PERFORMANCE ANALYSIS OF WIRELESS COMMUNICATIONS AGAINST MIMO AND OFDM

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Abstract

The trendy technique for a broadband records switch is now wireless verbal exchange structures primarily based on multi-antenna multi-service modulation techniques, along with multi-enter-multi-output (MIMO) and orthogonal frequency division multiplexing (OFDM). One of the maximum aggressive technologies for 4G mobile Wi-Fi systems is now the MIMO-OFDM device. MIMO-OFDM systems could make up for the shortcomings of MIMO systems and highlight their advantages. For a couple of-input a couple of-output orthogonal frequency-division multiplexing (MIMO-OFDM) structures for 4X4 antenna arrangement, a preferred Quasi orthogonal area time block code (QOSTBC) structure is proposed in this take a look at. The MIMO-OFDM system in this work uses the Zero-Forcing Equalization linear detection algorithm for signal detection.

The improvements offered by OFDM-based systems in comparison to linear systems are strongly constrained by these drawbacks. Therefore, it is essential to consider the effects of nonlinear HPA and non-ideal oscillator while assessing the effectiveness of OFDM-based systems. As a result, the main goal of this research is to examine how multi-user (MU) MIMO and OFDM-based CA systems perform when there are hardware flaws. Orthogonal frequency division multiplexing (MIMO-OFDM) systems for multiple users, multiple inputs, and multiple outputs When the transmitter has complete Channel State Information (CSI), the performance can be enhanced. At the receiver, the downlink channel's characterization is determined and fed back to the broadcaster. However, a delay or an error in the feedback loop could cause the transmitter to receive erroneous information. The presentation of the Bit Error Rate (BER) and the subsequent channel limit misfortune are evaluated. Framework boundaries are changed to concentrate on the BER and limit of MIMO-OFDM frameworks.

Keywords: Wireless Communications, MIMO and OFDM, Statistical Model.

1. Introduction

As the demand for high-information rate interactive media grows, various arrangements, including supporting the tweak request and utilizing different radio wires at the transmitter and recipient, have been inspected to work on the otherworldly proficiency. Present day correspondence networks often utilize the balance innovation known as symmetrical recurrence division multiplexing (OFDM). A portion of its advantages incorporate high range effectiveness,

ISSN- 2394-5125 VOL 7, ISSUE 19, 2020

protection from between image obstruction, simplicity of execution utilizing the quick Fourier change (FFT), and straightforward balance strategies. Various information numerous result (MIMO) innovation and OFDM frameworks have as of late drawn a ton of interest. These frameworks are alluded to as MIMO OFDM frameworks.

However, the multipath nature of the environment forces the MIMO channel to be frequency-selective when significantly higher throughputs are sought. It is notable that spatially multiplexed MIMO supports throughput. The recurrence viability of such a recurrence particular MIMO channel can be enormously expanded by using OFDM to partition it into various equal recurrence level MIMO channels. Thus, MIMO-OFM innovation has been read up as the reason for cutting edge wireless organizations.

The demand for frameworks that can uphold high information rates has expanded with the ascent in the utilization of uses that empower media transmission, like computer generated experience (VR), 3D films, and the web of things (IoT). In order to satisfy the demands of high-end multimedia data transmission in the future, the wireless network infrastructure must be urgently upgraded given the rate of technological improvement in the area of image resolutions. When we look back at key evolutionary turning points in the wireless communication sector, we discover that using the OFDM methodology was a crucial step in improving the data rate transmission. In actuality, OFDM has been heavily utilised by numerous well-known protocols, including wireless LAN.

Utilizing OFDM, which is actually a MCM approach, the high information rate stream is separated into streams with lower information rates. The information in OFDM is intrinsically impervious to recurrence specific blurring since the bandwidth expected for each stream is definitely not exactly the soundness bandwidth of the channel. Because of the low intricacy of OFDM frameworks, the fourth-age (4G) and fifth-age (5G) versatile organizations will likewise intensely depend on them to give end clients admittance to rapid information. The LTE wireless structures, which rely upon 4G OFDM wireless development, give an extent of traffic, fair preparation, and changed Quality of Service (QoS). LTE gives incredible QoS to a grouping of traffic types. The methodology of QoS changing arranging rules in a LTE downlink is urged to give unprecedented QoS to grouped traffic classes using MU-MIMO.

