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Original Article

Design and Performance Analysis of Optimum Linearly Scalable Dispersion Codes for 5G MIMO Systems

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Abstract *- One of the key challenges is the ability to communicate at high data rates while maintaining a low Bit Error Rate (BER) with improved diversity gain-the demands of the state-of-the-art 5G wireless communication systems. For a Multiple-Input Multiple-Output (MIMO) based 5G system, this work proposes an Optimized Linear Scalable Dispersion Code (O-LSDC) scheme to enhance the transmission performance and reliability. The method proposed is based on signal processing and scalable Coding techniques, which reduce the BER and detection complexity and enhance diversity performance. Different configurations of MIMO channels from 1×1 to 8×8 are simulated for various Signal-to-Noise Ratio (SNR) conditions. System performance is measured by BER, diversity gain and computational complexity. Results indicate a general improvement in system performance with an increasing SNR for all the MIMO configurations. The configuration with 4×4 MIMO configuration shows the best tradeoff between BER performance, diversity gain and complexity, and is chosen. Appropriate for 5G applications in practice. Higher-order configurations like 6×6 and 8×8 are able to get a little bit of a performance boost, but they need a lot more computational power. Therefore, the proposed O-LSDC scheme can be regarded as an efficient and scalable solution for the reliable and high-performance 5G wireless communication systems.*

Keywords *- MIMO, SNR, BER, O-LSDC, 5G communication.*

1. Introduction

The need to support higher data rates, enhanced reliability, and efficient use of the spectrum has led to the development of Fifth-Generation (5G) communication systems in the current era of wireless communication. MIMO and Orthogonal Frequency-Division Multiplexing (OFDM) systems are advanced technologies that are helpful in attaining these goals. High data rate transmission with robustness against multipath fading and MIMO systems with high system capacity and reliability through spatial diversity. Also, DFT-spread OFDM and other methods have been implemented in uplink transmission (e.g., 3GPP LTE) to address the high Peak-To-Average Power Ratio (PAPR) problem associated with traditional OFDM systems.

Regardless of these developments, there are still a number of issues that are critical in 5G wireless communication systems. The question of achieving low Bit Error Rate (BER) and high data rates has been an important issue, especially in channels subject to fading and interfering signals. Moreover, the enhancement of diversity gain is also a vital measure to provide reliable communication within different channel conditions. Meanwhile, it is important to reduce the complexity of detection to make it practical, particularly in large-scale MIMO systems, where the cost of computation rises sharply as the number of antennas increases.

There is a great deal of research that has been conducted in order to overcome these challenges. The channel estimation and prediction methods have been discussed so as to enhance the integrity of the system by enhancing the accuracy of the channel-state information. The applications of technologies such as massive MIMO, millimeter-wave communication and software-defined networking have made it easier to achieve better data rates and connectivity. Also, the coding methods, including the Space-Time Block Codes (STBC), the Low-Density Parity-Check (LDPC) codes and the polar codes, have all been extensively studied to achieve the best error performance and throughput. Also shown to have potential in dynamic channel environments are adaptive coding and modulation techniques, developed using machine learning. However, in the majority of situations, such strategies are related to tradeoffs. One such example is that, though advanced codes methods would lead to higher BER and diversity gain, they would tend to cause a rise in the computational complexity. Speaking of which, not only are large-scale MIMO systems performance-enhancing, but they also have the complexities of detection and the complexity of executing the system.

Therefore, based on the available literature, it is clear that an effective method of coding that can lead to high diversity gain, low BER, and reduced complexity of detection is still required. The existing approaches are either based on the enhancement of the performance measures of each specific instance or lack the scaling capabilities when implemented in higher-order MIMO designs.

To address these limitations, this paper proposes an Optimum Linearly Scalable Dispersion Code (O-LSDC) for 5G MIMO systems. Main contributions of this work are as follows:

- Design of O-LSDC: Development of an efficient linearly scalable dispersion coding scheme suitable for 5G MIMO systems.
- Enhanced Diversity Gain: Utilization of space-time coding principles to improve robustness in fading channels.
- Improved BER Performance: Reduction in Bit Error Rate through optimized coding and signal processing techniques.
- Reduced Detection Complexity: Design of a computationally efficient detection mechanism suitable for practical implementation.
- Scalability Across MIMO Configurations: Performance evaluation across multiple MIMO setups (1×1 to 8×8), identifying 4×4 as the optimal configuration.

The rest of this paper is structured in the following way: the background and related works of the 5G MIMO systems, classical coding approaches, namely STBC, LDPC, and dispersion coding approaches, and their drawbacks concerning BER, diversity gain and computational complexity are presented in Section II.

The proposed framework (Optimum Linearly Scalable Dispersion Code (O-LSDC)) is described in Section III, and its system and channel models, mathematical formulation, coding matrix design and complexity analysis for scalable MIMO configurations are detailed.The simulation setup and the performance evaluation of the proposed O-LSDC scheme for the Rayleigh channel, Rician channel and AWGN channel are discussed in section IV. Analysis presented in this work covers Bit Error Rate (BER), Signal-to-Noise Ratio (SNR), diversity gain, and computational complexity for various MIMO configurations from 1×1 to 8×8.

Finally, the main results are summarized in Section V, where it is concluded that the 4×4 configuration is the best compromise between performance and complexity and future research directions, such as adaptive detection algorithms and advanced signal processing techniques, are proposed.

2. Related Work

2.1. Existing Coding Techniques

Efficient coding mechanisms are very important in improving the performance and reliability of wireless communication systems. Space-Time Block Coding (STBC) has been popularly used in MIMO systems to utilize spatial diversity and overcome channel fading. Nevertheless, the STBC schemes tend to have lower spectral efficiency in higher-order antenna patterns. Low-Density Parity-Check (LDPC) and polar code are channel coding techniques that have been widely studied to enhance performance in terms of error. Research by [10, 11] showed that coded OFDM systems incorporating diversity techniques were effective in minimizing BER. On the same note, [1, 2] evaluated channel equalization algorithms in the context of 5G systems that use an OFDM-based system, and noted that effective signal processing is essential in enhancing the performance of 5G systems.

Moreover, DFT-spread OFDM has been suggested to overcome the problem of high Peak-To-Average Power Ratio (PAPR) in conventional OFDM systems. A study by [3, 4] showed that this method is effective in enhancing power efficiency in uplink transmission systems.

2.2. Dispersion Codes and MIMO Schemes

The techniques of dispersion coding have become a promising solution to enhance diversity and coding gain in MIMO systems. Specifically, the Linearly Scalable Dispersion Codes (LSDCs) can be used to provide flexibility in the choice of antenna configurations. The study conducted by [5] suggested the optimal LSDC-based signal processing algorithm, which exhibits better performance in multi-antenna systems.Moreover, [6] have studied adaptive signal processing methods for antenna arrays, and they have shown how these methods increase the efficiency of the systems. The patented work of [7] demonstrates progress in antenna signal processing.

Additionally, hybrid MIMO-OFDM systems are also under extensive investigation. A study carried out by [8] revealed a better performance of the system through Rayleigh fading channels with various antenna configurations. The use of channel prediction approaches based on machine learning, as proposed by [3], further emphasizes the significance of dynamically adaptive techniques in contemporary wireless systems. Also, [9] has explored the design of antennas to power 5G applications with a particular focus on compact multi-port MIMO systems.

2.3. Limitations of Existing Approaches

The reliability of the MIMO communication systems has been significantly improved by existing coding methods such as STBC, LDPC and conventional LDCs. However, STBCs have small coding rates and scalability, and LDPC-based ones have high iterative decoding complexity. Conventional LDCs also offer higher spectral efficiency, but may be more complicated to detect and not be easily extendable to higher-order MIMO systems. These restrictions inspire the proposed O-LSDC framework to strike a fair balance between BER performance, diversity enhancement, computational complexity and scalability in practical 5G MIMO communications.

2.4. Positioning of the Proposed Work

To overcome the limitations above, this paper presents an Optimum Linearly Scalable Dispersion Code (O-LSDC) for 5G MIMO systems. The approach proposed combines the scalable dispersion coding with the optimized signal processing methods in order to reach the balanced tradeoff between performance and complexity. The proposed O-LSDC increases the diversity gain, unlike traditional methods, and the proposed method ensures low BER and reduced complexity of detection. Moreover, it facilitates scalability to various MIMO setups; hence, it is applicable in real 5G implementations.

