscillator was a spearheading exertion. Ebert, Salz and Schwartz exhibited the adequacy of Cooley-Tukey fast Fourier transform (FFT) calculation to additionally decrease the computational unpredictability of DFT, in this way making it conceivable to use the OFDM procedure in business correspondence frameworks. Its utilization in business frameworks began with various wire-line norms, which included High piece rate Digital Subscriber Lines (HDSL), Asynchronous Digital Subscriber Lines (ADSL), and Very fast Digital Subscriber Lines (VDSL), to help a throughput upto 100Mbp. From that point, it has been used by remote gauges like DAB and WLAN, DVB and WMAN. In WMAN applications, OFDM is considered for the Worldwide Interoperability for Microwave Access (WiMax) usage by means of IEEE 802.16d, an, e norms. OFDM is additionally being considered for 3GPP Long term Evolution (LTE) and 3GPP LTE-Advanced. Without a doubt, OFDM can be a potential air interface possibility for group of people yet to come rapid remote correspondences frameworks. OFDM frameworks utilize cyclic prefix inclusion to wipe out the impact of ISI and require a basic one-tap equalizer at the less than desirable end. OFDM gets unmatched transfer speed reserve funds prompting higher otherworldly productivity. These properties make OFDM framework incredibly alluring for rapid remote applications. In OFDM frameworks
diverse regulation plans can be utilized on singular sub-carriers which are adjusted to the transmission conditions on each sub-carrier.

Although OFDM is widely accepted, it also has disadvantages:

- OFDM signals with their high Peak to-Average power proportions (PAPRs) require exceptionally direct enhancers. Something else, execution debasement happens and out-of-band power necessity will be upgraded.
- OFDM frameworks are more delicate to Doppler spread than single-carrier balanced frameworks.
- Phase clamor brought about by the defects of the transmitter and recipient oscillators debases the framework execution.
- Accurate frequency and time synchronization is required.
- Loss in otherworldly proficiency because of cyclic-prefix (CP) activity happens in OFDM frameworks.

2. LITERATURE REVIEW

[A. Hindy, 2020] proposed method of improving the multi-user (MU) multi-user (MIMO) input (MU) device efficiency is probably the biggest guarantee for conveying fifth-generation (5G) systems. Downlink preceding mechanisms that balance execution and uplink overhead criticism are being discussed in the third generation partner project (3GPP) new radio (NR) standardization efforts. Most recently, for the downlink NR Release (Reel.) 15, the high-resolution pre-coder (Type-II codebook) was displayed, wherein channel state information (CSI) input is packed through space by misusing a DFT base codebook structure. Increase of the NR Rel Type-II codebook, 16 which also violence recurrence linked to lower overhead critical CSIs are already being investigated. A diagram of some of Rel’s progressive reforms is given in this article. 16 Codebook type-II is given. A feature methodology that employs multi-stage codebook boundary quantization with a variable quantizing resolution is proposed, where the resolution is linked to the adequacy assessments of the coefficients. The CSI critique, contrasted and a similar quantization resolution is better used with this approach for all the coefficients. System-level simulation results show that the approach proposed effectively lowers the CSI input overhead, without any noticeable impact on output.[1]

[Jing guo, 2019] stated that these days, the commercialization of 5G is going all out everywhere throughout the world. Massive MIMO, as one of the promising advancements, will be applied in 5G systems. In any case, different Massive MIMO gear structures and various 5G sending situations (for example, Dense Urban/Urban/Suburban/Rural) make the arrangement of Massive MIMO systems extremely entangled. Accordingly, how to settle on sensible decisions of Massive MIMO gear structures for various pragmatic organization situations is a key issue. In this paper, top to bottom investigates on current items are directed first and afterward system-level simulations for various Massive MIMO sending situations are performed to give sensible advises to Massive MIMO hardware choice with thinking about the tradeoff among cost and system execution. [2]

[VM Baeza and Armada, 2019]in his paper defines the need to assess an enormous number of channels in massive MIMO (mMIMO) has prompted the proposition of noncoherent (NC) detection, where the channel state information (CSI) isn’t important. In this paper, we talk about the tradeoff between NC structures dependent on stage detection (PD) and those dependent on energy-detection (ED) for mMIMO as far as execution and unpredictability. Thus, we break down NC plans concerning their coherent partner. As a rule, the outcomes show that the PD ones are the most ideal alternative in regards to execution against the ED. In addition, we break down the blend of the two detection plans as an alluring arrangement at the exhibition level confronting the plans dependent on energy or stage, in return for increasing the multifaceted nature of the recipient. Likewise, we propose new star grouping plans for stage based detection multiuser NC-mMIMO systems which permit to multiplex an expanded number of users in a simpler manner. [3]