One of the latest empowering innovations to handle information rates across 5G (B5G) and 6th era (6G) networks is monstrous MIMO. The MIMO base station (BS) has a greater number of radio wires than the quantity of overhauled customers. MIMO supports network limit and information speed by scattering information parcels north of a few sign courses and empowering various clients to interface immediately (MU-MIMO). MIMO is expected to be used in B5G and 6G in light of the fact that for its potential benefits over MU-MIMO. MU-MIMO was utilized in before versatile ages because of its benefits over highlight point MIMO. With cutting edge highlights like higher range adequacy and smoothed out signal handling, MIMO is subsequently a superior type of MU-MIMO.

2. Literature review

Gigantic MIMO is being commended as a crucial methodology for 5G and 6G applications and other cutting edge wireless correspondence organizations. To support the end clients, MIMO is fitted with a sizable number of radio wires at the base station. Improved spectrum efficiency and good communication dependability are two benefits of MIMO. Massive MIMO systems favour OFDM systems due to their ability to fully interoperate with a variety of modulation schemes, among other advantages. Enormous MIMO frameworks today basically use OFDM to relieve the impacts of level blurring channels and multipath engendering. On account of its power and support serious areas of strength for from like OFDM, tremendous MIMO will undoubtedly be the most sought-after advancement for requirements for bleeding edge multi-media data move.

There have been a few past exploration that inspected picture transmission over OFDM correspondence frameworks, as per a study of the writing. For example, creators took a gander at the digit mistake proportion (BER) execution of a few sign planning techniques in an OFDM-based picture transmission framework over the AWGN channel. Creators in likewise assessed the BER execution of an alternate arrangement of sign planning calculations. The creators constructed an OFDM-put together picture transmission framework with respect to programming characterized radios (SDR) and inspected the BER execution for different transmission planning methods. Moreover, creators have contrasted picture transmission and sound and text transmission utilizing BER and mean-square mistake (MSE) as relative measurements. In a similar setting, an OFDM-based picture transmission framework's Rayleigh and Rician blurring channels and the BER of different sign planning calculations are analyzed. Furthermore, research incorporates a proposition for a submerged correspondence channel's image transmission framework in light of OFDM DWT-OFDM and FFT-OFDM-based picture transmission frameworks have been differentiated in How channel assessment influences picture transmission utilizing OFDM frameworks has been examined. The impacts of the different channel leveling techniques were researched on an image transmission framework in light of a multi-transporter code-division numerous entrance (MC-CDMA). At this stage, it is additionally conceivable to see that MC-CDMA is simply one more sort of OFDM, where complex images are dissipated all through all subcarriers in the recurrence space prior to going through IFFT.

Another area of study has zeroed in on reducing and managing the Peak to Average Power Ratio, a typical issue in OFDM structures (PAPR). For instance, the BER appraisal of an OFDM-based picture transmission structure has been made ensuing to including the controlling strategy for PAPR decline. It was furthermore settled how the tone reservation (TR) strategy for PAPR decline affected the examination of BER for OFDM-based picture transmission systems. The effect of cutting down the PAPR by utilizing discrete cosine change (DCT) and DFT precoding systems on the BER evaluation of a MCCDMA-based picture transmission structure was researched. In, the makers researched how PAPR decline in recognizable light correspondence affects the BER appraisal of an OFDM-based picture transmission system (VLC). The effect of a couple unwinding procedures on the BER evaluation of the MIMO-OFDM-based picture transmission structure has been proposed. The makers looked at how changed change systems

ISSN- 2394-5125 VOL 7, ISSUE 19, 2020

used for picture transmission in MIMO-OFDM structures affected the piece bumble rate (BER) by merging methodologies and assortment demand. In, the makers examined how PAPR decline affected the BER, MSE, and PSNR of a MIMO-OFDM-based picture transmission structure. At long last, the creators broke down SSIM, PSNR, and BER for MIMO-OFDM picture correspondence frameworks in light of FFT and DCT. Table 1 differences the benefits and detriments of past works. This article consolidates m MIMO with OFDM rather than the previous articles, and likewise assesses the exhibition of the proposed framework involving a visual model notwithstanding PSNR and SSIM. In this review, the exhibition of the proposed framework is additionally examined regarding the quantity of clients, the sort of OFDM transformer, and the request for the regulation.

