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Outage Probability and Capacity improvement of A Wireless Communication System

Mohamed S. El_Tokhy[1], Somaya Ismail Kayed[2] and Elsayed H. Ali[1*]

[(1)] *Engineering Department, NRC, Egyptian Atomic Energy Authority, Egypt*

[(2)] *Electrical Engineering Department (Electronics, Communication, computer and control), Obour High Institute for Engineering and Technology -Egypt*

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ABSTRACT

The paper focuses on improving wireless communication networks for nuclear radiation monitoring by analyzing and evaluating the performance of Multi Carrier Code Division Multiple Access (MC-CDMA) as a wireless communication system. The work aims to determine the outage probability as a quality-of-service parameter and investigate the average channel capacity under channel deterioration. They use closed form expressions to present the performances of these characteristics and study the impact of the number of branches and subcarriers on the outage probability. In addition, the authors propose a robust and reliable approach to channel under fading and study the capacity of MC-CDMA with the largest number of users. The results obtained from the study confirm that exponential channel fading achieves the lowest outage probability compared to other channel degradations. Moreover, the proposed results guarantee high average channel capacity and high throughput, which are essential for the successful deployment of MC-CDMA systems. The findings of this study provide valuable information for researchers and engineers working in the field of wireless communication systems, particularly those interested in the design and optimization of MC-CDMA systems. Overall, the paper contributes to the understanding of the performance of MC-CDMA systems under various channel conditions and provides insights into the design and optimization of such systems. The results show that the importance of utilizing robust and reliable wireless communication systems in nuclear radiation monitoring to ensure the accuracy and reliability of the data obtained.

1. INTRODUCTION

Efficient and reliable communication systems are critical in nuclear radiation monitoring, as they allow for the timely and accurate transmission of radiation data from detection devices to monitoring centers. As you mentioned, nuclear radiation is invisible, odorless, and silent, making it impossible for humans to detect without the use of radiation detection devices [1, 2]. These devices measure radiation levels in various environments, including on the surface of people, within the body, and in the surrounding environment. Improving the network for radiation monitoring is crucial for ensuring the safety of individuals and communities in areas that are at risk of exposure to radiation. One approach to improving the network is to measure and enhance the outage probabilities of wireless communication systems. One of the most widely used wireless communication systems for nuclear radiation monitoring is Code Division Multiple Access (CDMA) technology. CDMA is a wireless communication technology that allows multiple users to share the same frequency band by assigning unique codes to each user. This allows multiple users to transmit and receive data simultaneously, increasing the efficiency and reliability of the communication system. In nuclear radiation monitoring, CDMA technology can be used to transmit radiation data from detection devices to monitoring centers in real-time, providing crucial information for decision-making and emergency response. Multi-Carrier - Orthogonal Frequency Division Multiplexing (MC-OFDM) is a commonly used digital modulation technique for transmitting large quantities of data over a communication channel. It is utilised in a number of wireless communication systems,

Corresponding author: sayedmahdy@yahoo.com

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including Wi-Fi, LTE, and digital television [3-5]. CDMA is a digital cell phone technology that has transformed the field of communication engineering. CDMA is a spread spectrum technique that enables multiple users to share the same frequency channel by assigning each user a unique code. This technique has proved to be both highly effective and secure, making it a popular option in contemporary communication systems [6-8]. Mobile communication systems, such as cellular networks, satellite communication, and wireless broadband networks, have extensively adopted CDMA technology. In recent years, CDMA technology has expanded its use beyond traditional communication systems to include nuclear radiation monitoring. Monitoring nuclear radiation entails the detection and measurement of ionising radiation in various environments. Radiation must be detected precisely and promptly in order to guarantee safety and prevent potential dangers. Analogue technology, which is susceptible to interference and false alarms, is used in conventional radiation monitoring systems. By utilising CDMA, we are able to circumvent these limitations and increase the effectiveness of radiation monitoring. CDMA-based radiation monitoring systems measure ionising radiation levels with digital sensors and transmit the data to a central processing unit [9-11]. A unique code is assigned to each sensor, which is used to distinguish it from other sensors in the network. CDMA permits multiple sensors to transmit data simultaneously and securely, even in environments with high levels of noise and interference. In addition, CDMA-based systems can monitor and analyse data in real time, making them an effective instrument for early detection and prevention of radiation hazards [12, 13]. CDMA technology has several advantages over traditional analogue systems in radiation monitoring. CDMA offers greater sensitivity and precision in detecting radiation, as well as a quicker response time. Additionally, CDMA-based systems offer greater flexibility and scalability, allowing for simple integration with existing monitoring infrastructure. In addition, CDMA provides a high level of data security by assigning a unique code to each sensor, thereby preventing unauthorised access to the data. However, the use of CDMA in radiation monitoring has a number of limitations. Complexity of CDMA technology necessitates specialised knowledge and apparatus, which can increase implementation expenses. CDMA-based systems also necessitate precise calibration and maintenance to ensure precise data transmission and measurement [10, 14-16]. In MC-OFDM, data is transmitted over multiple parallel subcarriers that are closely spaced in frequency. The subcarriers are orthogonal to each other, which means that they do not interfere with each other. This property is achieved by using an inverse fast Fourier transform (IFFT) at the transmitter and a fast Fourier transform (FFT) at the receiver[17, 18]. The advantages of MC-OFDM over other modulation techniques include high spectral efficiency, robustness to frequency selective fading, and the ability to mitigate interference. However, it also has some disadvantages such as high peak-to-average power ratio (PAPR) and sensitivity to carrier frequency offset[19, 20].

Overall, MC-OFDM is a powerful modulation technique that has revolutionized modern wireless communication systems[21-23]. Wireless communication systems have become an essential part of modern society. These systems allow us to communicate with one another, access the internet, and conduct various types of transactions from anywhere in the world. However, wireless communication systems are often subject to interference and other types of noise, which can cause signal degradation and other types of problems[19]. One important metric for evaluating the performance of wireless communication systems is the outage probability. The outage probability is the probability that the system will fail to deliver the required level of service. It is an important metric because it helps to determine the reliability of the system. Several research studies have focused on improving the outage probability of wireless communication systems. For example, in a study by [24], the authors proposed a technique for reducing the outage probability of a wireless communication system. The proposed technique involved using an adaptive modulation and coding scheme (AMC) to adjust the modulation and coding parameters based on the channel conditions. The results showed that the proposed technique was effective in reducing the outage probability[24]. Another important metric for evaluating the performance of wireless communication systems is capacity. Capacity is the maximum amount of data that can be transmitted over the system. Several research studies have focused on improving the capacity of wireless communication systems. For example, in a study by [6], the authors proposed a technique for improving the capacity of a wireless communication system. The proposed technique involved using multi-user multiple-input multiple-output (MU-MIMO) technology to allow multiple users to transmit and receive data simultaneously.