[Jean Baptiste et al, 2014]in his paper suggests for5G to adapt to a high level of heterogeneity as far as administrations and prerequisites. Among these last mentioned, adaptable and effective utilization of all accessible non-adjacent spectra for various system arrangement situations is one test for the future 5G. To amplify range effectiveness, an adaptable 5G air interface innovation fit for planning different administrations to the best reasonable blends of recurrence and radio assets will likewise be required. In this work, a reasonable examination of a few 5G waveform applicants (UFMC, FBMC-QAM, and FBMC-QAM) is proposed under a typical system. Ghostly productivity, power phantom thickness, top to average force proportion and execution as far as bit blunder rate under different reasonable channel conditions are surveyed. The waveforms are then thought about in an offbeat multi-user uplink transmission. In light of these outcomes, so as to build the ghastly productivity, a piece stacking calculation is proposed to adapt to the non-uniform conveyance of the obstruction over the transporters. The advantages of these new waveforms for the anticipated 5G use cases are unmistakably highlighted. It is additionally focused on that a few ideas despite everything should be improved to accomplish the full scope of expected advantages of 5G. [4]
High PAPR and inter-carrier interference (ICI) are the two significant issues in the execution of an OFDM framework. The postulation targets investigating and showing up at proficient, low unpredictability plans for PAPR decrease in OFDM based frameworks (with and without ICI abrogation) for use. The main issue need to address aggressively in this theory is the high PAPR of an OFDM signal which has curbed badly the efficient usability. We start by investigating the current PAPR reducing methods and to discover the methodology that would enhance their points of interest and significant impediments for executing a down to earth OFDM framework in more efficient manner. Examination of productive PAPR decrease plans for an OFDM framework is along these lines considered as one of the difficult zones investigated in this proposal. OFDM brings every single significant advantage of a multicarrier plot yet dissimilar to single carrier regulation plans, it experiences the issue of ICI. In this postulation, we investigate the current ICI undoing plans and play out an examination of CIR and BER exhibitions. As examined over, the PAPR is a significant boundary that must be contemplated while structuring an ICI abrogation plot for the OFDM arrangement of reasonable use. Thus examination of PAPR execution of OFDM frameworks using ICI, wiping out plans is additionally considered as another territory to be investigated in this proposition. Last point of this proposal is to recommend a hybrid plan for concurrent PAPR decrease and ICI crossing out in OFDM frameworks.

3. PROBLEM DEFINITION

Cellular communication has grown rapidly because of the demand of high data rates and throughputs. To support these demands of a third generation partnership project (3GPP) has evolved a new technique called LTE/4G which uses orthogonal frequency division multiple access (OFDMA) technique for downlink communication and single carrier multiple access (SC-FDMA) technique for uplink communication. OFDMA and SC-FDMA techniques are modified forms of the orthogonal frequency division multiplexing (OFDM) and single carrier frequency division equalization (SC/FDE) techniques. SC-FDMA is used in view of the fact that its peak-to-average-power-ratio (PAPR) is smaller and more constant. Moreover it has a similar throughput and essentially the same overall complexity as the orthogonal frequency division multiple access (OFDMA) system.

\[ PAPR = \frac{\max|x(t)|^2}{E[|x(t)|^2]} \]  

We analyze the different mapping schemes of OFDMA and SC-FDMA in time domain and compare their PAPR and SER characteristics. We see that IFDMA performs better in PAPR reduction but at a cost of high symbol error rate (SER) as compared to LFDM.

5. PROPOSED METHODOLOGY

5.1 System Model

The chain to generate an OFDMA signal starts by parallelizing the symbols that need to be transmitted, after they are modulated (in LTE the modulation can be QPSK, 16AQM, 64QAM). Then they are mapped to different subcarriers using either localised (LFDM) or distributed (DFDMA) subcarrier mapping and then used as input bands for an inverse fast Fourier transform operation. This operation produces OFDMA symbols, which will be transmitted. Notice that a conversion from the frequency to the time
domain was made when the IFFT was used. Before the transmission, however, a cyclic prefix is included in the OFDMA symbols as a guard interval to mitigate the inter-symbol interference through the transmission in the multipath channel. These OFDMA symbols are then transmitted through a multipath channel and AWGN noise is added to simulate the noise in the channel. [22].