3. Challenges In Wireless Signal Transmission

The way of life of a human has been significantly influenced by wireless correspondence. Wireless organizations empower high velocity versatility for voice and information traffic coming from different sources. The essential peculiarity that makes transmission unsound is time-evolving blurring. The term "phenomenon" refers to the unpredictable fluctuations in signal intensity at the receiver brought on by the positive and/or negative interference of signals that arrive at the same antenna via different routes and, as a result, have different delays and phases. When signal power is significantly reduced by destructive interference, fading occurs. Deep fades drastically impair the signal quality at the receiver, occasionally rendering it impossible to decode or detect. They can occur at certain periods, frequencies, or locations in space. The non-coherent mix of signals that arrive at the receiving antenna causes multipath fading to occur.

In actual wireless communications, there are numerous types of interference. Multi-path propagation is one significant contributing factor. Due to multipath effects, ghost occurrences are seen in analogue TV broadcasting. The multi-path is what produces the delayed signal. This makes the past sign and the ongoing image cross-over. Entomb image impedance (ISI), which is welcomed on by this cross-over, decimates the sub-transporter symmetry in an OFDM framework. The multipath blurring can at times be moderately profound, i.e., the signs totally grow dim, despite the fact that it may not necessarily in every case make the sign fall under a specific useable force.

Impedance is brought about by profound blurs that happen at specific times, frequencies, or areas in space. Subsequently, the beneficiary's capacity to distinguish or interpret the signs is essentially compromised. There are numerous numerical models that have been created to portray these channels. The multipath fading phenomenon and sub-channel correlation are both taken into consideration by the model. To imitate the channel conditions of the real world, typical models frequently use the Rayleigh, Ricean, and Nakagami-m distributions. Fading can seriously impair the systems' performance (in terms of mistake rate). To obtain adequate performance, specific procedures may be needed because communication across these channels is challenging.

ISSN- 2394-5125 VOL 7, ISSUE 19, 2020

3.1. Causes of Fading

The primary source of fading is the multipath effect, which can result from radio waves from satellites being reflected off of objects. When antennas on the roof were still more prevalent than satellite dishes today, the same effect resulted in ghost images on television. In any earthbound radio correspondence framework, the transmission will arrive at the recipient straightforwardly as well as because of reflections off neighboring articles like designs, slopes, the ground, water, and so forth. The general transmission at the radio recipient is made by consolidating the range of transmissions being gotten. Considering that each sign has an interesting travel time and an alternate stage, signs will add or deduct in view of their relative stages. The multipath echo generation from a real target is shown in Figure 2. Reflection, diffraction, scattering, and Doppler shift are the main reasons of fading.

1) Reflection

This happens when a wave encounters a barrier that is substantially greater than the wavelength of the signal. Reflections from the soil and structures are two examples. The original signal may be negatively or positively affected by these reflections.

2) Diffraction

This happens when a solid object and a surface with sharp imperfections block the radio path between the sender and receiver (edges). This depicts how radio transmissions can go through metropolitan and provincial regions without any trace of a view (LOS) way.

3) Scattering

This occurs when many barriers with diameters on the order of the propagating wave's wavelength or smaller exist in the radio channel. Even tiny items, uneven surfaces, and other imperfections in the channel might cause them. It adheres to the same diffraction principles. It results in the transmitter's energy radiating in numerous directions. Examples of items that could spread include street signs and lampposts.