The usefulness of the approach offered is justified by in-depth simulations, which prove its efficiency compared to other methods. The main novelty of the work is the development of an Optimum Linearly Scalable Dispersion Code (O-LSDC) framework that optimally minimizes BER, diversity gain, detection complexity and scalability for MIMO systems. Compared with other dispersion coding methods, such as conventional STBC, LDPC, Polar and existing dispersion coding methods, which focus on optimizing various single performance metrics, the proposed O-LSDC uses structured, orthogonal and normalized dispersion matrices to realize scalable transmission by low-complexity symbol detection. The framework is tested for 1×1 to 8×8 MIMO configurations with Rayleigh channel, Rician channel, and AWGN channel with performance metrics of BER, diversity gain and computational complexity. The results indicate that the configuration of 4×4 O-LSDC is the most reliable, efficient and most scalable solution to the problem, and therefore suitable for next-generation 5G MIMO communication systems.

3. Materials and Methods

The proposed system considers a 5G MIMO communication framework employing the Optimum Linearly Scalable Dispersion Code (O-LSDC). As illustrated in Figure 1, the system consists of a transmitter, receiver antenna arrays, modulation (BPSK), coding scheme, and performance evaluation using Monte Carlo simulations. The system is analysed for multiple antenna configurations ranging from 1×1 to 8×8.

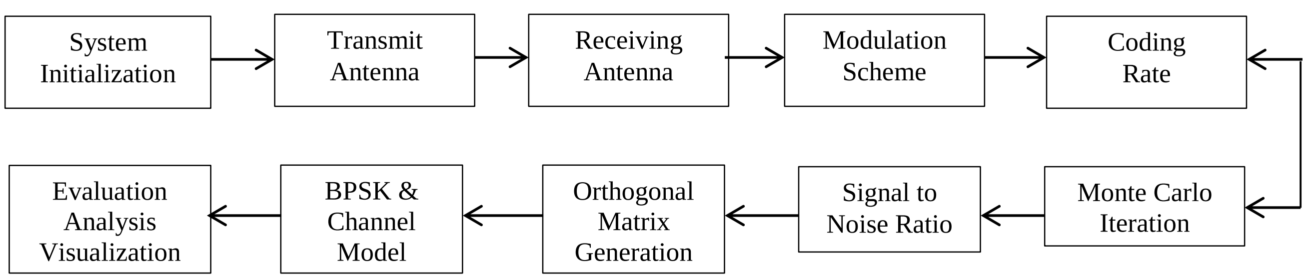

Fig. 1 Design process for OLSDC with 5G system

The main objectives are to enhance diversity gain, reduce Bit Error Rate (BER), and minimize detection complexity, as highlighted in Figure 2.

To evaluate the robustness of the proposed O-LSDC scheme, three different channel models are considered:

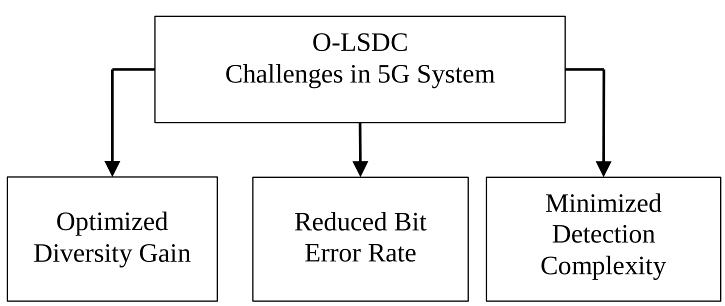

Fig. 2 Challenges in advanced systems

3.1. Rayleigh Fading Channel

A Rayleigh fading channel is simulated, which is a common model for MIMO systems operating in environments with scattering, such as urban areas. Each transmission is affected by independent fading for each path between the senders along reception antennas.

Realistic wireless channel communication is simulated by adding noise to the received signal. The noise power is adjusted according to the given SNR value to evaluate system performance in noisy conditions.

The channel matrix H follows a Rayleigh fading model, where each entry is a complex Gaussian random variable:

$$h\_(i,j) \sim CN(0,1) \tag{1}$$

The matrix H represents the channel betv ↓,N_t transmit and N_r receive antennas.

3.2. Rician Fading Channel

The Rician model accounts for both Line-Of-Sight (LOS) and scattered components. It is characterized by the Rician K-factor, which represents the ratio of LOS to scattered power:

$$H = \sqrt{\frac{K}{K+1}\, H_{LOS}} + \sqrt{\frac{1}{K+1}\, H_{NLOS}} \tag{2}$$

Where K is the Rician factor, HLOS represents the deterministic LOS component, and HNLOS represents the Rayleigh fading component.

3.3. AWGN Channel

In the AWGN model, the channel is assumed to be ideal without fading, and only additive white Gaussian noise affects the transmitted signal. This serves as a baseline for performance evaluation.

The transmitted signal vector is generated by applying BPSK modulation followed by O-LSDC encoding. The general MIMO system model is given by:

$$Y = H_x + n \tag{3}$$

Where,
$y \epsilon C^{Nr\times 1}$: received signal vector,
$H \in C^{Nr\times \mathrm{Nt}}$: channel matrix (Rayleigh/Rician/AWGN),
$x \in C^{Nt\times 1}$: transmitted signal vector,
n ∼ $\mathcal{CN}$(0,σ2): AWGN noise vector.

The receiver estimates the transmitted symbols using appropriate detection techniques, and system performance is evaluated in terms of BER. The following assumptions are considered:

- Perfect Channel State Information (CSI) is available at the receiver
- The channel is quasi-static over one transmission block
- BPSK modulation is used for all simulations
- Noise is AWGN with zero mean and variance σ2
- Independent fading across antenna elements
- Rician K-factor is predefined and constant during simulation
- Monte Carlo simulations are used for performance evaluation

4. Proposed Methodology

The Linearly Scalable Dispersion Codes (LSDCs) aim to take advantage of the spatial and temporal diversity of MIMO systems by spreading out symbols being transmitted. LSDCs are scalable, unlike conventional space time coding schemes, where the extension to new antenna designs would result in a large increase in computational complexity. The proposed Optimal LSDC (O-LSDC) takes this concept a step further by optimizing the dispersion matrices to achieve a balanced performance between the increase in diversity, Bit Error Rate (BER) and detection complexity. This makes a flexible and scalable MIMO setup very suitable for 5G-schemes.

The overall architecture of the O-LSDC-based MIMO communication system is shown in Figure 3. The channel encoder first processes the input binary data and then modulates it before encoding it with the proposed O-LSDC scheme. The encoded symbols are then mapped to several transmit antennas, using the MIMO mapper, and sent through the wireless channel under AWGN, Rayleigh or Rician fading with controlled SNR. The received signals are processed using the MIMO demapper, O-LSDC decoder, demodulator and channel decoder at the receiver to obtain the transmitted information.

Maximum Likelihood (ML) and Minimum Mean Square Error (MMSE) detectors are used on the receiver side to compare the performance of the detector and its complexity. Lastly, the recovered information is analysed with regard to BER and computational complexity, and the output data sink will provide the recovered data for the performance evaluation.

The proposed scheme involves using linear combinations of dispersion matrices and modulated symbols to construct the transmitted signal. The code word matrix transmitted is represented by:

$$\mathrm{X} = \sum_{\mathrm{K}=1}^{\mathrm{K}} \mathrm{s_k A_k} \tag{4}$$

Where X is the transmitted code matrix, s_k are the modulated symbols, A_k are the dispersion matrices, and K is the number of transmitted symbols per block.