The results showed that the proposed technique was effective in improving the capacity of the system. In conclusion, several research studies have focused on improving the outage probability and capacity of wireless communication systems. The proposed techniques include using adaptive modulation and coding, MU-MIMO technology, and other advanced techniques. These studies have important implications for improving the reliability and performance of wireless communication systems, and they represent an important area of research in the field of wireless communications. The use of MC-OFDM technology has been widely studied and explored due to its advantages in wireless communication. The need for higher data rates, widespread services, capacity improvement, higher spectral efficiency, and high-quality transmission has led to the exploration of this technology for future cellular communication systems [25]. MC-OFDM technology has been shown to be a powerful selection due to its ability to improve capacity under multipath fading and frequency selection fading in channels [25]. As a result, it has become one of the most important multicarrier communication systems for fourth-generation (4G) wireless communication systems [26]. Researchers have also considered it as a potential candidate for the next generation of wireless communication technology [27].

One of the main advantages of MC-OFDM is its ability to combine the advantages of both code division multiple access (OFDM) and orthogonal frequency division multiplexing (OFDM) [25, 28]. This technology operates in the frequency domain of spreading codes and time and can also be operated with time domain spreading code [26]. The outage probability of MC-OFDM can be accomplished as a function of signal-to-interference-plus-noise ratio (SINR) analysis. Furthermore, the capacity of cellular MC-OFDM systems has been extensively studied, and many methods have been suggested that exploit either the transmitter or receiver [29]. These studies have focused on improving the capacity of MC-OFDM systems under various conditions, including channel fading, interference, and noise. Overall, the use of MC-OFDM technology has shown great potential for improving the capacity and performance of wireless communication systems. Further research in this area could lead to the development of more advanced and efficient wireless communication technologies for future cellular communication systems. Various interference types are the main cause of capacity reduction within MC-OFDM technology [30]. On other side, the MC-OFDM performs better under multipath fading for simple structure of the receiver. Since, the channel is influenced by multipath propagation. Thus, an increase of the occurrence probability under fading and ISI is noted [31]. The implementation aspects of wireless technology lead to recent levels by the increasing demands of better quality of service (QoS) and rising number of channel users. In wireless mobile communication high data rate and capacity are basic necessity for better system performance. The outage probability plus average capacity for uplink of MC-OFDM cellular systems are evaluated. The properties of MC-OFDM over chi-square, Weibul and gamma fading are suggested. Specific parameters including multi receiver antenna and quantity of users into the cells are considered. In [29], a power control scheme is proposed to improve the performance of MC-OFDM systems in the presence of multiple access interference. The proposed scheme uses a genetic algorithm to optimize the transmit power levels of the users in the system, thus improving the system's capacity and reducing the outage probability.

This manuscript is organized as follows: in Section 2, we examine the outage performance of MC-OFDM by analysing the outage probability as a quality of service parameter. In Section 3, we present the MC-OFDM average capacity under channel deterioration. The obtained results and discussion are introduced in Section 4, where we present closed form expressions that demonstrate the performance of these characteristics, and evaluate the effect of the number of branches and subcarriers on the outage probability. Furthermore, we present a robust and reliable approach for channel fading that considers the effect of different channel degradations, including Rayleigh and Rician fading. Our results show that exponential channel fading achieves the lowest outage probability compared to other channel degradations.

In Section 5, we conclude our work by evaluating the capacity of MC-OFDM with a large number of users, which is a crucial aspect for modern wireless communication systems. We propose results that guarantee high average channel capacity and throughput, which are important factors for meeting the growing demand for high-speed data transmission. Therefore, we can say that the use of CDMA technology in nuclear radiation monitoring presents a promising alternative to traditional analogue systems' limitations. This manuscript will provide a comprehensive analysis of CDMA technology and its radiation monitoring applications. The efficacy of a CDMA-based radiation monitoring system will be compared to that of conventional analogue systems. In addition, we will evaluate the benefits and limitations of CDMA technology in this context and make suggestions for future research.

2. OUTAGE PERFORMANCE PROBABILITY ANALYSIS

Outage probability is a metric used to evaluate the reliability of a communication system. It represents the probability that the system's performance falls below a certain threshold level. In wireless communication systems, the outage probability is often used to evaluate the quality of service (QoS) provided to users [32, 33]. To perform an outage probability analysis, the following steps can be taken:

Define the system model: This includes defining the communication system's parameters such as the transmission power, channel conditions, and noise power.

Determine the threshold level: This is the minimum acceptable performance level for the system. For example, in a wireless system, it could be the minimum signal-to-noise ratio (SNR) required to achieve a certain data rate.

Calculate the outage probability: This is the probability that the system's performance falls below the threshold level. The outage probability can be calculated using analytical expressions or simulations.

Evaluate the system performance: Once the outage probability is calculated, the system's performance can be evaluated by comparing it with the desired QoS level. If the outage probability is higher than the desired QoS level, then the system needs to be improved. Outage probability analysis is important in the design and optimization of communication systems, especially for wireless systems where the channel conditions can vary rapidly. By understanding the outage probability, system designers can make informed decisions on the system's parameters to achieve the desired QoS level [34-36]. In addition, the outage probability is the figure-of-merit of wireless communication systems. It is an important performance metric of wireless communications systems[37, 38]. Outage probability is the falling of the SINR below a specified threshold value, η. In the same way, outage probability stands for protection value of SNR above which a satisfied quality of channel is realized [39, 40]. At this point, outage probability of OFDM technology over path loss is analyzed. The outage performance probability is given by [11, 41, 42].

$$P_{out} = Pr(\gamma \prec S) = \int_0^S f_\gamma(\gamma)\, d\gamma \quad \textbf{(1)}$$

where S and f(γ) denote the minimum threshold SNR that depends on the employed modulation scheme and PDF under chi-square fading which based on MGF, respectively. Thus, the MGF is related to Laplace transform by [11, 38]

$$M_\gamma(s) = \int_0^\infty \int_0^\infty \int_0^\infty \ldots \int_0^\infty e^{\left(-s\sum_v^U \gamma_v\right)} f(\gamma_1, \gamma_2, \ldots, \gamma_U) d\gamma_1 d\gamma_2 \ldots d\gamma_U \quad \textbf{(2)}$$

where U denotes the number of subcarriers. This formula can be modified to take the following form

$$M_\gamma(s) = \int_0^\infty \int_0^\infty \int_0^\infty \ldots \int_0^\infty \prod_{v=1}^U e^{-s\gamma_v} f(\gamma_1, \gamma_2, \ldots, \gamma_U) d\gamma_1 d\gamma_2 \ldots d\gamma_U \quad \textbf{(3)}$$

The channel is frequency non-selective fading. Accordingly, instantaneous SNR is stated as [11, 41].

$$\gamma = \sum_{v=1}^{U} \gamma_v = \sum_{v=1}^{U}\sum_{m=1}^{M_t} \gamma_{v,m} = \sum_{v=1}^{U}\sum_{m=1}^{M_t}\sum_{n=1}^{N_t} \gamma_{v,m,n} \quad \textbf{(4)}$$

where M_t and N_r are the number of transmit antennas and receive antennas, respectively. The $\gamma_{v,m,n}$ is modelled as a chi square fading distribution. From Eq. (4), the MGF can be modelled as [43].

