# COMPARATIVE ANALYSIS OF BER AND PAPR FOR OFDM, OFDM–CDMA, OFDM-MC-CDMA & OFDM–IDMA SYSTEMS

## [1]SHIVAM YADAV, [2]PRASHANT KUMAR, [3]RAVI KUMAR SINGH, [4]VIVEK RAJ, [5]DEVASIS PRADHAN

[1,2,3,4] Final Year U.G Students, Department of Electronics & Communication Engineering, Acharya Institute of Technology, Bengaluru - 560107, Karnataka, India
[5]Assistant Professor, Department of Electronics & Communication Engineering, Acharya Institute of Technology, Bengaluru -560107, Karnataka, India
Email: [5]devasispradhan@acharya.ac.in

**Abstract** - Remote correspondence innovation has been created dependent on investigating new versatile interchanges recurrence groups, sensible utilization of recurrence assets and minimization, compactness, and multifunction's of portable stations. The innovation of remote correspondences with the duplex transmission is one of the quickest growing on the planet today. OFDM-IDMA innovation frames the fundamental stage for the fourth era portable correspondence i.e.4G when performed impeccably. In this paper, we present the reproduced aftereffects of the OFDM framework in presence of blurring impact and noticed the impediment and disadvantages of utilizing it. Paper finishes up by examining the benefits OFDM-IDMA framework in contrast with OFDM-CDMA.

**Keyword** - BER; PAPR; OFDMA; IDMA; CDMA; Mc-CDMA

## I. INTRODUCTION

Today as the requirement for progression and request has expanded the remote correspondence framework in order to get high velocity, high dependability and high information rate. Consequently, there was a need to go past OFDM-CDMA (4G) innovation. This was finished by coordinating the idea of IDMA rather than CDMA in OFDM-CDMA in order to accomplish OFDM-IDMA. This thought of an OFDM – IDMA which is a half breed correspondences plot consolidating OFDM and IDMA has been proposed and studied. In OFDM – CDMA innovation we utilize the idea of spreading, to spread the codes on the whole data transmission and furthermore to separate among the clients. In any case, as per Coding hypothesis it's anything but a solid methods for spreading the codes, since because of this the framework can't get coding acquire and the band likewise expands, this is additionally an issue identified with the OFDM – CDMA framework.[1-2] Similarly, IDMA allows a easy and powerful rapid-type iterative multiuser detection (dust) algorithm relevant to the machine with having a massive quantity of customers, which is important for the device to acquire high throughput. Within the OFDM – IDMA machine, it isn't required to spreading the codes, because the codes are differentiated the use of interleaved & because of this the entire band spreading of the machine can be used for FEC to get a better benefit. Simultaneously it also overcomes the difficulties in the sooner OFDM – CDMA gadget [1]. In each systems, BER is the essential performance parameter that shall we us recognize regarding the error inside the obtained sign. It's miles

discovered that BER is bad in OFDM –CDMA in comparison to OFDM – IDMA, the negative BER may result in the image fading in the OFMD –CDMA device, and as BER performance is observed out to be tremendous in OFDM – IDMA and due to the use of Interleaves we get better performance on this gadget.[3] MC-CDMA and OFDM systems are broadly used inside the exiting third and 4th generation of wi-fi networks. It is the maximum promising technique for excessive bit rate and high-pace facts transmission in cellular communications. One of the fundamental terrible elements of MC-CDMA is the excessive height-to-common electricity Ratio (PAPR). Excessive PAPR consequences in nonlinear distortion at a high strength amplifier (HPA) and degradation of the bit errors price (BER).[4]

## II. OFDM SYSTEM- OVERVIEW

The basic concept of OFDM is that it makes use of a massive wide variety of parallel slender-band sub-companies in preference to a single wideband carrier to transport statistics. The precept of orthogonally have to be happy some of the customers so that it will preserve the gadget efficient. Thus OFDM is a virtual modulation approach used to split a wideband signal to a narrowband sign. As of now Orthogonal Frequency division Multiplexing (OFDM) has grown to be the most famous device & technique for digital communication over a wideband bandwidth. Attributable to this OFDM is utilized in all of the programs which require excessive bandwidth like television system, audio & video broadcasting, higher generations of cell communications i.e. 3G & 4G.