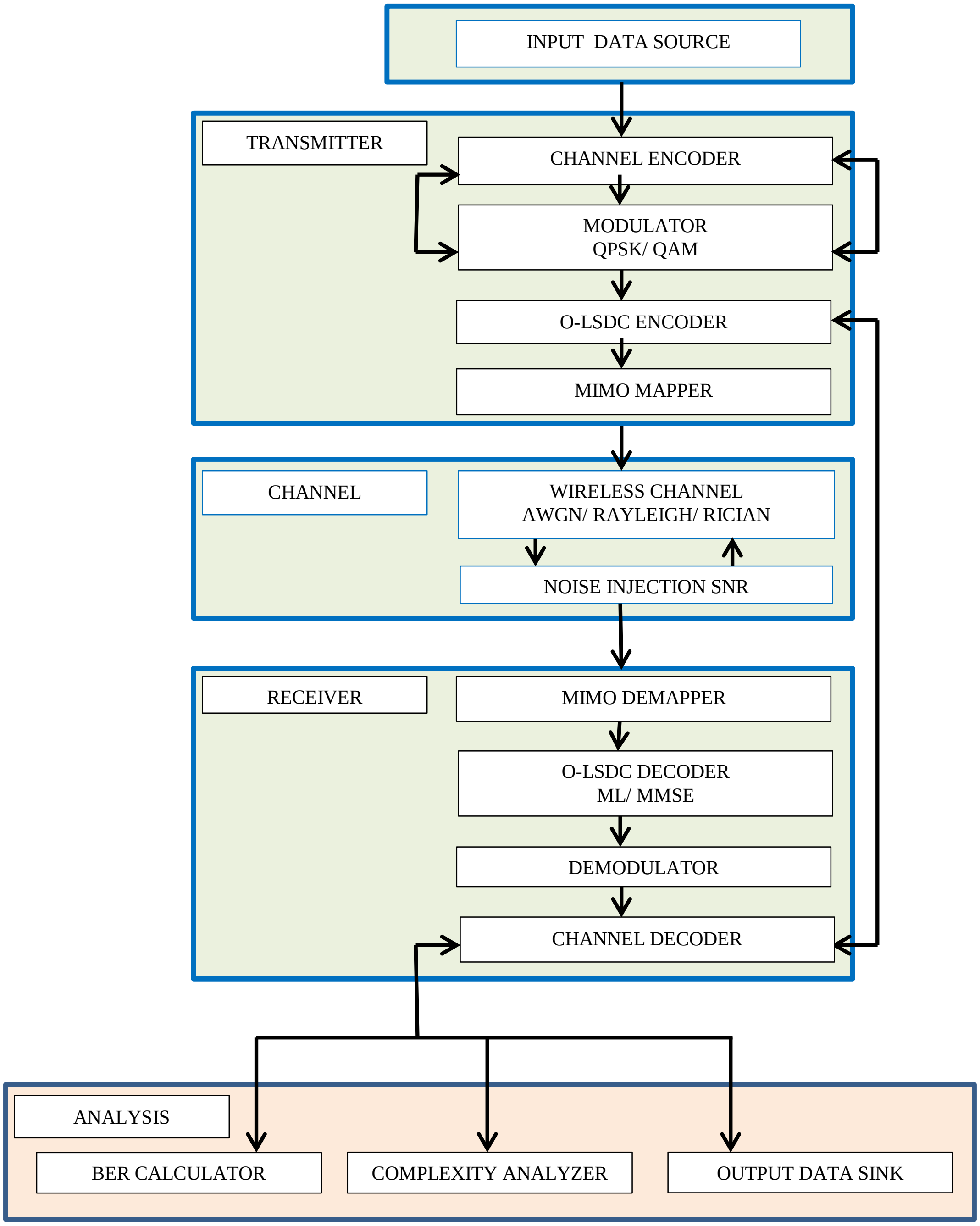

Fig. 3 Functional flow diagram of the proposed MIMO-O-LSDC communication system

Perfect Channel State Information (CSI): All simulations in this proposed O-LSDC framework are assumed to have perfect Channel State Information (CSI) available at the receiver. This assumption allows for analyzing the intrinsic performance of the proposed dispersion coding scheme when channel errors are neglected, thus separating out the impact of the dispersion coding scheme from that of channel estimation errors. The received signal over the MIMO channel is given by:

$$Y = HX + N \tag{5}$$

N is the additive noise matrix, H is the channel matrix, which is Rayleigh, Rician or AWGN. Both simulations are conducted at the perfect CSI at the receiver on AWGN, Rayleigh and Rician channels. This assumption is widely used to assess the performance of coding without worrying about inaccuracies in channel estimation.

The assumption of the present study is that there is perfect CSI at the receiver. For a real wireless system, the BER and detection performance may be impacted by channel estimation errors. Hence, efficient channel estimation methods and their influence on the proposed O-LSDC system are significant research challenges. The goal is to design A_k for the system to have maximum diversity gain, minimum BER and detection complexity.

The effectiveness of the O-LSDC scheme is based on the appropriate construction of the dispersion matrices. In this work, the matrices are built according to the following criteria:

- Orthogonality: Guarantees independent detection of symbols, and inter-symbol interference is minimized.

$$A_i^H\ A_j = \begin{cases} I, & i = j, \\ 0, & i \neq j, \end{cases} \tag{6}$$

- Normalization: M keeps the transmit power of all antennas the same.

$$T_r\left(A_q A_q^H\right) = T_r\left(B_q B_q^H\right) = 1 \tag{7}$$

- Scalability: Scales down lower-order MIMO systems to higher-order MIMO systems.

$$A_{q,}B_q \in\ C^{Nr\times \mathrm{Nt}} \tag{8}$$

- Energy Efficiency: Spreads signal energy equally among antennas.

The matrices of dispersion are obtained through the use of orthogonal basis functions and are normalized to meet power requirements. This design guarantees a strong performance in Rayleigh and Rician fading channels and stability in AWGN conditions.

Algorithm 1. O-LSDC-Based MIMO Transmission
Input: N_t, N_r modulation (BPSK), SNR range
Output: BER, diversity gain, complexity
1. Initialize system parameters (N_t, N_r, SNR, iterations)
2. Generate random input bits
3. Perform BPSK modulation
4. Generate dispersion matrices A_k
5. Encode signal using O-LSDC
6. Select channel model (Rayleigh / Rician / AWGN)
7. Transmit signal through the channel
8. Apply the detection algorithm at the receiver
9. Compute BER
10. Repeat for all SNR values and average results

The computational complexity of MIMO detection increases significantly with the number of transmits antennas. In conventional systems using maximum likelihood (ML) detection, complexity grows exponentially as:

$$\mathrm{O}(\mathrm{M}^{\mathrm{N_t}}) \tag{9}$$

Where M is the modulation order, and N_t is the number of transmit antennas.

Proposed O-LSDC reduces this complexity by utilizing structured dispersion matrices, enabling simplified detection. The resulting complexity is approximately:

$$\mathrm{O}(\mathrm{N_t M}) \tag{10}$$

This reduction renders the proposed scheme computationally efficient and allows it to be implemented practically in 5G. It is worth noting that simulation results show that a 4×4 MIMO configuration has the best performance/complexity trade-off.

For the assessment of the proposed O-LSDC scheme in 5G MIMO systems, the following performance metrics are considered: Bit Error Rate (BER) is a basic measure to evaluate the reliability of a communication system-the ratio of the number of bits that were received in error to the number of bits transmitted.

$$BER = \frac{N_{error}}{N_{total}} \tag{11}$$

Where Nerror is the number of erroneous bits, and Ntotal is the total number of transmitted bits. A lower BER indicates better system performance. In this work, BER is evaluated over a range of Signal-to-Noise Ratio (SNR) values using Monte Carlo simulations.

Signal-to-Noise Ratio (SNR) quantifies the strength of the transmitted signal relative to noise. It is expressed as:

$$SNR = \frac{P_{signal}}{P_{noise}} \tag{12}$$

In practical systems, SNR is usually expressed in Decibels (dB)

$$SNR(dB) = 10Log_{10}(\frac{P_{signal}}{P_{noise}}) \tag{13}$$

Higher SNR values correspond to improved signal quality and reduced BER.

Diversity gain reflects the improvement in communication reliability achieved by exploiting multiple independent signal paths in MIMO systems.

It is defined as the rate at which BER decreases with increasing SNR. Mathematically, diversity gain can be expressed as:

$$G_d = -Lim_{SNR} \rightarrow \infty \frac{Log_{BER}}{Log_{SNR}} \tag{14}$$

A higher diversity gain indicates better robustness against fading, which is particularly important in Rayleigh and Rician channel conditions. The proposed O-LSDC scheme is designed to maximize diversity gain through efficient dispersion matrix design.The performance of the proposed O-LSDC scheme is evaluated through Monte Carlo simulations under different MIMO configurations and channel conditions (Rayleigh, Rician, and AWGN). Simulation parameters are summarized in Table 1.