$$M_\gamma(s) = \prod_{n=1}^{N_r}\prod_{m=1}^{M_t}\prod_{v=1}^{U}\int_0^\infty e^{-s\gamma_{v,m,n}} f(\gamma_{v,m,n}) d\gamma_{v,m,n} \quad \textbf{(5)}$$

where $f(\gamma_{v,m,n})$ is the power density function (PDF) under chi square channel fading. Hence, the MGF can be modelled by

$$M_\gamma(s) = \prod_{n=1}^{N_r}\prod_{m=1}^{M_t}\prod_{v=1}^{U}\int_0^\infty e^{-s\gamma_{v,m,n}} \frac{1}{2^{\bar{\gamma}}\Gamma\bar{\gamma}_{v,m,n}} \gamma_{v,m,n}{}^{\bar{\gamma}_{v,m,n}-1} e^{-\frac{1}{2}\gamma_{v,m,n}} d\gamma_{v,m,n} \quad \textbf{(6)}$$

where $\bar{\gamma}$ refers to average SNR. As a consequence, γ and $\bar{\gamma}$ are supposed to be $\gamma_{v,m,n}$ and $\bar{\gamma}_{v,m,n}$, respectively. Therefore, the integral in Eq. (6) is manipulated. Subsequently, inverse of Laplace transform is taken

$$f_\gamma(\gamma) = L^{-1}[M_\gamma(s)] \quad \textbf{(7)}$$

The PDF of underlined channel fading can be stated as

$$f_\gamma(\gamma) = \prod_{n=1}^{N_r}\prod_{m=1}^{M_t}\prod_{v=1}^{U} \frac{1}{2^{\bar{\gamma}}\Gamma\bar{\gamma}} \gamma^{\bar{\gamma}-1} e^{-\frac{1}{2}\gamma} \quad \textbf{(8)}$$

Then, the outage probability is found by substitution from Eq. (8) in Eq. (1) as follows

$$P_{out}^{Chi} = \prod_{n=1}^{N_r}\prod_{m=1}^{M_t}\prod_{v=1}^{U}\int_0^S \frac{1}{2^{\bar{\gamma}}\Gamma\bar{\gamma}} \gamma^{\bar{\gamma}-1} e^{-\frac{1}{2}\gamma}\, d\gamma \quad \textbf{(9)}$$

The integral in Eq. (9) is manipulated to derive the proposed outage probability under chi-square fading.

$$P_{out}^{Chi} = 2\left(\frac{1}{2}\left(\frac{\tau(\zeta)}{\varepsilon(\bar{\gamma})}\right)^{M_t+1} \frac{\zeta(\bar{\gamma})^2}{\tau(\zeta)}\right)^{N_r+1} \frac{\tau(\zeta)\mu(S)^2\varepsilon(\bar{\gamma})}{\left(\mu(S)\zeta(\bar{\gamma})\right)^{M_t+1}} \quad \textbf{(10)}$$

Using appropriate techniques and transformations, the integral in Eq. (9) is mathematically manipulated to derive the analytical expression for the proposed outage probability under chi-square fading. This modification enables us to precisely characterise the probability of an outage occurring in the MC-CDMA system under the specific fading conditions described by the chi-square fading model.

$$P_{out}^{Weibul} = \left(\frac{\left(\prod_{v=1}^{U}\beta\right)^{M_t+1}}{\prod_{v=1}^{U}\beta}\right)^{N_t+1} \frac{\prod_{v=1}^{U}\beta}{\left(\prod_{v=1}^{U}\beta\right)^{M_t+1}} \quad \textbf{(11)}$$

where $\beta = \lim_{\gamma \to 0} -b^{-c}\left(\beta_1 + \beta_2 - \beta_3 - \beta_4\right)$.

3. CHANNEL CAPACITY ANALYSIS

The greatest rate at which information may be sent over a communication channel with a particular bandwidth and signal-to-noise ratio (SNR) is referred to as channel capacity. Channel capacity analysis in the context of multi-carrier code division multiple access (MC-OFDM) entails finding the highest attainable data rate for a given set of system factors such as the number of subcarriers and users, the modulation scheme, and the coding scheme.[44]. A communication system's channel capacity is generally limited by variables such as noise, interference, and distortion. The use of numerous subcarriers and spreading codes in the case of MC-OFDM can assist offset some of these constraints and boost channel capacity. [45, 46]. To apply this formula to MC-OFDM, the channel bandwidth can be divided into N subcarriers, each of which can carry its own data stream. The SNR can then be expressed as a function of the number of subcarriers and users, as well as the power allocation and spreading codes used in the system. The resulting expression for the channel capacity can be used to evaluate the performance of the system and optimize its parameters for maximum throughput. Channel capacity corresponds to upper limit of channels or users that may be supplied within a fixed frequency band. It guesses the spectrum efficiency of wireless technology [47]. Capacity of OFDM system is interference limited. A linear increase of capacity can be attained with diminished channel interference. In other words, the channel performance for each user increases as the number of users decreases [44]. The Shannon channel capacity for AWGN fading is considered. Thus, its general formula is described by [48, 49].

$$C = W\, log_2(1+\gamma) \quad \textbf{(12)}$$

where W denotes the channel bandwidth. Equation (7) is averaged over PDF of SNR in order to deduce the channel capacity as [48, 50].

$$\frac{C}{W} = \int_0^{\infty} log_2(1+\gamma)\, f(\gamma)\, d\gamma \quad \textbf{(13)}$$

since $f(\gamma)$ corresponds to the PDF of fading that depends on the MGF. The instantaneous SNR is obtained from Eq. (4). Therefore, $\gamma_{v,m,n}$ is modelled as a channel fading distribution. Therefore, the MGF can be introduced by

$$M_\gamma(s) = \prod_{n=1}^{N_r}\prod_{m=1}^{M_t}\prod_{v=1}^{U}\int_0^{\infty} e^{-s\gamma_{v,m,n}} f\left(\gamma_{v,m,n}\right) d\gamma_{v,m,n} \quad \textbf{(14)}$$

where $f\left(\gamma_{v,m,n}\right)$ denotes the PDF over fading. So, MGF is modelled by

$$M_\gamma(s) = \prod_{n=1}^{N_r}\prod_{m=1}^{M_t}\prod_{v=1}^{U}\int_0^{\infty} e^{-s\gamma_{v,m,n}} \frac{1}{\gamma_{v,m,n}} e^{-\frac{\gamma_{v,m,n}}{\bar{\gamma}_{v,m,n}}} d\gamma_{v,m,n} \quad \textbf{(15)}$$

where $\bar{\gamma}$ denote the average signal to noise ratio. As well, γ and $\bar{\gamma}$ are supposed to be, $\bar{\gamma}_{v,m,n}$ and $\gamma_{v,m,n}$ respectively. The integral form within Eq. (15) is solved. It is followed by taking inverse Laplace transform. Accordingly, PDF of exponential fading is computed as

$$f_\gamma(\gamma) = \prod_{n=1}^{N_r}\prod_{m=1}^{M_t}\prod_{v=1}^{U}\frac{1}{\bar{\gamma}} e^{-\frac{\gamma}{\bar{\gamma}}} \quad \textbf{(16)}$$

The average value of channel capacity can be obtained by substitution from Eq. (16) in Eq. (13) as follows

$$\left.\frac{C}{W}\right|_{Exponential} = \prod_{n=1}^{N_r}\prod_{m=1}^{M_t}\prod_{v=1}^{U}\int_0^{\infty} log_2(1+\gamma)\frac{1}{\bar{\gamma}} e^{-\frac{\gamma}{\bar{\gamma}}} d\gamma \quad \textbf{(17)}$$