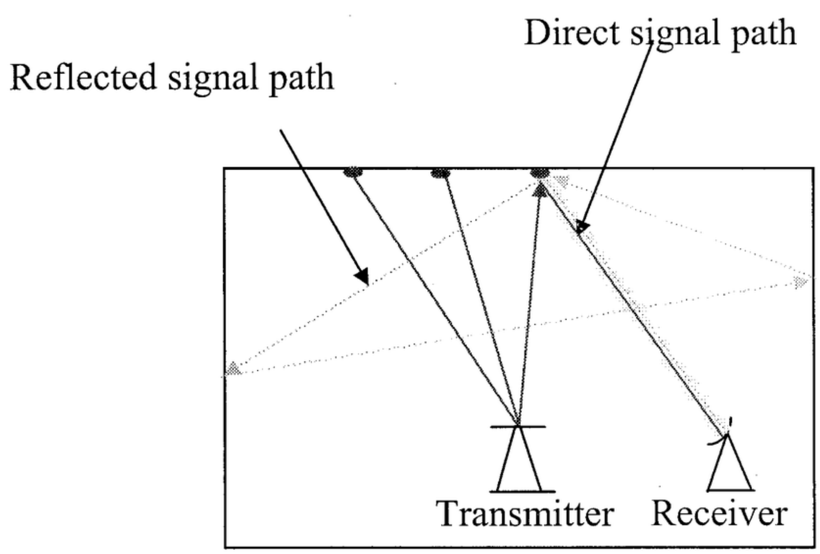

Figure: 1. Multipath Phenomenon

ISSN- 2394-5125 VOL 7, ISSUE 19, 2020

4. Statistical Model for Fading Channels

To completely understand wireless communications, one should see what befalls the transmission during its section from the transmitter to the collector. One of the fundamental components of this way between the transmitter and collector is the event of blurring, as was at that point depicted. For the likelihood dispersion capability (PDF) of the sign plentifulness presented to versatile blurring, there are many models accessible to describe such blurring occasions. The Rayleigh, Ricean, and Nakagami obscuring models are the most remarkable of these models in view of their wide use in exploration and practical applications.

4.1. Rayleigh Fading Channel:

When all of the components are out of line of sight, the received signal envelope distribution is referred to as rayleigh fading. The fundamental Rayleigh blurring model makes the supposition that a got multipath signal is made out of countless (hypothetically imperceptibly many) reflected waves with free and indistinguishably circulated (i.i.d) in stage and quadrature amplitudes. One of the attributes of the indoor or portable radio channel is multipath gathering. There are many radio waves that are reflected as well as an immediate view (LOS) radio wave in the transmission that is shipped off the recipient. The LOS is typically blocked in urban settings by barriers, which results in a mobile antenna picking up a range of waves with different delays. These reflected waves interfere with the direct wave, severely decreasing the link's performance. Additionally, if the antenna moves, the channel will change over time and space as a result of the shifting relative phases of the reflected waves. The received signal's amplitude and phase will gradually change over time, which will cause fading. The Bit Error Rate (BER) rapidly decreases in a non-fading (and, consequently, fixed), radio channel when the signal-to-noise ratio is increased, or, more specifically, when the signal-to-interference ratio is increased. Even with a high (average) signal-to-noise ratio, this phenomena still exists. Plotting the BER on a log-log scale reveals that it only increases extremely gradually and with a set slope. A wireless system must be built to reduce the negative effects of multipath fading.

The cumulative distribution function (CDF) FR(r) and probability density function (PDF) fR(r) of the random variable R after Rayleigh fading are given by,

$$\mathbf{F_R(r) = 1 - exp(\frac{-r2}{2\sigma^2})}$$

And

$$\mathbf{f_R(r) = \frac{r}{\sigma^2} e \frac{-r^2}{2\sigma^2}}$$

In the above, σ^2 is the variance of the random variable. The Rayleigh distribution above has been derived for slow fading channel.

4.2. Ricean Fading Channel

With the exception of the presence of a sizable dominant LOS component, Ricean fading's mechanism is similar to that of Rayleigh fading. A more complex Ricean model considers the following factors as well:

ISSN- 2394-5125 VOL 7, ISSUE 19, 2020

- The dominant signal, such as the line-of-sight plus a ground reflection, can be created by adding the phasors of two or more dominant signals. Following that, much of this combined signal is handled as a deterministic (completely predictable) procedure, and
- Shadow attenuation may also affect the dominant wave. This is a widely held belief when modelling satellite channels.

5. Nakagami Fading Channel

Multipath scattering with various wave clusters and reasonably significant delay-time spreads results in Nakagami fading. Individual reflected waves' phases vary randomly within each cluster, but all waves' delay periods are about the same. As a result, each cumulated cluster signal's envelope has a Rayleigh distribution. It is presumable that each cluster has a significantly different average time delay. At the point when the postpone lengths likewise fundamentally surpass the piece term of a computerized association, the unmistakable groups essentially increment between image obstruction (ISI), and the multipath self-impedance then generally looks like the situation of co-divert impedance by quite a few people in lucid Rayleigh blurring signals. The primary realities about Nakagami blurring are introduced in the sections that follow. The instantaneous power is Gamma distributed if the envelope is Nakagami distributed.