Table1. Simulation parameters

Parameter	Description	Value
(N_t)	Number of transmit antennas	Variable (1-8)
(N_r)	Number of receive antennas	Variable (1-8)
Modulation order	Modulation scheme	BPSK, QPSK, 16-QAM
Num bits	Number of transmitted bits	1000
Coding rate	Coding rate	1 (no channel coding)
SNR range	Signal-to-noise ratio (dB)	0 to 30 dB (step size = 5)
Monte Carlo iterations	Number of simulation runs	100

The simulation works by producing random binary values, which are then modulated by the modulation scheme of choice (BPSK, QPSK or 16-QAM). The proposed O-LSDC scheme is used to encode the modulated symbols and transmit them over various channel models, such as the Rayleigh, Rician, and AWGN. The signal sent is received and demodulated at the receiver, and Bit Error Rate (BER) is calculated by comparing the number of bits sent with that of the bits received. This is repeated over the specified SNR range, and Monte Carlo averaging is done to get stable performance results. Table 2 shows the simulation parameters that were used to assess the performance of the proposed O-LSDC scheme with various modulation schemes, coding rates, and channel conditions.

Table 2. Proposed O-LSDC scheme with various modulation schemes, coding rates and channel conditions

Parameters	Configuration 1	Configuration 2	Configuration 3
N_t x N_r	1x1 to 8x8	1x1 to 8x8	1x1 to 8x8
Modulation	BPSK	QPSK	16-QAM
Coding Rate	1	1/2	½
Channel Model	Rayleigh	Rician	AWGN
SNR Range (dB)	0 to 30 (6 intervals)	0 to 30 (6 intervals)	0 to 30 (6 intervals)

The three setups all consider scalable MIMO setups (between 1 x 1 and 8 x 8), which allow a comprehensive study of the system performance over a variety of antenna configurations. Binary Phase-Shift Keying (BPSK) modulation with a coding rate of 1 (uncoded transmission) is used over a Rayleigh fading channel in Configuration 1. This configuration can be considered a base case to check the performance of the system with extreme multipath fading conditions without code redundancy.

Configuration 2 is Quadrature Phase-Shift Keying (QPSK) with a coding rate of 1/2, and the system is tested in a Rician fading channel. A Line-of-Sight (LOS) component to the Rician model allows assessment of system performance in mixed propagation environments. The lower coding rate brings about redundancy and enhances error correction capability at the cost of spectral efficiency.

Configuration 3 assumes that the modulation is 16-QAM with a coding rate of 1/2 and an Additive White Gaussian Noise (AWGN) channel. This configuration is used to test the system performance with channel conditions being perfect with higher-order modulation and to measure the spectral efficiency and the sensitivity to noise. Signal-to-Noise Ratio (SNR) is varied between 0 and 30 dB in 6 equal steps, so that Signal-to-Noise Ratio (SNR) is uniformly compared in different circumstances.

This arrangement will allow an overall assessment of the O-LSDC scheme under varying channel and system conditions in terms of Bit Error Rate (BER), diversity gain, and complexity of detection.

5. Results and Discussion

To evaluate the proposed O-LSDC scheme, it is evaluated by analysing the change in the Bit Error Rate (BER) of the scheme under various MIMO configurations at various Signal-to-Noise Ratio (SNR) conditions. BER is an important key performance indicator, indicating the dependability of the communication system by measuring the ratio of incorrect bits to the number of bits sent.

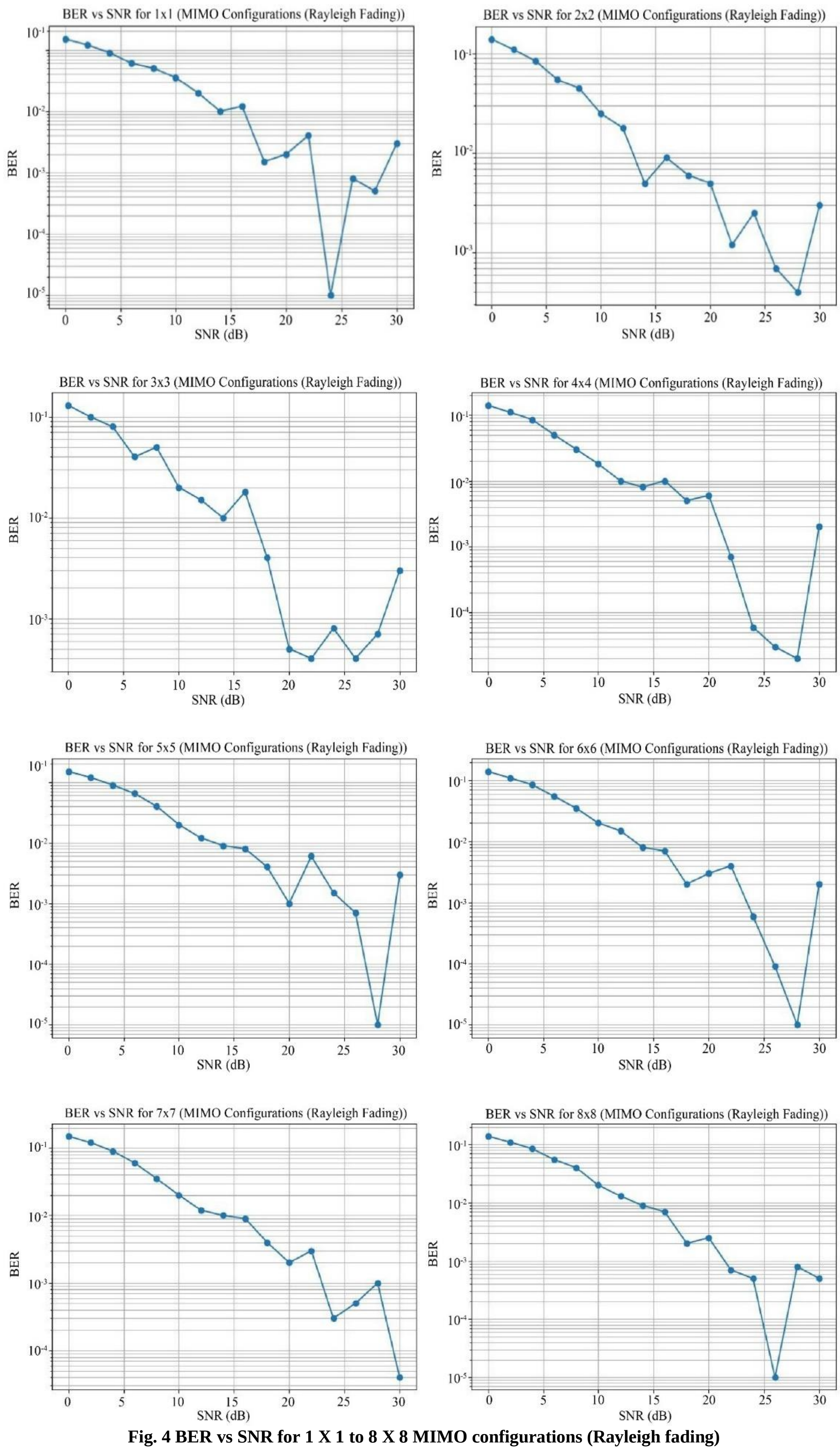

Fig. 4 BER vs SNR for 1 X 1 to 8 X 8 MIMO configurations (Rayleigh fading)

The results of the simulation of MIMO configurations between 1 x 1 and 8 x 8 under the conditions of Rayleigh fading are found in Table 3 [Appendix] and Figure 4. The analysis takes into account a variety of performance metrics, such as SNR (in dB), BER, the complexity of computations, in Floating-Point Operations (FLOPS), and diversity gain. The result indicates that BER decreases steadily with an increase in SNR in all the configurations, which indicates the improvement of the reliability of the transmission with a rise of the SNR in all the configurations. In addition, higher-order MIMO schemes, e.g. 6×6 and 8×8, have much lower BER than lower-order schemes at the same SNR level. This is also assisted by a more enhanced spatial diversity and the number of independent signal paths, which actually counteract the effects of the multipath fading.

However, the performance improvement with larger MIMO settings is also accompanied by a dramatic increase in the computational complexity. This can be observed in the fact that the value of FLOPS increases with an increase in the number of antennas, and indication of the tradeoff between the performance and the cost of implementation. Moreover, the gain of diversity increases with the number of antenna configurations, which adds to the greater robustness to channel impairments. Although higher-order MIMO systems have better BER performance, the incremental gains over higher-order MIMO systems are rather modest compared to the incremental increase in computational complexity. Accordingly, the 4x4 MIMO design can be the best compromise, which gives a satisfactory tradeoff between BER performance, diversity gain and computational efficiency.