This integral is evaluated. Therefore, a formula for the channel capacity is presented and simplified as

$$\left.\frac{C}{W}\right|_{Exponential} = \frac{\prod_{v=1}^{U}\psi}{\left(\prod_{v=1}^{U}\psi\right)^{M_t+1}}\left(\frac{\left(\prod_{v=1}^{U}\psi\right)^{M_t+1}}{\prod_{v=1}^{U}\psi}\right)^{N_r+1} \quad \textbf{(18)}$$

where $\psi = lim_{\gamma\to\infty} - \frac{e^{-\frac{\gamma}{\bar{\gamma}}} ln(1+\gamma) + e^{-\frac{1}{\bar{\gamma}}} Ei\left(1, \frac{1+\gamma}{\bar{\gamma}}\right) - e^{-\frac{1}{\bar{\gamma}}} Ei\left(1+\frac{1}{\bar{\gamma}}\right)}{ln(2)}$.

The channel capacity under chi-square distribution is presented. An expression for channel capacity under chi-square distribution is proposed. The channel capacity is an important parameter that characterizes the maximum amount of information that can be transmitted over a communication channel. In wireless communication systems, the channel capacity is affected by various factors such as fading, interference, noise, and channel bandwidth[48, 50]. One way to model the channel behaviour in wireless systems is by using probability distributions. One such distribution is the chi-square distribution, which is commonly used to model the fading behaviour of wireless channels. The chi-square distribution arises from the sum of squared Gaussian random variables and is characterized by a single parameter known as the degree of freedom. The channel capacity expression under the chi-square distribution indicates that the capacity of a wireless system is directly proportional to the bandwidth and the logarithm of the SNR. This implies that increasing the bandwidth or the SNR can increase the system capacity. In summary, the channel capacity under the chi-square distribution is an important parameter that characterizes the maximum amount of information that can be transmitted over a wireless channel. It depends on various factors such as bandwidth, transmit power, noise, and interference, and can be expressed as a function of the signal-to-noise ratio.

4. RESULTS AND DISCUSSION

4.1 Outage probability results

In Fig. 1 and Fig. 2, the outage probability is shown against the minimum signal-to-noise ratio (SNR) for different numbers of subcarriers under chi-square and Weibull channel fading, respectively. The outage probability represents the probability that the system fails to transmit information due to insufficient SNR. From these figures, it can be observed that the probability of system failure increases as the minimum SNR decreases. This is because as the minimum SNR decreases, it becomes more difficult to accurately decode the transmitted signal, leading to a higher probability of transmission errors. Furthermore, it can be seen that increasing the number of subcarriers can improve the performance of the system. This is because the use of multiple subcarriers enables more efficient use of the available frequency spectrum, thereby increasing the overall capacity of the system. Additionally, it is noted that the exponential channel fading model exhibits the lowest outage probability in comparison to other fading models at the same system parameters, indicating that it is the most efficient model for this type of system. In Fig. 3, the outage probability is shown against the number of receiving antennas under chi-square channel fading. It can be observed that as the number of receiving antennas increases, the outage probability decreases. This is because an increase in the number of receiving antennas allows for more efficient use of the available signal power, thereby increasing the probability of receiving the signal and reducing the probability of transmission errors. Finally, in Fig. 4, the outage probability is shown against the lowest SNR at different numbers of transmitting antennas under chi-square channel fading. It is observed that as the number of transmitting antennas increases, the power of the transmitting signal increases, which in turn increases the probability of receiving the signal. Consequently, the outage probability decreases, and the overall performance of the system improves. Overall, these figures demonstrate the importance of considering factors such as the number of subcarriers, antennas, and channel fading models when designing and optimizing communication systems. By understanding the impact of these factors on the outage probability, system designers can make informed decisions to improve the performance and reliability of the system.

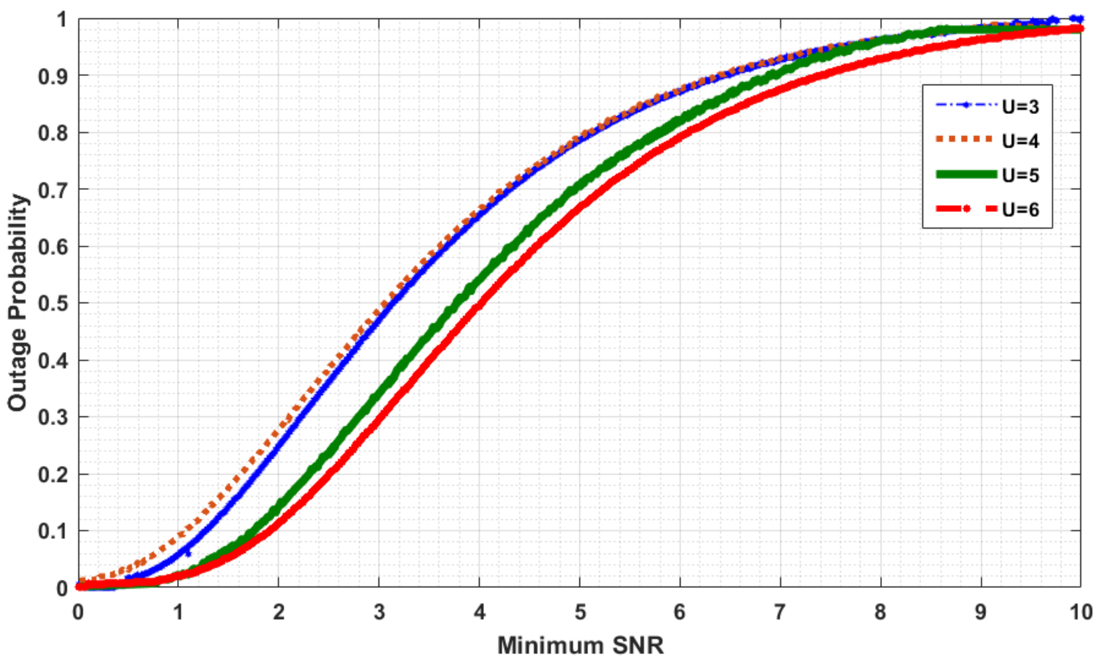

Fig. (1): Outage probability against minimum signal to noise ratio at different number of subcarriers under Chi square channel fading