- The "m" parameter, which is defined in equation 6, describes nakagami fading. The Nakagami or Gamma distribution's parameter m is known as the "shape factor."
- Rayleigh fading is recovered (from the Nakagami distribution) in the particular case m = 1, but with an exponentially dispersed instantaneous power.
- In contrast with Rayleigh blurring, the sign strength varieties are decreased when m > 1.

Rayleigh and Ricean fading can both be explained by a single model based on the Nakagami distribution. The Nakagami and Rayleigh distributions have been mapped one to the other.

6. OFDM Methodology

It likewise addresses the multipath and inactivity issues for wireless correspondence when utilized for high information rate transmission through the correspondence framework. Multi-transporter is utilized in OFDM to increment information throughput and bandwidth effectiveness [49]. In this work, we use OFDM using different FFT, DWT, and FrFT execution techniques. An OFDM transmitter and gatherer can be depicted using the blocks of Inverse Discrete Fourier Transform (IDFT) and Discrete Fourier Transform (DFT).

6.1.DWT Method

DWT utilizes different goal innovation to show signals in the recurrence and time spaces all the while. Drive Response Half Band Low Pass Filter (LPF) and Impulse Response Half Band Low Pass Filter (HPF) signs and convolutions utilized in the QMF (Quadrature Mirror Filter) bank of wavelet-based frameworks. FFTs can be exchanged for DWTs to represent subcarriers as OFDM multiresolution signals in low and high filter configurations.

Where d is the shift boundary and is the mother wavelet, which is underlying a way that permits the first sign to be recuperated when it is transformed, The IDWT can therefore additionally manifest as:

$$x_n = \sum_{d=0}^{\infty} \sum_{j=-\infty}^{\infty} x_{j,d}\, \Psi(2-^{j}n - d),$$

6.2. FrFT Method

The FrFT can also be used to replace the FFT of traditional OFDM systems. This framework approach is known as the FrFT-based OFDM framework and can be numerically communicated as:

$$x_n = \sum_{n=0}^{N-1} X_n F_\alpha(m,n), 0 \leqslant m < N,$$

Where $\alpha = p.\frac{\pi}{2}$ ($0 < \alpha < \pi$, p is the fractional of the transform, u is the sample space. When $\alpha \leq \frac{\pi}{2}$ the transform will be a conventional OFDM

7. Massive MIMO System Model

Imagine a huge MIMO system as shown in Figure 1. Here, the base station BS is equipped with a colossal number of recieving wires M, outfitting a singular receiving wire client K with a choice of time and band repeat. The baseband beneficiary sign is given in the going with ways:

$$y = \sqrt{PHx + z},$$

where $\sqrt{px}$ z Is a free and indistinguishably conveyed (i.i.d.) AWGN with zero mean and variance (0, 2). Where is hailing data (mean send power is P) and H is the channel among BS and K clients. This is the Rayleigh obscuring channel model. Multiply the linear detector matrix A by the MK weight as follows to use linear detection to separate the K users on the uplink.

$$y = \sqrt{PA^H Hx + A^H}z,$$

The weight matrix of linear detection can be conduct with different linear receivers such as MRC, ZF, and MMSE.

8. OFDM-Massive MIMO

MIMO is made by consolidating OFDM as displayed in Figure 2. Every client sends information at a block of IFFT-N focuses on the uplink and adds a cyclic prefix (CP) before the information block is conveyed over the channel. The CP is essential for the finish of the block contained toward the start of the block. After the CP is removed, the received signal from each BS antenna goes through the FFTN point block of the BS, and the generated signal is sent to the following detection techniques. B. Mini-mental state error (MMSE) or zero forcing. A stream outline for the proposed OFDM huge scope MIMO framework to accomplish the ideal PSNR and SSIM values is displayed in Figure 3 Electronics 2022, 11, 621 9 of 26. The communicated signal information for every client is addressed as the N point of the IFFT.

$$\mathbf{x}_{k,i} = \frac{1}{N} \sum_{k=1}^{K} \sum_{n=0}^{N-1} \mathbf{X}_{k,n} e^{\frac{j2\pi ni}{N}},$$

Every one of the above conditions addresses the OFDM with various plan techniques like FFT, DWT and Frft, with various boundaries.