Overall, the findings do support the efficiency of the proposed O-LSDC scheme to improve the performance of the system with a manageable level of complexity, which makes it a good candidate for practical 5G wireless communication systems.

Table 4 [Appendix] and Figure 5 give a detailed performance analysis of Multiple-Input Multiple-Output (MIMO) systems and configurations in a Rician fading channel, with the size of the antenna varying between 3x3 and 8x8. It will examine three performance measures of the key critical performance, Bit Error Rate (BER), computational complexity (in FLOPs) and diversity gain, therefore giving a complete picture of the performance-complexity tradeoffs in MIMO systems.

The trend in the performance of the BER is a consistent decreasing pattern with an increasing SNR level of all the configurations, indicating that the better the reliability, the greater the SNR level. Interestingly, the lower loads resulted in fewer changes to the material properties. The SNR level in higher-order MIMO systems (6×6 to 8×8) has a slightly lower BER than lower-order systems, and so are not so effective in noise-limited systems. At higher SNR, however, larger MIMO systems are characterized by a larger MIMO antenna array. Smaller systems will experience a smaller reduction in BER than a steeper reduction in BER for larger systems. This shows how higher-dimensional MIMO systems can take advantage of the spatial diversity and can be allowed to achieve a higher error performance for high SNR situations.

Conversely, the computational complexity increases monotonically with the number of antennas. The least complex (0.01 FLOPs) and most complex (0.15 FLOPs) models are the 3x3 model and the 8x8 model, respectively. This has been attributed to the extra signal processing burden of channel estimation, detection algorithms and matrix operations in the larger antenna arrays.

Though higher-order MIMO systems have a better BER performance, their increased computational needs can be an issue for real-time execution and system design that is energy-efficient. The diversity gain analysis shows that the 4x4 MIMO configurations have the highest gain (0.14), and bigger configurations have a tendency of saturating within the range of 0.10-0.11. This result demonstrates that the rate of increase in the diversity in response to the increase in the dimensions of the antenna is after a medium size. Though the increases of antennas adds spatial diversity, marginal utility decreases, which implies that there is a viable maximum efficient system design.

Overall, it is seen that there is a critical tradeoff between the error performance, computational complexity, and diversity gain. Although large-scale MIMO configurations are much more successful at enhancing the BER at higher SNR levels, it comes at a high cost in terms of increased computation costs and limitations in the diversity gain enhancement. So mid-scale setups, particularly 4x4 and 5x5 setups, emerge as good contenders, which provide a good tradeoff between performance and implementation efficiency.

Findings are particularly relevant when it comes to designing a next-generation wireless communication system, since the performance and resource constraints have to be considered.

Figure 6 and Table 5 [Appendix] give a detailed analysis of the simulation-based analysis of MIMO systems with 1x1 to 8x8 systems over an Additive White Gaussian Noise (AWGN) channel. This is characterized by key performance indicators, including Bit Error rate (BER), computational complexity (quantity of FLOPs), as well as diversity gain at various Signal-to-Noise Ratio (SNR) levels, which can help to understand how systems behave when operating under the noise-limited conditions. The performance of the BER performance exhibits a smooth decline towards higher SNR in every setting, and eventually reaches zero at 10 dB.

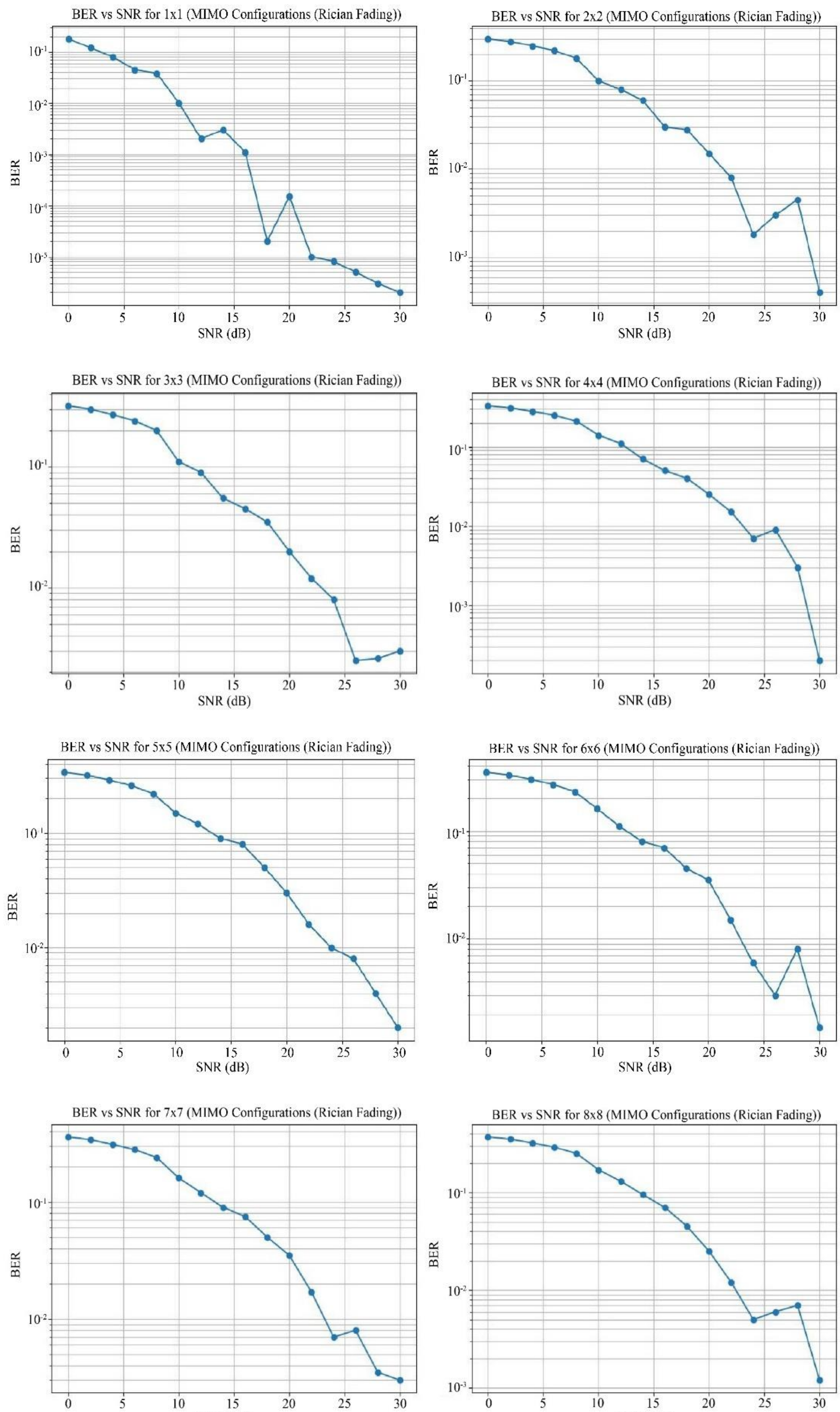

Fig. 5 BER vs SNR for MIMO configuration (Rician fading channel)