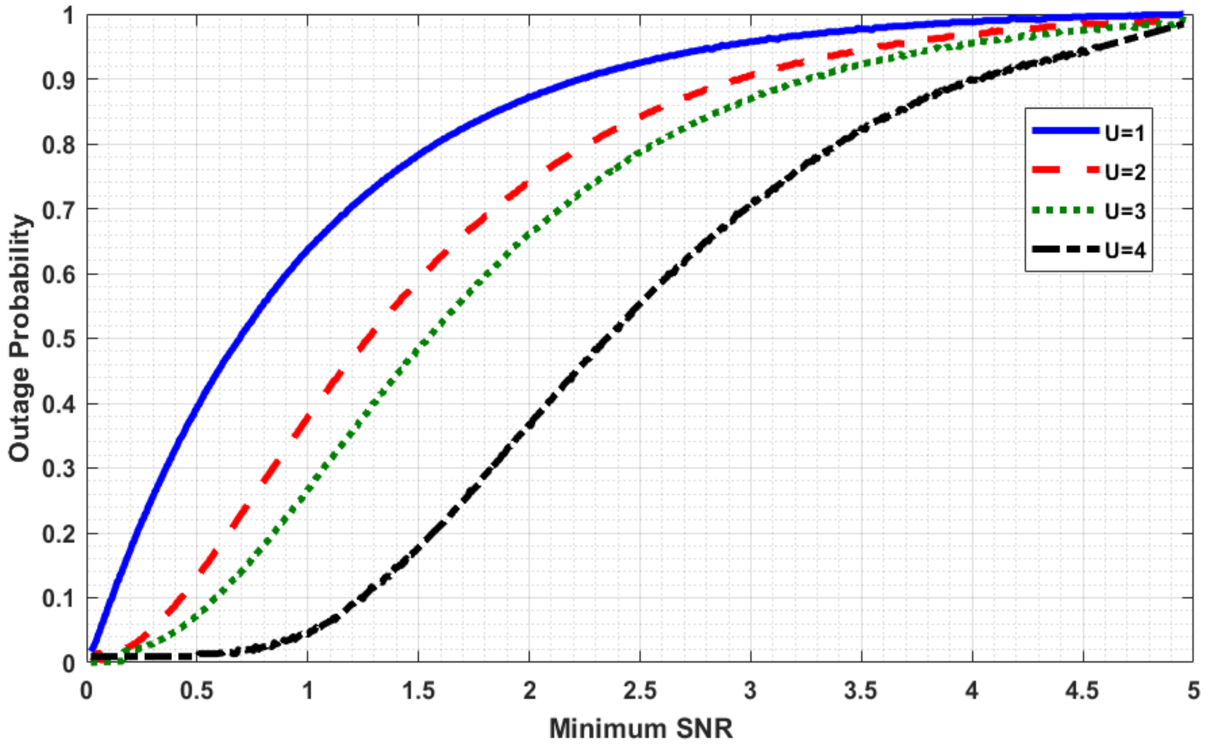

Fig. (2): Outage probability against minimum signal to noise ratio at different number of subcarriers under Weibul channel fading

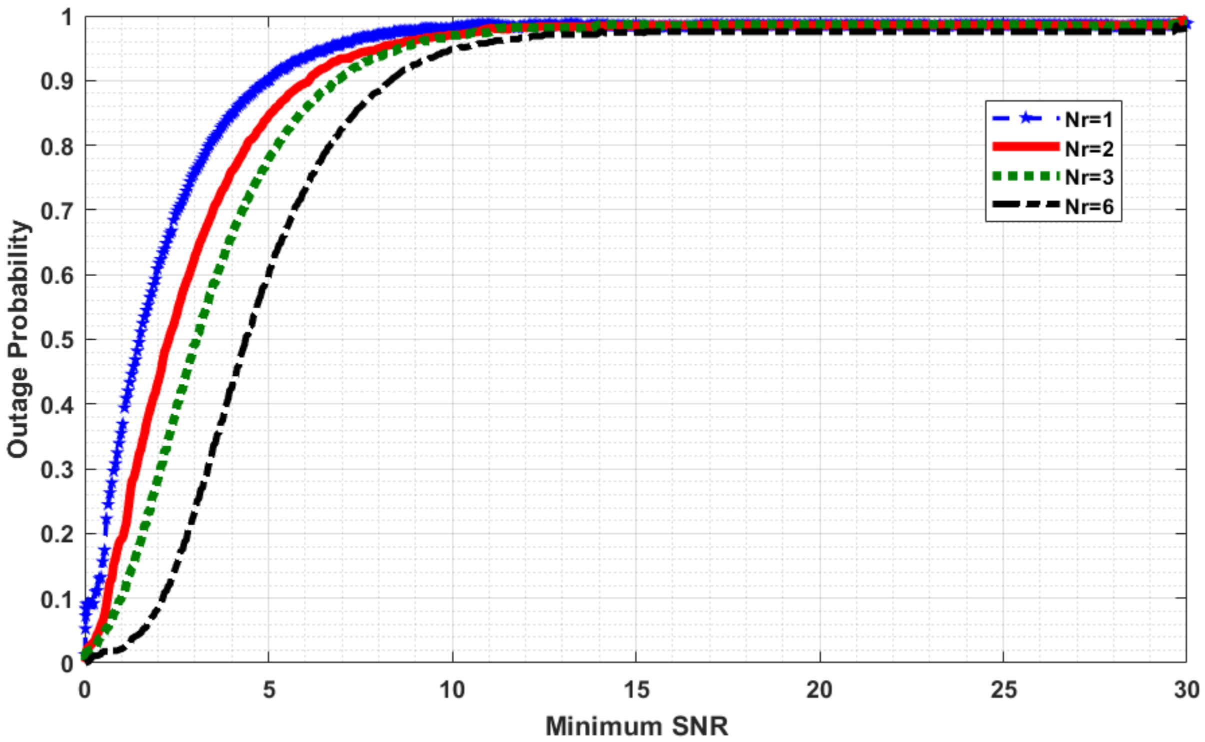

Fig. (3): Outage probability against minimum signal to noise ratio at different number of receiving antennas under Chi-square channel fading