OFDM makes use of more than one service frequencies on which it encodes the digital facts for transmission, & considering that virtual facts is been used it gives higher speed excellent security to the data been processed.[4-5] For orthogonally it is required that the sub-service need to have spacing of

$\Delta f = \frac{k}{TU}$ Hertz, where TU seconds is the beneficial symbol period and okay is a effective integer, in which this price is generally equal to one. Consequently, if we have N sub-providers, the total pass band bandwidth of $B \approx (N * \Delta f)Hz$. Figure 2. Shows functional block diagram for OFDM system.
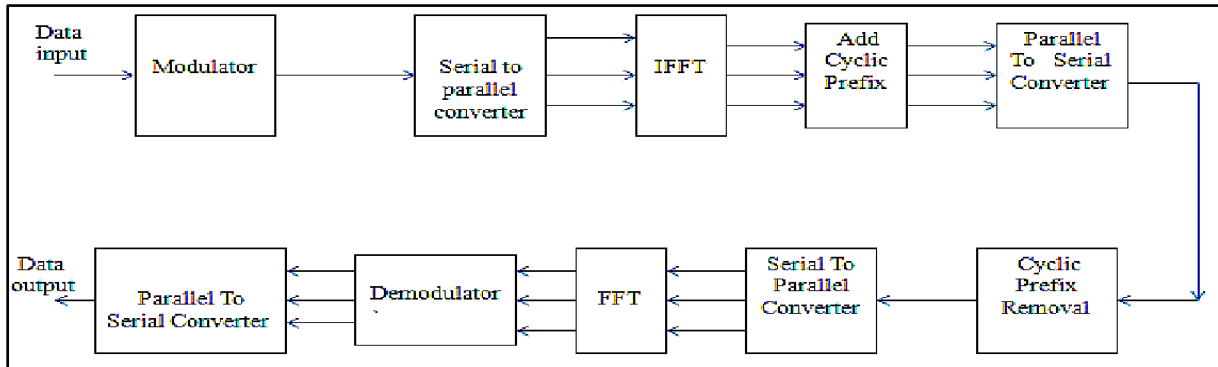


**Figure 2. Block diagram for OFDM System**

In OFDM, for demodulation of subcarriers, we use the concept of the defend band. Additionally, the usage of orthogonal subcarriers could permit the subcarriers' to overlap the spectrum, as a consequence increasing the spectral efficiency. As long as orthogonally is maintained, the person subcarriers' alerts may be recovered despite their overlapping spectrums [1].In the above block diagram [1]. Cyclic Prefix (CP) is used for you to avoid the ISI (Inter symbol Interference). This is accomplished by using placing the CP earlier than the starting of every image at some point of transmission. On receiving the symbol on the receiver facet this CP is eliminated & the code is obtained due to this the hassle of ISI is prevented. This concept of CP is used solely in OFDM generation and it isn't utilized in FDM or some other approach. Due to this OFDM is favored over FDM & approach for information transmission with high pace & high statistics rate.[6-7]