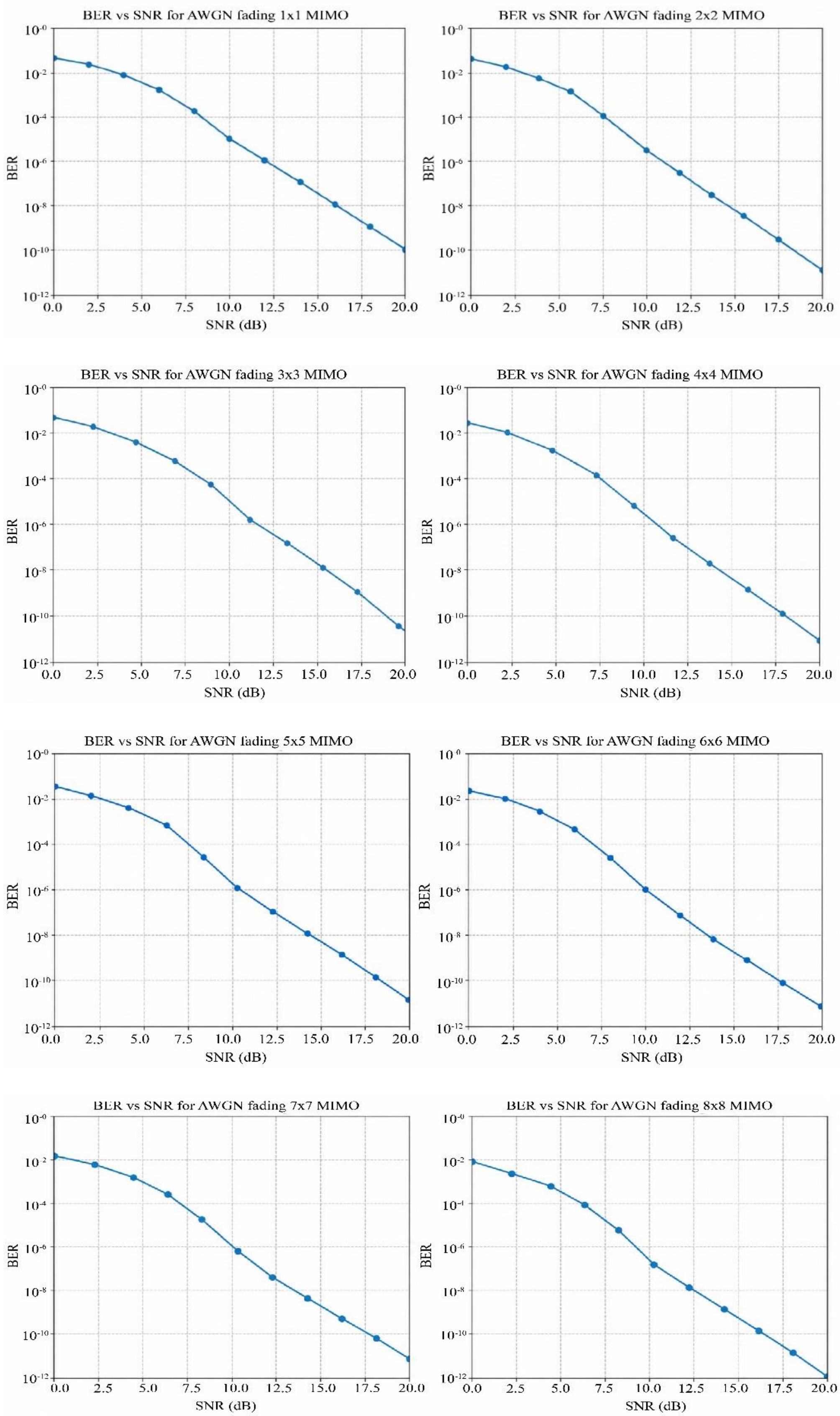

Fig 6: BER vs SNR for MIMO Configuration (AWGN fading)

This implies that the error-free transmission is almost perfect at higher SNR conditions, as would otherwise be the case in AWGN conditions. Interestingly, the BER curves of all the MIMO configurations overlap to a significant extent in the entire SNR range, which implies that under the conditions considered, the addition of more and more antennas does not steepen the BER curve significantly. This observation implies that, unless a consideration of the fading and spatial correlation effects is made, the advantages of higher-order MIMO systems in terms of error reduction are modest.

The trend of computational complexity, on the other hand, has a definite upward trend with the size of the antennas. Smaller-scale systems, such as 1x1, do not come with a substantial number of computational resources, but larger-scale systems (e.g., 8x8) are associated with a significantly higher number of computational resources. The corresponding complexity is not compensated by any corresponding increase in the BER performance in the specified scenario, which can be considered an inefficient tradeoff between the cost of computations and performance increase in the given scenario.

Besides, the gain of diversity is not in any way changed under all configurations, and the point suggests that the system is not actually exploiting spatial diversity. This can be attributed to the nature of the AWGN channel, which is not characterized by multipath fading, or the absence of diversity-enhancing schemes in the simulation scheme, e.g. space-time coding, or more advanced combining schemes.

Overall, the results indicate that, with AWGN, the number of antennas in MIMO systems does not necessarily translate into performance gains in terms of either BER or diversity gain, and incurs a very high computational cost. These findings reveal that high-level signal processing and diversity procedures can be used to achieve the full potential of MIMO designs in real wireless communication systems.The comparative study of the three scenarios of MIMO configurations under AWGN channel conditions shows that there are consistent trends of the Bit Error Rate (BER), computational complexity (FLOPs), and diversity gain that provide important insights into the performance and scalability of the systems. The performance of BER in all configurations portrays the evident negative correlation with Signal-to-Noise Ratio (SNR). BER in the low-SNR range (010 dB) is a gradual decrease, indicating the sensitivity of the system to noise. Beyond 10 dB, however, BER is very close to zero for all antenna configurations and signifies that transmission can occur with near-zero error. Interestingly, as the size of MIMO increases, the BER curves tend to converge in the high SNR regime, indicating that there is no significant improvement in the performance of the MIMO size in the high SNR regime. This action highlights the minor contribution of antenna scaling to the enhancement of error performance in noise-dominated conditions in the absence of fading effects.

Computational complexity-wise, a progressive increase is seen with the scaling of MIMO configurations. The 1x1 system has a very low computational cost because there is no multi-antenna processing. The FLOPs needed to complete the task also increase with the system dimension: a 2×2 to 4×4 system requires approximately 0.01 FLOPs to complete a task, a 5×5 to 7×7 system requires around 0.02 FLOPs to complete a task, and the 8×8 system takes up to 0.03 FLOPs to complete a task. This is a tendency of the greater signal processing load that higher-dimensional matrix processing operations and detection schemes entail. Notably, the rise in the cost of computation is not met with a corresponding improvement in the performance of the system in the provided context, which is an indication of an inefficient tradeoff between the cost of processing and the system benefit in the given context.

Moreover, there is always a constant 0 gain of diversity in any configuration and SNR. This implies that the system does not capitalize on spatial diversity, probably because of the lack of diversity-enhancing techniques like beam forming, space time block coding or a combination of techniques in the simulation model. Consequently, the natural benefits of MIMO systems in overcoming channel impairments are not achieved, restricting overall system robustness.

Overall, the discussion shows that in the context of AWGN, there is no visible improvement in BER or diversity gain when the dimensions of the MIMO system are increased. These results underline the importance of combining sophisticated diversity and signal processing strategies to enable MIMO systems to maximize their potential, especially in realistic wireless environments with channel fading and multipath effects.

Table 6 introduces a comparative study of different MIMO schemes of the OLSDC-based 5G systems, and it brings out the tradeoffs between Bit Error Rate (BER), Diversity Gain (DG), and the computational complexity. Based on the results, the 4×4 MIMO configuration provides the best balance of these performance measures and hence can be a good candidate to be used in a real-life application.

The BER analysis shows that the value increases significantly with the increase in the MIMO order. The 1×1 MIMO is provided just for a baseline comparison of performance. There is no spatial diversity, and the proposed O-LSDC does not provide diversity gain in this case. It is worth noting here that any BER improvement gained is due to signal processing characteristics and not due to spatial diversity. With more antennas, the performance of BER is enhanced, and the 4×4 configuration provides a reasonable value of about 10-4 with an SNR of 20 dB. This is the optimum performance of any feasible practically configurations, and further increase in the size of MIMO (that is, beyond 4×4) does not proportionately increase the BER improvements.