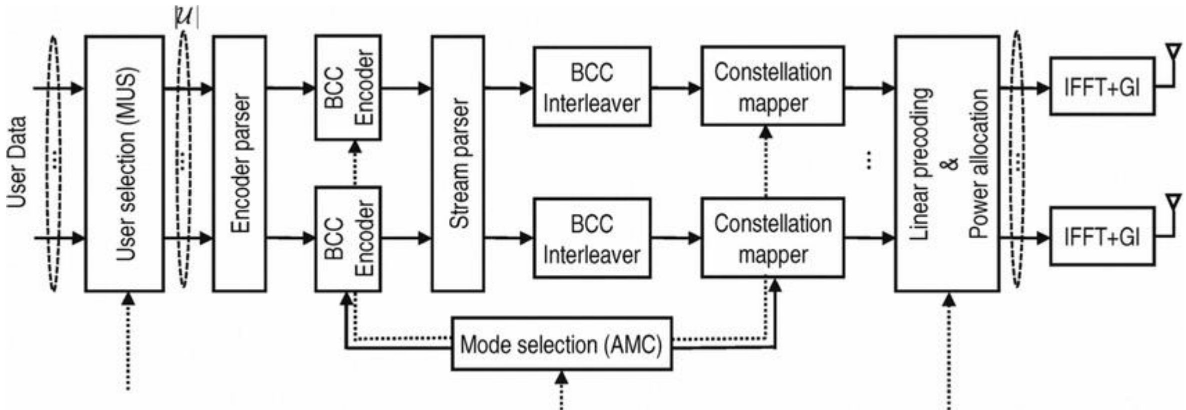

Figure: 2. Block diagram of OFDM Massive MIMO systems in the uplink.

MIMO	Parents	Timing	Impact Percentage
INPUT 100	20	3hr	32%
INPUT 100	20	3hr	42%
INPUT 100	20	3hr	28%
INPUT 100	20	3hr	19%
INPUT 100	20	3hr	29%

Table: 1. Percentages of MIMO

The relationships established between network optimization and passively coordinated control have so far only provided analytical results and have not helped derive synthetic methods. Now address the issue of imposing a specific steady state on a closed control loop

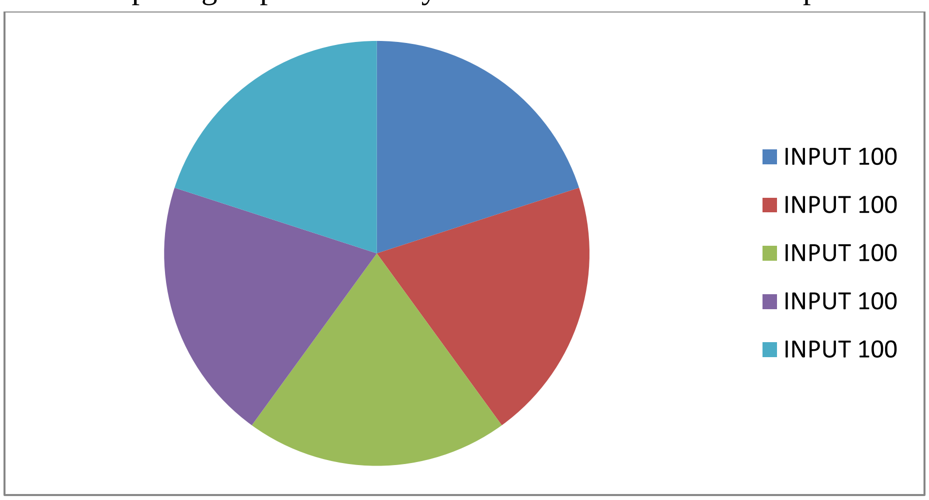

Figure: 3. Input Percentages of MIMO

OFDM	DATA EVALUATION	Timing	Impact Percentage
INPUT 100	20	3hr	42%
INPUT 100	20	3hr	43%