## III. IDMA SYSTEM – OVERVIEW

The basic concept of IDMA is that it uses the interleave for different users for the separation of codes. This minimizes the problems of fading and information loss. So IDMA is special form of CDMA in which different interleaves are used for separation. The main advantage of using IDMA is that it protects the signal from fading, which is quite difficult in CDMA system. Therefore, as IDMA uses interleaves, we get good BER results, also the usability of spectrum is good & the complexity of receiver is less, since no orthogonally is required. So the main function of interleave is to just separate out the different users in one single channel [1]. The performance of code-division multiple-access (CDMA) systems is mainly limited by multiple access interference (MAI) and Inter Symbol Interference (ISI). Encouraged by the success of turbo codes in additive white Gaussian noise (AWGN) channels. This led to the need for going further to IDMA technology so as to overcome it. Figure 3. Shows the functional block diagram for IDMA system.[2,3-6]
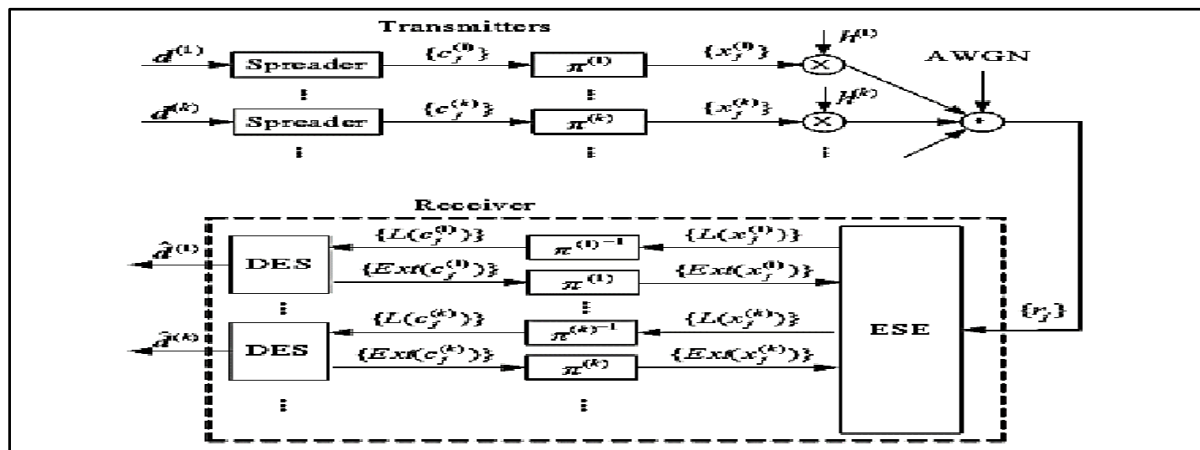


**Figure 3. Block Diagram for IDMA System.**

Comparative Analysis of BER and PAPR for OFDM, OFDM–CDMA, OFDM-MC-CDMA & OFDM–IDMA Systems

The most coding gain may be obtained by means of combining the coding with the spreading operations with using low-charge codes. It's far discovered out that conventional random waveform CDMA (RW-CDMA) gadget (together with IS-95) is having separate coding & separate operations. On studying theoretically when the complete bandwidth expansion is devoted to coding it's far feasible to achieve the most useful a couple of get entry to Channel (MAC).[7-8]