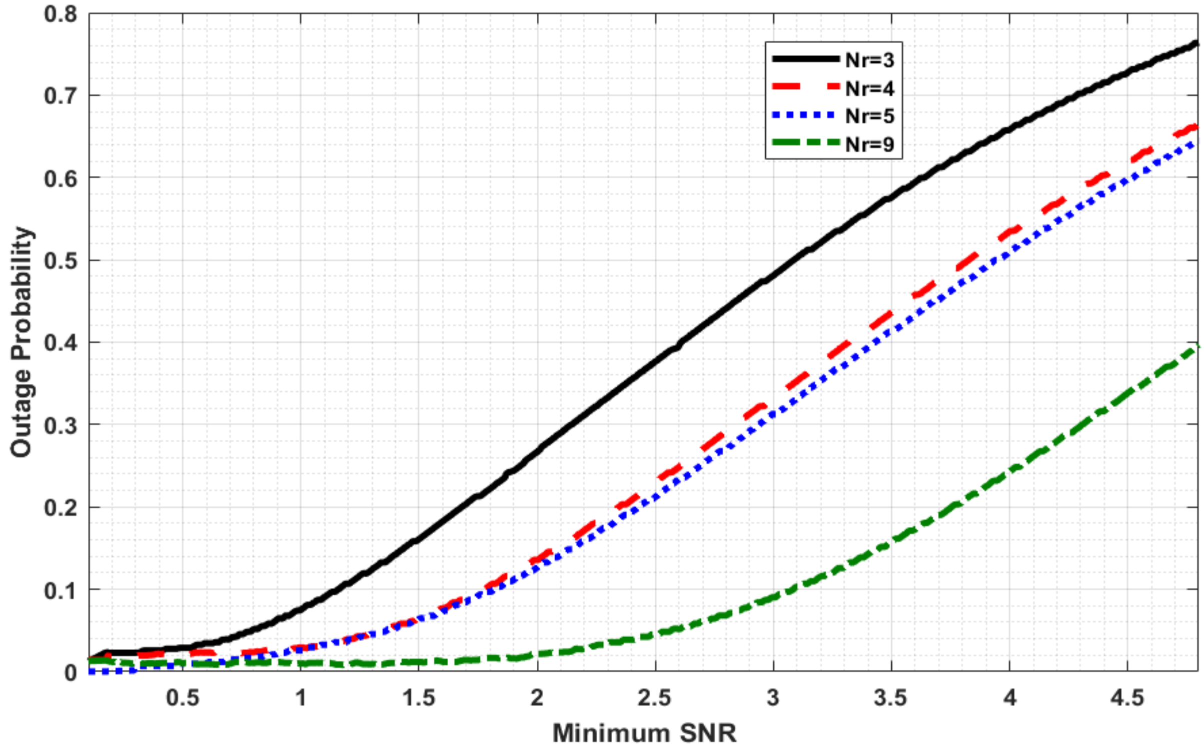

Fig. (4): Outage probability against minimum signal to noise ratio at different number of transmitting antennas under Chi-square channel fading

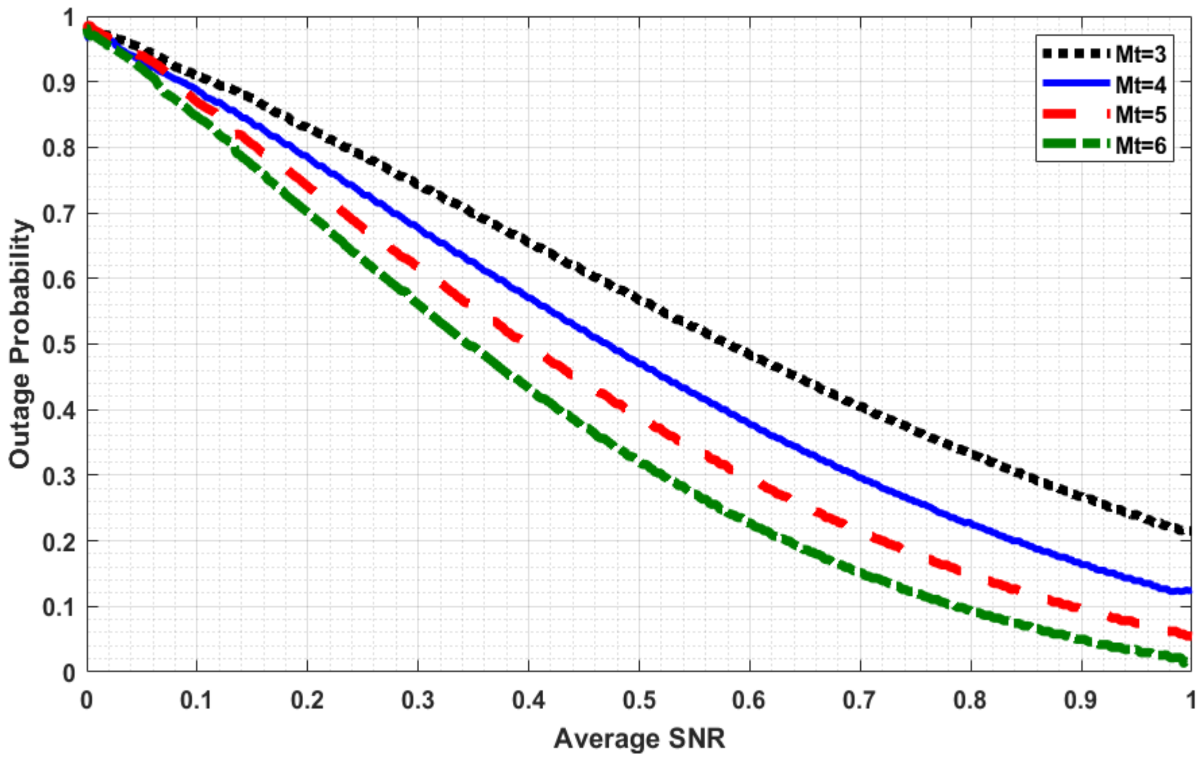

Fig. (5): Outage probability against average signal to noise ratio at different number of transmitted antennas under Chi-square channel fading

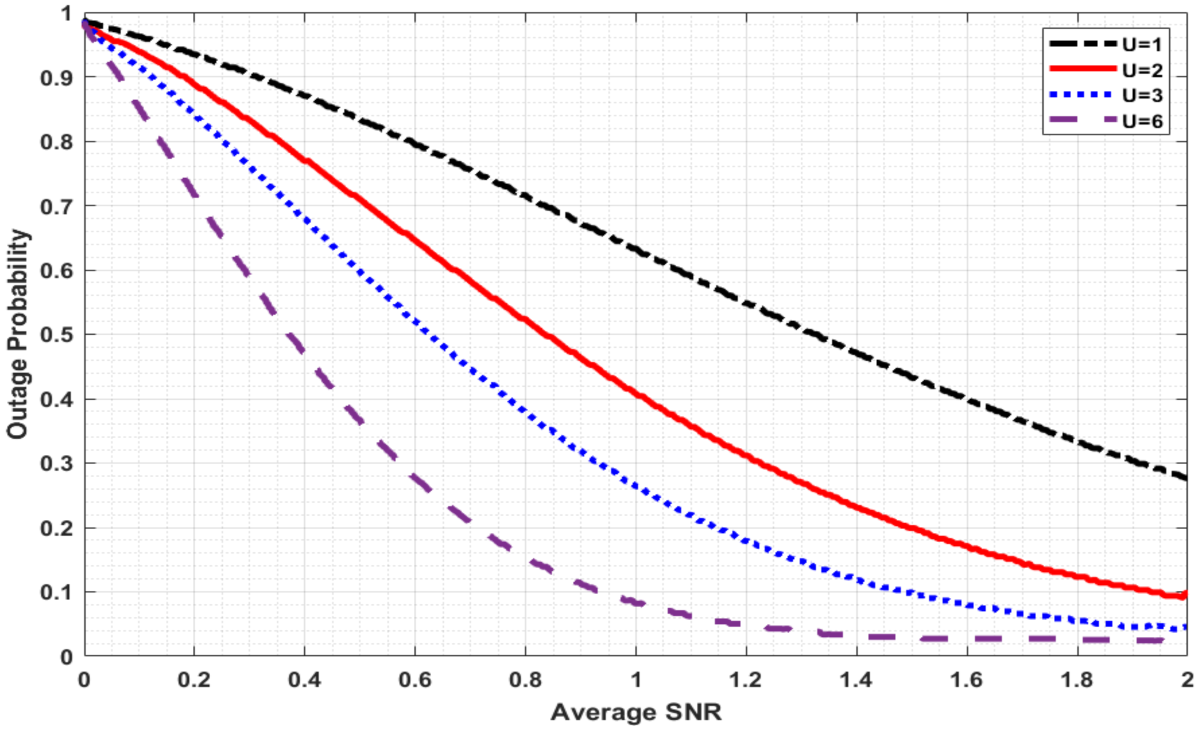

Fig. (6): Outage probability against average signal to noise ratio at different number of subcarriers under Chi-square channel fading

Figures 5 and 6 show the outage probability against the average SNR for different numbers of transmitter antennas and subcarriers, respectively, under Chi-square channel fading. The outage probability represents the probability that the signal quality falls below a certain threshold, which is required for reliable communication. The average SNR represents the ratio of the signal power to the noise power, and it is a measure of the quality of the received signal. Figure 5 shows that as the average SNR increases, the outage probability decreases. This is because as the signal strength increases, the probability of receiving the signal with satisfactory channel quality also increases, resulting in better system performance. Moreover, as the number of transmitter antennas increases, the outage probability decreases, as more antennas provide a more robust and reliable signal. Figure 6, on the other hand, illustrates the impact of the number of subcarriers on the outage probability. It shows that the performance of the MC-OFDM system is affected by the number of subcarriers, as the outage probability decreases with an increase in the number of subcarriers. This is because increasing the number of subcarriers allows for better frequency diversity, which can mitigate the effects of channel fading and improve system performance.