Table 6. Analysis of different MIMO configurations for OLSDC

MIMO Size	SNR Range (dB)	BER (at 20 dB SNR)	DG (Rayleigh)	DG (Rician)	DG (AWGN)	Computational Complexity	Recommended for 5G
1×1	0 - 30	$\sim 10^{-2}$	Not Applicable	Not Applicable	Not Applicable	Low	No spatial diversity
2×2	0 - 30	$\sim 10^{-3}$	0.38	0.12	0	Moderate	Only for low-SNR regions
3×3	0 - 30	$\sim 10^{-3}$	0.06	0.1	0	Moderate-High	Not effective
4×4	0 - 30	$\sim 10^{-4}$	0.45	0.14	0	Optimal	Best for OLSDC in 5G
5×5	0 - 30	$\sim 10^{-4}$	0.14	0.11	0	High	No real advantage
6×6	0 - 30	$\sim 10^{-4}$	0.26	0.1	0	Very High	Marginal improvement
7×7	0 - 30	$\sim 10^{-4}$	0.13	0.11	0	Very High	Not efficient
8×8	0 - 30	$\sim 10^{-4}$	0.1	0.11	0	Extremely High	Too complex with minimal gain

The gain analysis of diversity also maximizes the benefits of moderate-scale MIMO systems. Rayleigh fading is the most diverse channel with the highest diversity gain (DG = 0), followed by Rician fading and AWGN channels, which have none at all (DG = 0). The maximum amount of the degree of diversity gain that is observed is 4x4 MIMO systems, which gives a diversity gain of 0.45 in Rayleigh channels and 0.14 in Rician channels. Conversely, the higher-order configurations (5 x 5 to 8 x 8) have diminishing returns of diversity gain, which implies saturation effects with the growing number of antennas.

The complexity of computing scales hugely with MIMO scaling. Though larger configurations in theory should help increase the performance of the system, the large size introduces an enormous processing load, in terms of matrix operations and complexity of detection. The ratio of computation load and high level of BER and diversity performance in the 4x4 setup is good. Other forms, like 8x8, that provide the same degree of BER are deliberately allocated disproportionately high computational costs, making them unfeasible in practice in the 5G implementation of real-time uses. In general, the obtained results indicate that one of the critical design tradeoffs of the MIMO systems based on the OLSDC is that, though the size of the antennas could be increased to enhance the performance metrics, the computational overhead and the reduction in diversity gains as the size of the antennas increased limit scalability.

The 4x4 MIMO configurations prove to be a great solution, which offers a balanced tradeoff between reliability, diversity exploitation, and the complexity of implementation. These outcomes reveal that there is a need to design the performance efficiency and field deployment issues of the next generation wireless communication networks through optimal system design. Different current studies on MIMO communication have considered different methods of improving the reliability of transmissions, including Space-Time Block Coding (STBC), LDPC and polar codes, OFDM-based transmission, adaptive signal processing, channel prediction and dispersion coding. STBC technique applies for taking advantage of spatial diversity as well as being resistant to fading, but this technology may result in loss of spectral efficiency with the increase of the number of specified antennas. LDPC and polar coding systems feature a high level of error-cutting performance, but they also bring about more complexity in decoding. Prior research on linear dispersion codes showed their viability for flexible multi-antenna transmission, along with the positive influence of the techniques of adaptive signal processing and MIMO OFDM on the overall performance of the systems under consideration. However, the existing investigations generally focus on different tasks only, like reducing BER, increasing diversity, ensuring spectral efficiency, and improving detection parameters, and their interaction regarding performance and complexity is not studied thoroughly.

This presents a major research gap presented as an increase in the number of antennas could lead to better spatial diversity and BER performance at the same time. The current research seeks to fill this gap through the creation of the Optimum Linearly Scalable Dispersion Code (O-LSDC) framework and a detailed analysis of MIMO configurations ranging from 1×1 to 8×8 under Rayleigh, Rician, and AWGN channel conditions. The study analyses BER in conjunction with diversity gain and computation, and therefore calculates a useful performance complexity compromise. The results of the study show that out of all configurations, the most optimal one is the 4×4 configuration. Moreover, it follows from the findings that an increase in the number of antennas leads to an increase in performance benefits at minimal computational cost. It is important that the proposed research is unique in that it combines the analysis of all key factors accounting for the performance of new technologies.

The proposed O-LSDC framework is compared with the latest state-of-the-art studies in Table 7. Most of the works are dedicated to individual aspects of wireless communication such as channel equalization [1] and 6G communication frameworks [2, 3] are dedicated to machine learning for channel prediction; optical OFDM [4] is dedicated to optical OFDM; conventional LSD coding [5] is dedicated to conventional LSD coding; adaptive antenna processing [6] is dedicated to adaptive antenna processing; reference signal design [7] is dedicated to reference signal design; MIMO-OFDM antenna configurations [8] is dedicated to MIMO-OFDM antenna configurations; MIMO antenna design [9] is dedicated to MIMO antenna design; cooperative diversity [10] is dedicated to cooperative diversity; and antenna selection [11] is dedicated to antenna selection. The proposed O-LSDC, on the other hand, offers a unified framework that can address the BER performance, diversity enhancement, scalability and complexity of computation simultaneously.

The simulation results show that the proposed scheme can ensure a BER of about 10-4. Delivers optimal performance to computational complexity tradeoff at 20 dB SNR for the 4×4 MIMO configuration, and under AWGN, Rayleigh, and Rician channel conditions. Furthermore, the proposed O-LSDC revealed that the 4×4 MIMO configuration would be the most appropriate design for the practical 5G system, while higher-order MIMO would yield only small improvements in BER at high computational complexity. The results show that the proposed framework is novel and of practical value over previous studies.

Table 7. Comparison of existing MIMO techniques and the proposed O-LSDC

References	Existing Work	Limitation	Proposed O-LSDC
[1]	OFDM channel equalization	Focuses on equalization only	Optimized MIMO dispersion coding with BER and complexity analysis
[2]	6G communication vision	Conceptual overview	Practical O-LSDC implementation for 5G MIMO
[3]	ML-based channel prediction	Channel prediction only	BER improvement through optimized dispersion coding
[4]	Optical DFT-OFDM	Optical communication	Wireless MIMO dispersion coding
[5]	Optimum LSD coding	Limited scalability analysis	Scalable O-LSDC with optimized 4×4 configuration
[6]	Adaptive antenna processing	No dispersion code optimization	Optimized dispersion matrix design
[7]	Multi-antenna reference signals	Reference signal design	Complete transmitter-receiver O-LSDC framework
[8]	MIMO-OFDM antenna configurations	No BER-complexity tradeoff	BER, diversity, and complexity evaluation
[9]	MIMO antenna design	Hardware-oriented	Signal processing-based coding framework
[10]	Cooperative diversity	Conventional diversity techniques	Optimized scalable dispersion coding
[11]	Antenna selection	Focuses on antenna optimization	Joint BER, diversity, scalability, and complexity optimization

6. Conclusion

This paper presented a design, development and performance evaluation of an Optimum Linearly Scalable Dispersion Code (O-LSDC) framework of 5G wireless communication systems. The proposed scheme is good in that it avoids the waste of diversity gain, reduces Bit Error Rate (BER) and reduces detection complexity, which are the primary challenges with high-performance MIMO-based communication systems. The results of the simulations confirm that O-LSDC is the best of all the methods of coding and is especially more reliable in the low SNR regimes. A general comparison of the different MIMO architectures reveals that the 4x4 MIMO systems provide the most preferred tradeoff between BER performance, diversity gain and computational complexity. Although larger configurations, such as 6×6 and 8×8, can offer some marginal benefit in performance, this benefit is also countered by the large increase in computational overhead, which restricts their applicability in practice.

The results also indicate that the linear scalability property of O-LSDC enables O-LSDC to easily accommodate the dynamic system needs that may arise due to changes in system requirements in the next generation wireless networks. This work can help to develop the design of efficient and scalable coding methods for 5G and beyond communication systems. The findings show that a tradeoff between the performance measures and the complexity of the implementation should be made so as to achieve workable and energy-efficient system designs. The directions of future research include optimization of the O-LSDC parameters and its implementation using more advanced signal processing techniques, including adaptive detection algorithms and deep-learning-based frameworks, to further improve the performance of such systems in dynamic wireless settings.

Conflicts of Interest

The authors confirm that no financial, professional, or personal relationships exist that could have influenced the design, execution, analysis, or reporting of the research presented in this manuscript.