## IV. OFDM-CDMA SYSTEM – OVERVIEW

The fundamental idea of OFDM – CDMA technology is that code is assigned to each consumer & more than one customers use the identical channel frequency at the equal, the codes are differentiated a good way to keep the orthogonality. In maximum third-technology cell phone systems it's far been proposed to apply Code division more than one get entry to (CDMA) as their modulation method [2]. Its miles a sort of unfold spectrum approach used for outside surroundings verbal exchange that uses neither frequency channels nor time slots. In CDMA, the narrow band signal is getting expanded with the aid of a big bandwidth sign that's a pseudo-random noise code.[9]
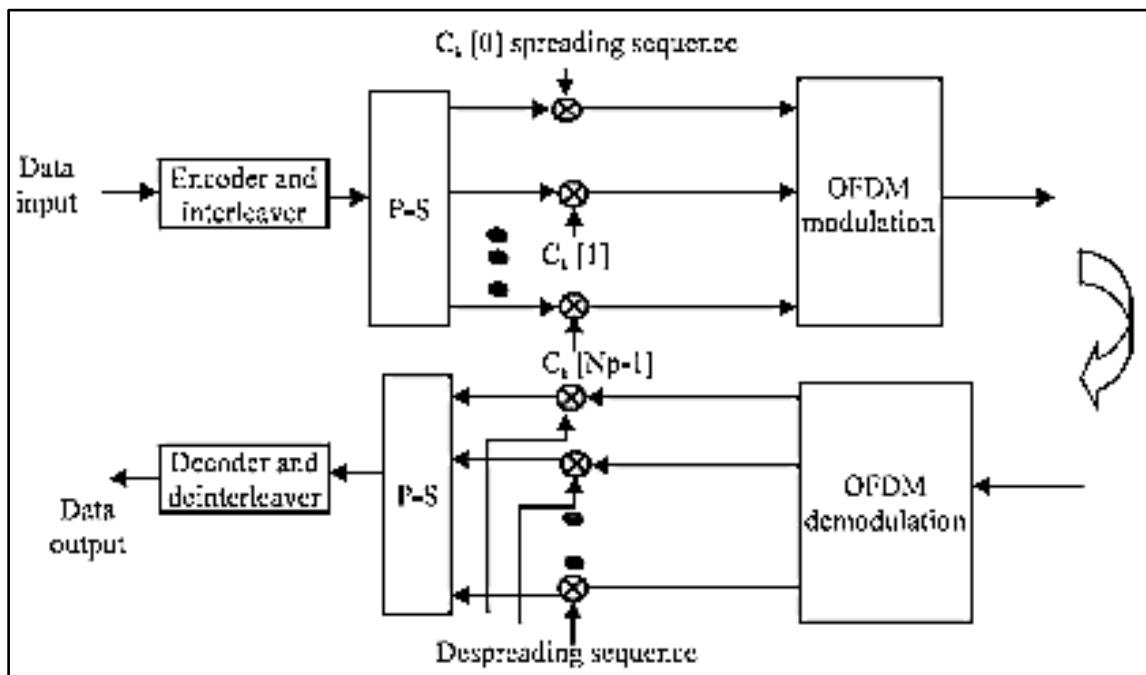


**Figure 4. Functional block diagram for OFDM-CDMA System**

So to conquer it many proposals were proposed which stated that OFDM need to be combined with CDMA so that you can received better outcomes for wireless conversation with fulfilling all the homes & by means of taking the care that there ought to not be any downside must be encountered. With OFDM – CDMA many modulated subcarriers are used over which a couple of statistics symbols are transmitted. OFDM – CDMA offers accurate spectral homes, wherein the OFDM technique remedy the frequency selectivity in multipath fading channels. Figure 4. Shows the brief ideal representation of basic block diagram of ODFM-CDMA System.[10]