In summary, Figures 5 and 6 demonstrate the impact of the average SNR, number of transmitter antennas, and number of subcarriers on the outage probability of an MC-OFDM system under Chi-square channel fading. The results show that improving these parameters can lead to better system performance and reduce the outage probability.

4.2 Capacity improvement results of OFDM

Figure 7 illustrates that as the number of subcarriers increases, so does the average channel capacity. This is due to the fact that with more subcarriers, more signals can be transmitted concurrently, thereby increasing the channel capacity. Nonetheless, channel quality also plays a role in determining the average channel capacity. As the average SNR rises, the quality of the channel improves, leading to an increase in the probability of transmitting and receiving the signal, as well as an increase in the average channel capacity. It is also essential to note that Rayleigh channel fading achieves the highest average channel capacity at lower average SNR values compared to other fading models.

This indicates that Rayleigh fading is more optimal for increasing channel capacity under conditions of low SNR. Overall, these results indicate that MC-OFDM technology is capable of achieving high performance in terms of average channel capacity under a variety of channel fading conditions. In Fig. 7, the average channel capacity with average SNR for various subcarrier counts under exponential channel fading is depicted. Important metric for evaluating the performance of communication systems, the average channel capacity represents the average quantity of information that can be transmitted over the channel per unit time. As shown in Figure 7, the average channel capacity increases as the number of transmitting signals increases with each subcarrier. This is due to the fact that the use of multiple subcarriers permits a more efficient utilisation of the available frequency spectrum, thereby increasing the system's overall capacity. However, channel quality also plays a significant role in determining the average channel capacity. As the SNR increases, so does the probability of transmitting and receiving the signal, resulting in an enhancement in channel quality and an increase in the average channel capacity. In addition, it is observed that Rayleigh channel fading achieves the maximum average channel capacity at a lower average SNR than other fading models. This indicates that the most effective model for this type of system under these conditions is Rayleigh fading. Figure 7 summarises the significance of contemplating the number of subcarriers, signal-to-noise ratio, and channel fading models when designing and optimising communication systems. By comprehending the effect of these variables on the average channel capacity, system designers can make informed decisions to enhance the system's performance and efficacy. Figure 8 depicts the average channel capacity and SNR for different numbers of receiving antennas under Chi-square channel fading. Error probability is observed to decrease as the number of branches increases, resulting in an enhancement in system performance. In addition, there is an increase in the number of users, which raises the average capacity of the channel.

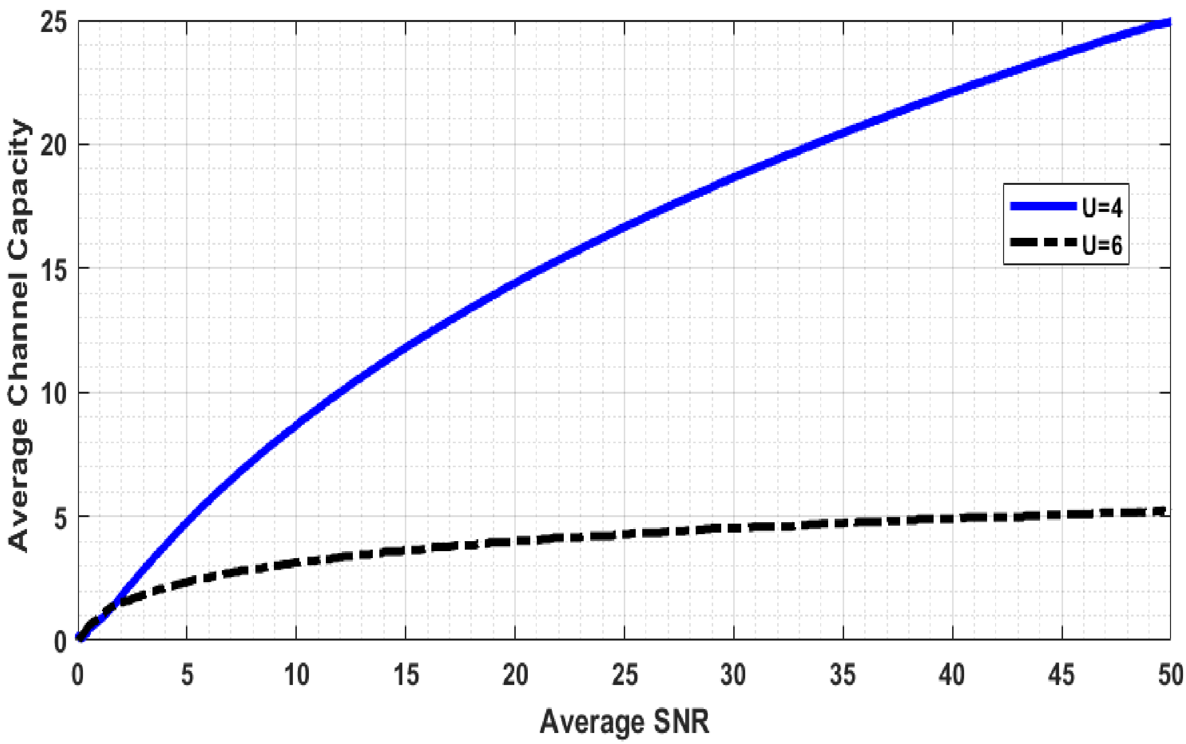

Fig. (7): The average channel capacity against average signal to noise ratio at different number of subcarriers under exponential channel fading