In SC-FDMA one extra module DFT is added before the IFFT module in the transmitter chain and IDFT is added in the receiver chain. This converts OFDMA chain into SC-FDMA chain. Without this two modules the chain is referred as OFDMA transmit and receive chain. At the receiver’s end CP is removed which is further followed by FFT operation to convert the symbols from time domain back to frequency domain. Subcarrier demapping and demodulation is done to get back the original symbols. Also during simulation channel equalization was applied before demodulation to mitigate the effect of inter-symbol interference (ISI) introduced by the channel impulse response variation in order to decrease the probability of error.

In this work we have focused on the performance analysis of OFDMA and SCFDMA systems in terms of SER and PAPR. Three types of channel (pedAchannel, vehAchannel and AWGN channel) were introduced along with two types of subcarrier mapping.

Figure 5.1 Model of OFDMA and SC-FDMA

Figure 5.2 Example of different subcarrier mapping modes for M=4, Q=3 and N=12
(localised and distributed, IFDMA is a special case of DFDMA). For all types of channel, it was observed that LFDMA subcarrier mapping shows better SER performance than IFDMA and DFDMA subcarrier mapping because of its better immunity to multiple access interference (MAI). Also the SER performance for IFDMA subcarrier mapping is almost similar to that of DFDMA subcarrier mapping. Furthermore, in case of OFDMA system LFDMA sub-carrier mapping gave similar SER performance for pedAchannel and vehAchannel but a slightly better performance with AWGN channel. IFDMA subcarrier mapping and DFDMA shows similar performance with vehAchannel and AWGN channel but a slightly better performance with pedAchannel. In the SCFDMA system LFDMA subcarrier mapping gave best SER performance with vehAchannel with slightly reduced performance with pedAchannel and least performance with AWGN channel. IFDMA subcarrier mapping and DFDMA subcarrier mapping gave best performance with AWGN channel with slightly reduced performance with pedAchannel and least performance with vehAchannel. It was also observed that for all types of channel and subcarrier mapping, SER performance of SCFDMA is better than OFDMA systems. For OFDMA system, the PAPR performance of LFDMA and DFDMA is almost similar and IFDMA gives a better performance as compared to LFDMA and DFDMA in OFDMA. In case of SCFDMA system, the PAPR performance of LFDMA and DFDMA is almost similar in case of SCFDMA and IFDMA gives a better performance as compared to LFDMA and DFDMA in OFDMA. It was concluded that the PAPR performance of SCFDMA was significantly better in all three subcarrier mapping techniques i.e. LFDMA, IFDMA and DFDMA, when compared to their counterparts in OFDMA.

6. RESULTS AND SIMULATION

The results have been simulated by taking into account the standard requirements. We have used the following data for our analysis:

- 64-QAM modulated signals
- FFT/IFFT length = 512
- Input-data block size = 32
- Cyclic Prefix (CP) Length = 20
- SNR ∈ [0, 30 dB]

To evaluate the SER performance of OFDMA System three different channels were used, which are pedAchannel, vehAchannel and AWGN channel. Furthermore, the SER vs SNR [dB] plots were plotted for 3 different subcarrier mapping: localised FDMA (LFDMA), interleaved FDMA (IFDMA) and distributed FDMA (DFDMA).

A. pedAchannel

![Figure 6.1: SER vs SNR [dB] for OFDMA in pedAchannel using LFDMA, IFDMA and DFDMA subcarrier mapping. (right side figure is added as a subplot to show the values as they are overlapped in left one)](image-url)
While using pedAchannel for OFDMA we observe that the SER performance of LFDMA is better than IFDMA and DFDMA technique because of its robustness against multiple carrier interference. Also DFDMA and IFDMA are almost the same in their SER performance (and hence are overlapped when plotted in single figure).

B. vehAchannel

![Figure 6.2: SER vs SNR [dB] for OFDMA in vehAchannel using LFDMA, IFDMA and DFDMA subcarrier mapping. (right side figure is added as a subplot to show the values that are overlapped in left one)](image)

While using vehAchannel for OFDMA we observe that the SER performance of LFDMA is better than IFDMA and DFDMA technique because of its robustness against multiple carrier interference. Also DFDMA and IFDMA are almost the same in their SER performance (and hence are overlapped when plotted in single figure).