## V. OFDM- IDMA SYSTEM – OVERVIEW

OFDM-IDMA combines maximum of the advantages of each OFDM and IDMA, the important thing benefit of OFDMIDMA is that mud may be realized correctly with complexity is appreciably decrease than that of other alternatives. In wireless communique, the major sources of impairments have been located as more than one-get entry to interference (MAI) and inter-symbol interference (ISI). The solution to this became Multi-user Detection (mud) & also time-area equalization turned into determined out very highly-priced. So there has been a need to overcome some of these drawbacks & to increase an top-quality answer for wireless verbal exchange, & it became discovered out that by way of the use of the combination of OFDM & IDMA those interferences may be conquer & the fading trouble may be resolved.[10-12]
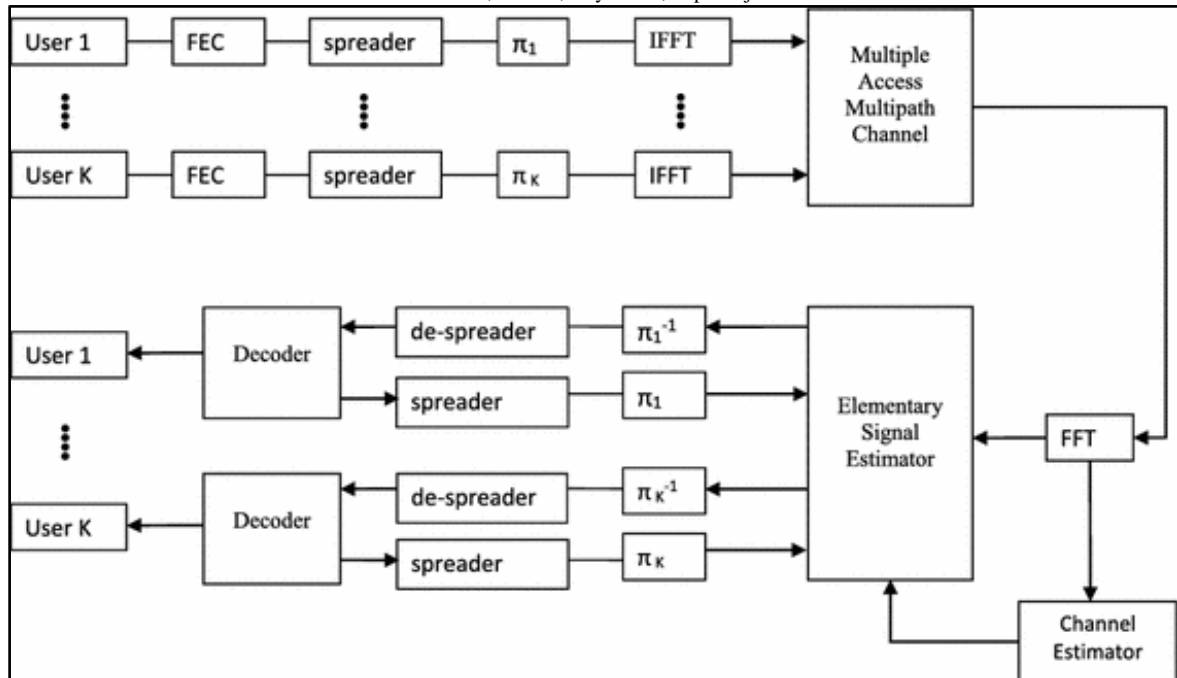
**Figure 5. Functional block diagram for OFDM-IDMA System**

The coded signals are first interleaved by user specific interleaves $\{p_k\}$. Then the resultant signals, again denoted by $\{xk(n)\}$, are modulated onto subcarriers by using IDFT. Each subcarrier can be occupied by several users, so users are solely distinguished by their interleavers. Let dkbe the data stream of user-k. This data stream is encoded by a forward error correction (FEC) code, generating a chip sequence ck. (Here, "chip" is used instead of "bit" as the FEC encoding may include spreading or repetition coding.) Then ck is permutated by a user-specific interleaver-k. After symbol mapping, the symbol sequence xk= [xk(1); ¢ ¢ ¢ ; xk(j); ¢ ¢ ¢ ; xk(J)]T is produced, where J is the frame length. Then these symbols are modulated onto different subcarriers by IFFT.[11-13]

In the receiving end, OFDM signal is demodulated before iterative multi-users detection, we assume that the max delay of multi-path channels is smaller than cyclic prefix (CP), if CP and OFDM demodulation are removed, the received signal i. Let dk be the data stream of user-k, which is given as [14-15]:

$$d_k = [\, d_k(1), d_k(2) \ldots \ldots d_k(i), \ldots \ldots d_k(I)\,]\ldots\ldots(i),$$

Where, I is the length of information code. This data stream is encoded by a forward error correction (FEC) code which gives output [1]: $b_k = [\, b_k(1), b_k(2) \ldots \ldots b_k(l), \ldots \ldots b_k(L)\,]\ldots\ldots(ii)$

Generating a chip sequence ck : $c_k = [\, c_k(1), c_k(2) \ldots \ldots c_k(j), \ldots \ldots c_k(J)\,]\ldots\ldots\ldots(iii)$