INPUT 100	20	3hr	38%
INPUT 100	20	3hr	37%
INPUT 100	20	3hr	31%

Table: 2. percentage of OFDM

Unique Word Orthogonal Frequency Division Multiplexing (UW-OFDM) is a new type of signaling concept in which guard intervals are implemented as deterministic sequences, so-called unique words. UWs are created by introducing a certain level of redundancy in the frequency domain. The comparison of various data estimation strategies with UW-OFDM's favorable bit error rate (BER) performance and competing concepts has already been discussed in detail in previous articles. This work focuses on different ways in which UW-OFDM signals can be generated. The optimality of the two-step approach to the direct approach in systematic UW-OFDM is analytically proven, and a heuristic algorithm that enables high-speed numerical optimization of redundant subcarrier positions is presented and uniquely spreads redundant subcarriers. The systematically coded UW-OFDM is also virtually optimal for transceiver-based cost functions by minimizing average redundancy energy. Finally, we derive a closed-form approximation of the statistical symbol distribution and redundant energy distribution of the individual subcarriers and compare them with the numerically obtained results.

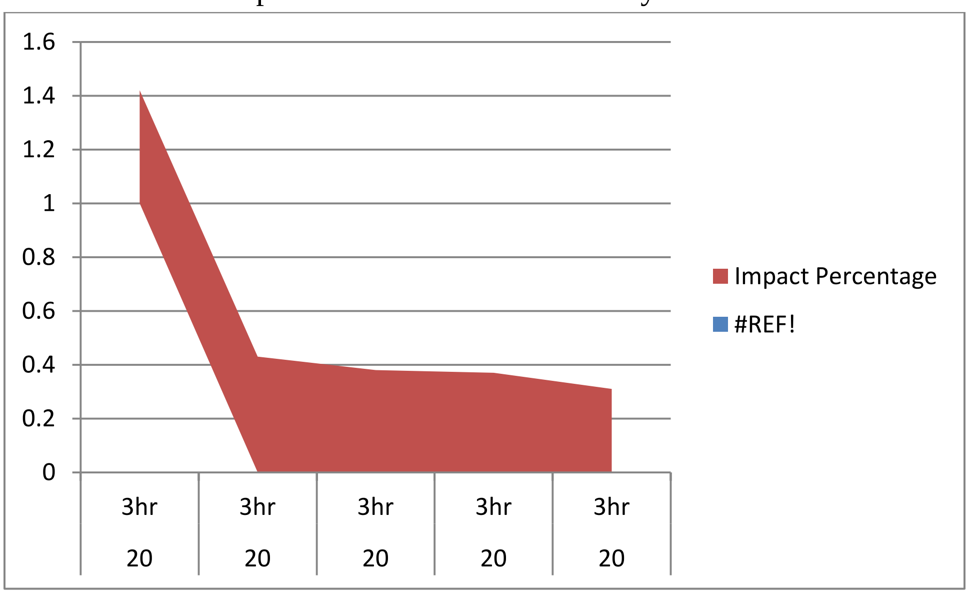

Figure: 4. Percentage of OFDM Input

9. Conclusion

In this study, we used a hybrid combination of large-scale MIMO and OFDM systems and various transforms such as FFT, FrFT, and DWT to achieve the fast, bandwidth-efficient, and reliable requirements for 5G and 6G systems. Provides high image communication ideas. Analysis of Rayleigh fading channels has been shown at various M-PSK modulation levels. The reenactment results plainly show that the picture quality break down as the quantity of clients increments from 10 to 50 at a specific SNR level. In any case, the higher the SNR, the better they got picture quality. Looking at the got picture nature of cross breed Massive MIMO and OFDM

ISSN- 2394-5125 VOL 7, ISSUE 19, 2020

frameworks improved with FFT, FrFT, and DWT changes, the FFT expanded OFDM framework obviously beats the FFT broadened OFDM framework. In any case, assuming you supplant the DWT change with the FrFT change, you will observe that they got picture quality is fundamentally moved along. The detailed qualities for PSNR and SSIM can be utilized to get to picture quality upgrades notwithstanding visual assessment. Furthermore, our review showed that DWT-improved OFDM has preferred PSNR and SSIM scores over FrFT and FFT-upgraded OFDM. Nonetheless, the PSNR and SSIM values for all unique regulation levels and change approaches decline as the quantity of clients increments. Describes how feedback delays and feedback errors affect the performance of MUMIMOOFDM. Numerical results for various system specifications were displayed to investigate the impact of feedback latency. Analysis shows that if feedback is not updated properly, system performance will suffer. The ICI was supposed to be the result of a feedback error. BER performance and capacity with feedback errors are investigated and shown for various system parameters.

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