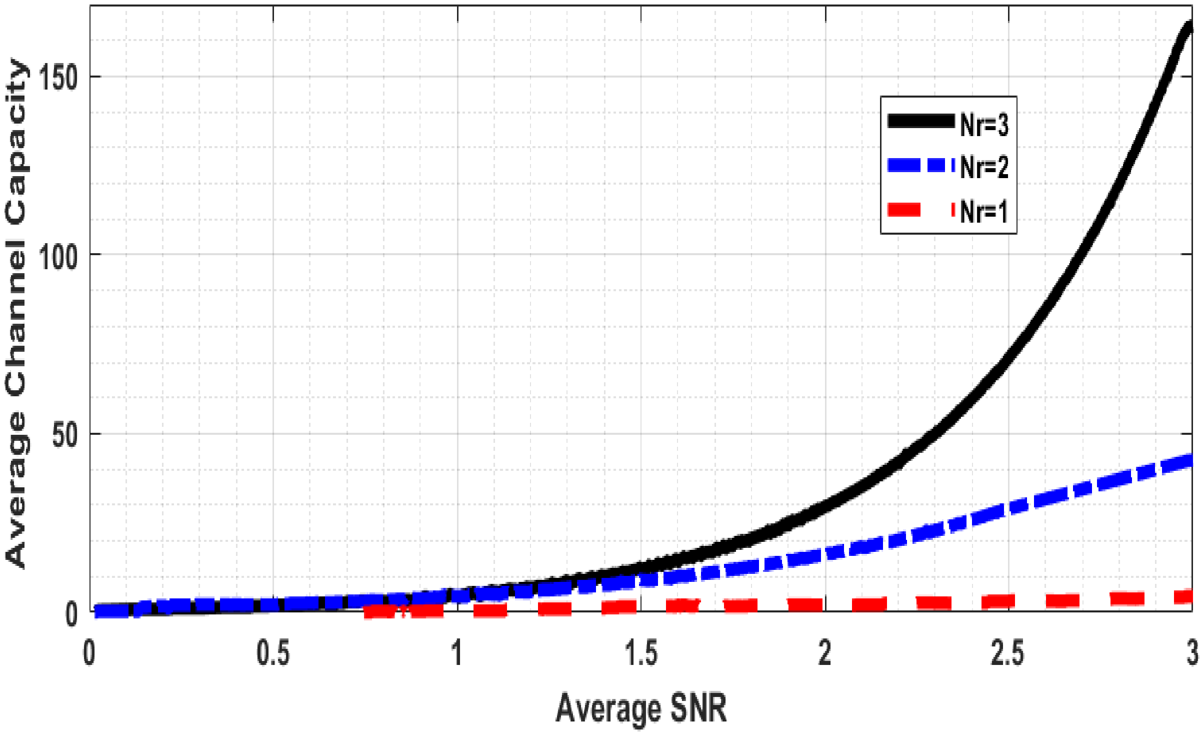

Fig. (8): The average channel capacity against average signal to noise ratio at different values number of receiving antennas under Chi-square channel fading

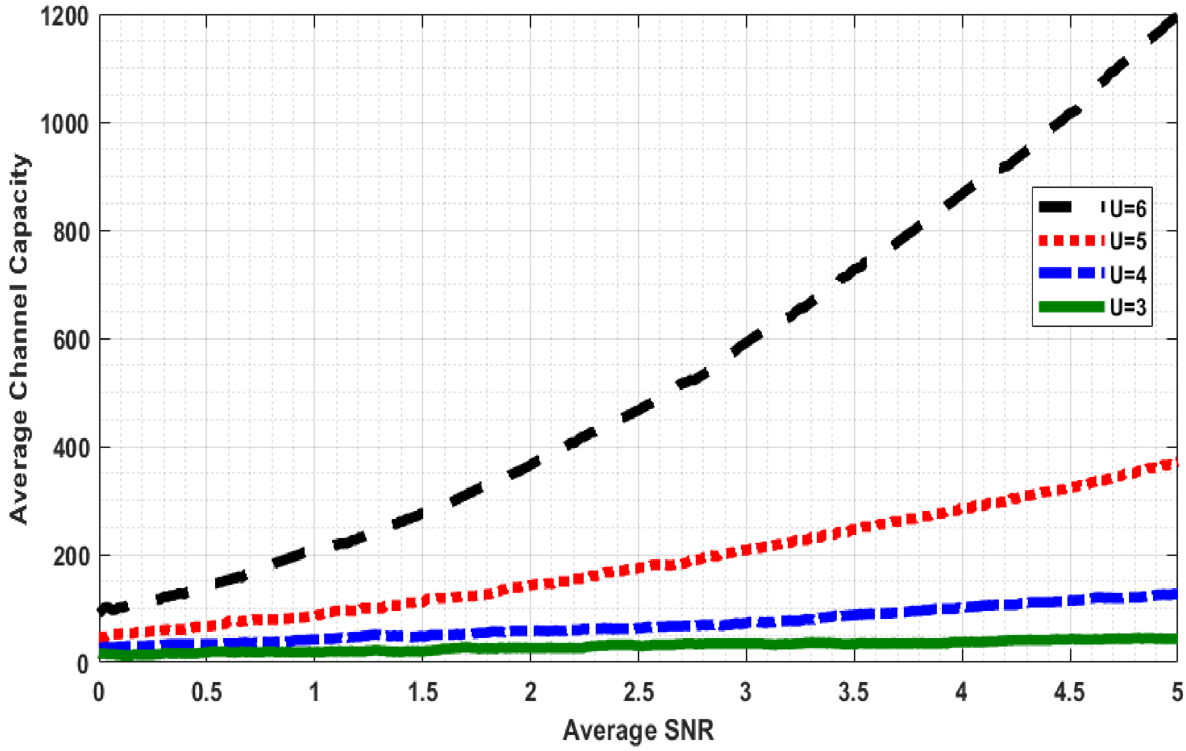

Fig. (9): The average channel capacity against average signal to noise ratio at different number of subcarriers under Chi-square channel fading

Figure 9 depicts the average capacity with average SNR for various subcarrier counts under Chi-square channel fading. Observably, the OFDM performance improves as the number of subcarriers increases, resulting in a rise in the number of users and, consequently, an increase in the average channel capacity. Figures 8 and 9 demonstrate the significance of contemplating the number of receiving antennas and subcarriers, respectively, when enhancing the performance and efficiency of communication systems. By increasing these parameters, the system can accommodate a greater number of users and transmit more data, thereby increasing the average channel capacity.

5. CONCLUSION

According to the study's results, Multi Carrier Code Division Multiple Access (MC-CDMA) systems have the potential to revolutionize nuclear radiation monitoring by improving the efficiency and dependability of wireless communication networks. The investigation focused on evaluating the performance of MC-CDMA as a wireless communication system by calculating outage probability as a quality-of-service parameter and investigating average channel capacity under various channel deteriorations. The study used closed-form formulas to depict the performance of these features and investigated the effect of branch and subcarrier count on outage probability. The authors proposed a reliable and robust approach to channel fading and investigated the maximum user capacity of MC-CDMA. According to the study's findings, MC-CDMA beats other systems when running under exponential fading, with the lowest outage probability of 16%. Multiple branches were discovered to efficiently reduce transmission errors and improve overall system performance, reducing the possibility of MC-CDMA network disruptions. Furthermore, the study evaluated the average channel capacity under various fading models and revealed that Rayleigh channel fading achieves the maximum average channel capacity at a low average SNR of 2dB when compared to other fading models. The results show that MC-CDMA technology can provide dependable and efficient communication even under difficult channel conditions, which is critical for the successful deployment of wireless communication systems in nuclear radiation monitoring. The analysis of the study provides useful insights into the design and optimization of MC-CDMA systems, and the findings are critical for wireless communication system researchers and engineers. Furthermore, the study emphasizes the importance of using reliable wireless communication technologies in nuclear radiation monitoring to assure the quality and dependability of the data obtained.

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