Then ck is permutated by a user-specific inter-leaver-k. After symbol mapping, the symbol sequence is produced,

$$x_k = [x_k(1), x_k(2) \ldots \ldots x_k(j), \ldots \ldots x_k(J)]^T \ldots\ldots$$
(iv)

where J is the frame length. Then these symbols are modulated onto different subcarriers by IFFT. If we consider the QPSK signaling method, then xk is given as

$$x_k(j) = x_k^{Re}(j) + x_k^{Img}(j)\ldots\ldots\ldots(v)$$

At the receiver side, OFDM demodulation is carried out before iterative MUD processes. Assuming that the duration of cyclic prefix is longer than the maximum channel delay, the received signal after OFDM demodulation can be expressed. Then the CBC detection algorithm for complex single-path channel can be applied[13].

The optimized OFDM-IDMA scheme possesses several attractive properties, including:
a. Very high spectral efficiency
b. Flexibility in multi-user as well as single-user mode transmission,
c. Multi-user gain in fading channels

## VI. OFDM- MC-CDMA OVERVIEW

MC-CDMA is a more than one get right of entry to scheme that allows the device to aid a couple of customers at the equal time. The block diagram of the MC-CDMA transmitter is shown in Figure 6. The working of every block describes as:

a. K user information: The source of facts can be a symbol of okay consumer. It transmits the records symbol of ok user concurrently on numerous slim-band sub-channels.
b. Spreader: The maximum important motive of the spreading codes is to assist hold orthogonality amongst exceptional bodily channels of the uplink consumer. Walsh-Hadamard codes, additionally known as OVSF (Orthogonal Variable Spreading

issue) codes are used for the frequency spread coding to gain orthogonality amongst users.

c. Modulator: Modulation is the technique with the aid of which the signal wave is converted over the verbal exchange channel as a way to reduce the impact of noise. QPSK modulation is used. [13]

d. Serial to parallel converter records to be transmitted is within the form of a serial data circulate. So a serial to parallel conversion stage is needed to convert the input serial bit circulate to the statistics to be transmitted in every OFDM image.

e. IFFT: by way of running with MC-CDMA in the frequency domain the modulated QPSK records symbols are fed onto the orthogonal sub-vendors. But the switch of sign over a channel is simplest viable in its time area. For which we implement IFFT which converts the MCCDMA signal from the frequency area to the time domain. [10]

f. Parallel to serial converter: The parallel to serial converter is used to converted facts back into a serial records form.

g. Digital to Analog Converter and high power amplifier: After the parallel to serial conversion of the records move despatcher to the digital to analog converter observed by way of the excessive strength amplifier and up convertor for transmission.
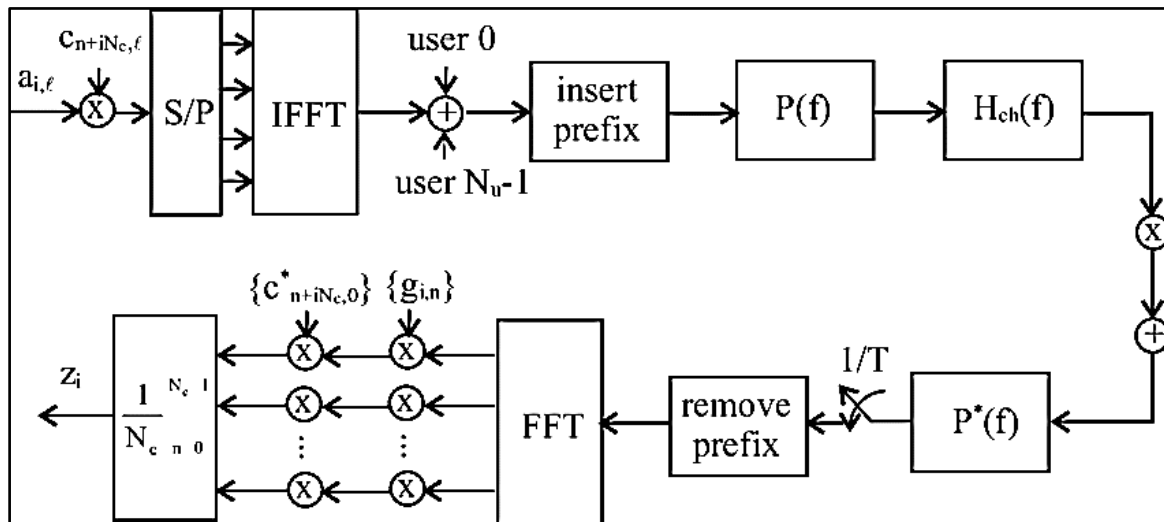