When compared to pedAchannel, the LFDMA SER performance is the same as in vehAchannel but IFDMA and DFDMA SER performance is better for pedAchannel.

C. AWGN Channel

![Figure 6.3: SER vs SNR [dB] for OFDMA in AWGN Channel using LFDMA, IFDMA and DFDMA subcarrier mapping. (right side figure is added as a subplot to show the values as they are overlapped in left one)](image)
While using AWGN channel for OFDMA we observe that the SER performance of LFDMA is better than IFDMA and DFDMA technique because of its robustness against multiple carrier interference. Also DFDMA and IFDMA are almost the same in their SER performance (and hence are overlapped when plotted in single figure).

When compared to pedAchannel, the LFDMA performance is slightly better in AWGN channel but IFDMA and DFDMA performance is better for pedAchannel.

When compared to vehAchannel, the SER performance of LFDMA is slightly better while IFDMA and DFDMA SER performance is almost same.

7. CONCLUSION & FUTURE SCOPE

7.1 Conclusion

In this paper, we develop a new strategy for the optimization of the PAPR-reduction cost function-based issue. Productive performance has been demonstrated by the performance of the proposed PAPR reduction method for MIMO OFDM. Results have shown a comparative comparison of the proposed approach with the traditional PAPR method based on side-related details, such as the selective mapping and the partial sequence of transmission better known as SLM or PTS. In this project we have focused on the performance analysis of OFDMA and SCFDMA systems in terms of SER and PAPR. Three types of channel (pedAchannel, vehAchannel and AWGN channel) were introduced along with two types of subcarrier mapping (localised and distributed, IFDMA is a special case of DFDMA). For all types of channel, it was observed that LFDMA subcarrier mapping shows better SER performance than IFDMA and DFDMA subcarrier mapping because of its better immunity to multiple access interference (MAI). Also the SER performance for IFDMA subcarrier mapping is almost similar to that of DFDMA subcarrier mapping.

Furthermore, in case of OFDMA system LFDMA sub-carrier mapping gave similar SER performance for pedAchannel and vehAchannel but a slightly better performance with AWGN channel. IFDMA subcarrier mapping and DFDMA shows similar performance with vehAchannel and AWGN channel but a slightly better performance with pedAchannel.

In the SCFDMA system LFDMA subcarrier mapping gave best SER performance with vehAchannel with slightly reduced performance with pedAchannel and least performance with AWGN channel. IFDMA subcarrier mapping and DFDMA subcarrier mapping gave best performance with AWGN channel with slightly reduced performance with pedAchannel and least performance with vehAchannel. It was also observed that for all types of channel and subcarrier mapping, SER performance of SCFDMA is better than OFDMA systems. For OFDMA system, the PAPR performance of LFDMA and DFDMA is almost similar and IFDMA gives a better performance as compared to LFDMA and DFDMA in OFDMA.

In case of SCFDMA system, the PAPR performance of LFDMA and DFDMA is almost similar to SCFDMA and IFDMA gives a better performance as compared to LFDMA and DFDMA in OFDMA.

It was concluded that the PAPR performance of SCFDMA was significantly better in all three subcarrier mapping techniques i.e LFDMA, IFDMA and DFDMA, when compared to their counterparts in OFDMA.

7.2 Future Work

A reflection on the MIMO-OFDM systems exhibition and on different antenna arrangements is being incorporated in the present work. The system can also be tested under various channels and configuration of MIMO-OFDM system. Using higher order modulation, the system MIMO-OFDM can be modified to achieve enormous data limitation. Whatever the case, the BER (bit error) problem increases as the modulation request increases. Since the demodulator selection district in the group of stars decreases additionally when expanding the modulation request, the demodulator delivers incorrect results at its efficiency. The channel will drag the signal even harder on lower SNR (noise proportion signal) figures. These pressures would cause the community of stars to shift the signal and cause the demodulator to yield the corrupt results. Whatever the case, with the increase in the influence of the SNR bends offered by the channel, the effect of the BER will also decrease. Along these lines, enormous data limits can be reached via the current channels by higher demand modulation, the most important thing to note is the extent to which the SNR calculations can be defined.

REFERENCES