**Figure 6. Functional block diagram for OFDM- Mc CDMA System**

## VII. PERFORMANCE PARAMETER

### 1.1 Bit Error Rate (BER)

In a digital transmission system, the BER is the share of bits which have mistakes relative to the overall numbers of bits obtained in a transmission, usually expressed as ten to the poor electricity BER is a sign of the way often a records unit must be retransmitted due to mistakes. BER is measured by BERT (Bit blunders price Testers). BER occurs because of noise & trade in propagation pattern. It makes use of the concept of Cyclic Prefix (CP) so as to increase the length of symbol waveform through including a protect duration to the begin of each symbol which reduces ISI & ICI. Following are the factors affecting BER: Interference, High Transmission energy & Low Bandwidth.

$$BER = \frac{No.\ of\ Error}{Total\ No.\ of\ Bits}$$

Right here, we've got taken into consideration the parameter BER in order to analyze all the above-noted system & to find out that which of the amongst offers the ideal outcomes.

### 1.2 Peak to Average Power Ratio (PAPR)

OFDM signal comprises of various freely modulated the subcarrier signal, which extensive Peak-to-Average Power (PAP) ratio when included intelligently. At the point when N symbols are included with the same stage, they deliver a crest power that is N times of the average power.

$$PAPR = \frac{\max[|x_k|^2]}{E[|x_k|^2]}$$

where E[.] denotes expected value.

## VIII. COMPARISON BETWEEN CHANNEL ACCESS SYSTEM

The table 1. Discuss about the comparison between OFDM-CDMA, OFDM-Mc-CDMA and OFDM-IDMA

| Sl.No. | Parameter | OFDM-CDMA | OFDM-IDMA | OFDM-MC -CDMA |
|--------|-----------|-----------|-----------|----------------|
| 1 | BER | Substantially higher | Substantially higher than OFDM–CDMA | Lower than OFDM – CDMA. |
| 2 | MUD problems | Can be overcome without any system complexity. | Complexity is less as compared to OFDM-CDMA | Can be avoided but makes the system complex, and system become unreliable. |
| 3 | ISI & ICI problems | They are avoided by the use of Interleaver | ISI is less | They can occur in the system, causing fading & information loss. |
| 4 | Quality of Service (QOS) | High | Much higher than OFDM – CDMA | Lower than OFDM – IDMA |
| 5 | Throughput | Better in this system(By using Superposition coding technique[ | Better than OFDM-CDMA | Low compared to OFDM - IDMA |

**Table 1. Comparison between various access technique.**

## IX. RESULTS & DISCUSSION

In exclusive OFDMA schemes, PAPR and BER are the two maximum essential overall performance parameters. On this segment, we're going to examine the PAPR and BER performances for extraordinary MA schemes based on OFDMA. For the motive of comparing the performance of OFDM, MC-CDMA and OFDMA (interleaved and localized), we set the number of users Q = four, in which all of the customers use the equal transmit energy. The quantity of subcarriers in keeping with user is N = 32, consequently the FFT size for OFDM and MC-CDMA is M = N = 32, and for interleaved OFDMA and localized OFDMA the FFT length is M = NQ = 128 [10]. Right here we estimate the BER and PAPR Performances of OFDM, MC-CDMA, localized OFDMA and interleaved OFDMA through laptop simulations and verify our outcomes with the outcomes.
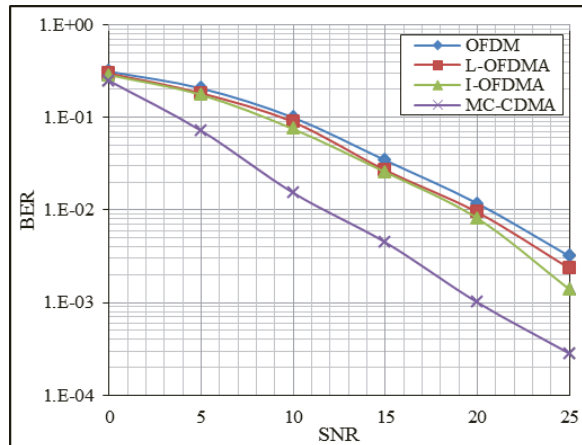


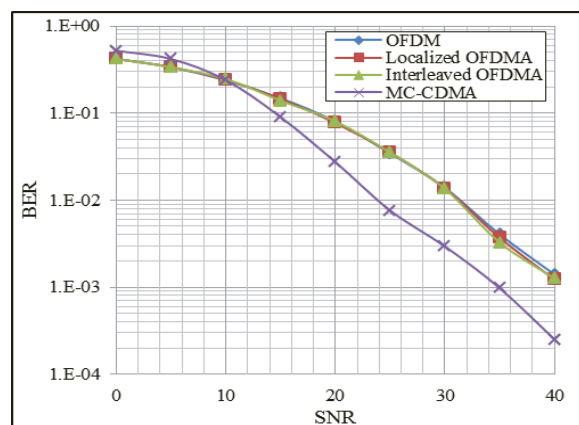**Figure 7. BER performances of different Multiple Access techniques using QPSK.**



**Figure 8. BER performances of different Multiple Access schemes using 16-QAM**
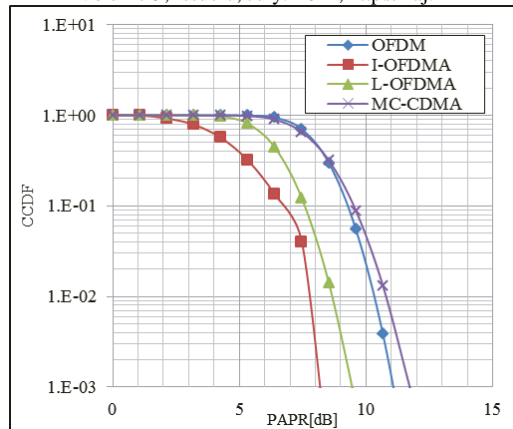
**Figure 9.PAPR performances of different Multiple Access schemes**

The above figure are the executed simulation performed for various Multiple Access Scheme. It's been discovered from the figures above that as SNR increases, BER decreases. Further, the BER overall performance of OFDM, localized OFDMA and interleaved OFDMA overlaps. The MC-CDMA offers satisfactory BER overall performance due to inclusion of CDMA technique. Similarly, we check out 2d most crucial parameter specifically PAPR. High PAPR has been recognized as one of the fundamental sensible trouble related to OFDM modulation. High PAPR effects from the nature of the modulation itself where multiple subcarriers are delivered collectively to form the sign to be transmitted. The variation of the envelope of a multi-service signal can be defined through the height-to-average strength ratio (PAPR). The complementary cumulative distribution function (CCDF) is used to indicate the statistical opportunity that the PAPR of a records block exceeds a given threshold PAPR0. Parent eight describe the CCDF comparison of OFDM, MC-CDMA, localized OFDMA and interleaved OFDMA with QPSK modulation. It's far honestly observed that I-OFDMA offers first-class PAPR performance followed L-OFDMA. Accordingly, I-OFDMA (OFDM-IDMA) proves to be the satisfactory techniques presenting minimum PAPR and tolerable BER overall performance.

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