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References

[1] Umar Farooq, and Amalia Miliou, "Assessment of Different Channel Equalization Algorithms for a Converged OFDM-based 5G mm-Wave A-RoF System at 60 GHz," *Applied Sciences*, vol. 12, no. 3, pp. 1-18, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[2] Guan Gui et al., "6G: Opening New Horizons for Integration of Comfort, Security, and Intelligence," *IEEE Wireless Communications*, vol. 27, no. 5, pp. 126-132, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[3] Pedro E. Gória Silva et al., "An Efficient Machine Learning-based Channel Prediction Technique for OFDM Sub-Bands," *2024 IEEE 99th Vehicular Technology Conference (VTC2024-Spring)*, Singapore, pp. 1-5, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[4] Fanggang Wang, and Xiaodong Wang, "Coherent Optical DFT-Spread OFDM," *Advances in Optical Technologies*, vol. 2011, no. 1, pp. 1-4, 2011. [CrossRef] [Google Scholar] [Publisher Link]

[5] Priyanka Pateriya, Rakesh Singhai, and Piyush Shukla, "Design and Implementation of Optimum LSD Coded Signal Processing Algorithm in the Multiple-Antenna System for 5G Wireless Technology," *Wireless Communications and Mobile Computing*, vol. 2022, no. 1, pp. 1-12, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[6] Igor Boyko et al., "Algorithms for Multiple Signals Adaptive Processing in Radio Engineering Systems Antenna Arrays," *2021 Systems of Signal Synchronization, Generating and Processing in Telecommunications (SYNCHROINFO*, Kaliningrad, pp. 1-6, Russia, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[7] Stefano Sorrentino, and Sebastian Faxér, "Multi-Antenna Processing for Reference Signal," U.S. Patent 10,892,929, 2021. [Google Scholar]

[8] Robert O. Abolade et al., "Hybridization of MIMO-OFDM Wireless System with Different Antenna Configurations over Rayleigh Channel," *Journal of Wireless Networking and Communications*, vol. 5, no. 2, pp. 67-74, 2015. [Google Scholar]

[9] Ouafae Elalaouy, Mohammed El Ghzaoui, and Jaouad Foshi, "A Low Profile Four-Port MIMO Array Antenna with Defected Ground Structure for 5G IoT Applications," *Jordan Journal of Electrical Engineering*, vol. 9, no. 4, pp. 496-508, 2023. [CrossRef] [Google Scholar]

[10] Saif E.A. Alnawayseh, "Performance Comparison of Coded OFDM System with Cooperative Diversity and Multi-Antenna Receiver Diversity using QAM Modulation," *Jordan Journal of Electrical Engineering*, pp. 111-123, 2015. [Publisher Link]

[11] Jiongyuan Zhou et al., "Optimal Design of Multiple Antennas based on Maximum Rate and Antenna Selection Algorithm," *2022 3rd China International SAR Symposium (CISS)*, Shanghai, China, pp. 1-4, 2022. [CrossRef] [Google Scholar] [Publisher Link]

Table 3. 1×1 to 8×8 MIMO configuration simulation results, including SNR (dB), BER, and complexity (flops), along with the diversity gain value: MIMO channel (Rayleigh fading)

	Configuration (1×1)			Configuration (2×2)			Configuration (3×3)			Configuration (4×4)			Configuration (5×5)			Configuration (6×6)			Configuration (7×7)			Configuration (8×8)		
SNR (dB)	BER	Complexity	DG	BER	Complexity	DG	BER	Complexity	DG	BER	Complexity	DG	BER	Complexity	DG	BER	Complexity	DG	BER	Complexity	DG	BER	Complexity	DG
0	0.160	0	0.5	0.137	0	0.38	0.143	0.01	0.06	0.148	0.02	0.45	0.153	0.04	0.14	0.149	0.06	0.26	0.139	0.1	0.13	0.134	0.15	0.1
2	0.105	0	0.5	0.121	0	0.38	0.100	0.01	0.06	0.115	0.02	0.45	0.125	0.04	0.14	0.109	0.06	0.26	0.122	0.1	0.13	0.102	0.15	0.1
4	0.076	0	0.5	0.082	0	0.38	0.070	0.01	0.06	0.072	0.02	0.45	0.076	0.04	0.14	0.070	0.06	0.26	0.085	0.1	0.13	0.075	0.15	0.1
6	0.049	0	0.5	0.047	0	0.38	0.032	0.01	0.06	0.046	0.02	0.45	0.059	0.04	0.14	0.051	0.06	0.26	0.048	0.1	0.13	0.041	0.15	0.1
8	0.042	0	0.5	0.037	0	0.38	0.041	0.01	0.06	0.025	0.02	0.45	0.036	0.04	0.14	0.02	0.06	0.26	0.029	0.1	0.13	0.035	0.15	0.1
10	0.033	0	0.5	0.021	0	0.38	0.018	0.01	0.06	0.016	0.02	0.45	0.018	0.04	0.14	0.020	0.06	0.26	0.018	0.1	0.13	0.019	0.15	0.1
12	0.016	0	0.5	0.018	0	0.38	0.014	0.01	0.06	0.009	0.02	0.45	0.013	0.04	0.14	0.011	0.06	0.26	0.010	0.1	0.13	0.013	0.15	0.1
14	0.006	0	0.5	0.005	0	0.38	0.007	0.01	0.06	0.008	0.02	0.45	0.008	0.04	0.14	0.009	0.06	0.26	0.009	0.1	0.13	0.006	0.15	0.1
16	0.011	0	0.5	0.009	0	0.38	0.016	0.01	0.06	0.008	0.02	0.45	0.008	0.04	0.14	0.006	0.06	0.26	0.009	0.1	0.13	0.006	0.15	0.1
18	0.001	0	0.5	0.005	0	0.38	0.003	0.01	0.06	0.005	0.02	0.45	0.004	0.04	0.14	0.001	0.06	0.26	0.003	0.1	0.13	0.001	0.15	0.1
20	0.001	0	0.5	0.004	0	0.38	0.000497	0.01	0.06	0.0057	0.02	0.45	0.000977	0.04	0.14	0.002	0.06	0.26	0.001	0.1	0.13	0.002	0.15	0.1
22	0.003	0	0.5	0.001	0	0.38	0.000449	0.01	0.06	0.000725	0.02	0.45	0.005669	0.04	0.14	0.004	0.06	0.26	0.002	0.1	0.13	0.000669	0.15	0.1
24	0.000008	0	0.5	0.002	0	0.38	0.000733	0.01	0.06	0.000061	0.02	0.45	0.001518	0.04	0.14	0.000428	0.06	0.26	0.000278	0.1	0.13	0.000539	0.15	0.1
26	0	0	0.5	0.00057	0	0.38	0.000374	0.01	0.06	0.00003	0.02	0.45	0.0007	0.04	0.14	0.000085	0.06	0.26	0.000468	0.1	0.13	0.000012	0.15	0.1
28	0.0004	0	0.5	0.000484	0	0.38	0.000597	0.01	0.06	0.000021	0.02	0.45	0.000001	0.04	0.14	0.000007	0.06	0.26	0.001	0.1	0.13	0.000722	0.15	0.1
30	0	0	0.5	0	0	0.38	0.002	0.01	0.06	0	0.02	0.45	0.002	0.04	0.14	0.000001	0.06	0.26	0.000036	0.1	0.13	0.000438	0.15	0.1

Table 4: 1×1 to 8×8 MIMO configuration simulation results, including SNR (dB), BER, and complexity (flops), along with the diversity gain value: MIMO channel (Rician fading)

	Configuration (1×1)			Configuration (2×2)			Configuration (3×3)			Configuration (4×4)			Configuration (5×5)			Configuration (6×6)			Configuration (7×7)			Configuration (8×8)		
SNR (dB)	BER	Complexity	DG	BER	Complexity	DG	BER	Complexity	DG	BER	Complexity	DG	BER	Complexity	DG	BER	Complexity	DG	BER	Complexity	DG	BER	Complexity	DG
0	0.188	0	0	0.301	0	0.12	0.329	0.01	0.1	0.341	0.02	0.14	0.346378	0.04	0.11	0.351346	0.06	0.1	0.356168	0.1	0.1	0.357411	0.15	0.11
2	0.117	0	0	0.283	0	0.12	0.300	0.01	0.1	0.297	0.02	0.14	0.31109	0.04	0.11	0.313051	0.06	0.1	0.315923	0.1	0.1	0.328182	0.15	0.11
4	0.075	0	0	0.226	0	0.12	0.255	0.01	0.1	0.281	0.02	0.14	0.277017	0.04	0.11	0.280682	0.06	0.1	0.295091	0.1	0.1	0.270386	0.15	0.11
6	0.042	0	0	0.195	0	0.12	0.220	0.01	0.1	0.239	0.02	0.14	0.221734	0.04	0.11	0.231056	0.06	0.1	0.22787	0.1	0.1	0.250306	0.15	0.11
8	0.034	0	0	0.163	0	0.12	0.178	0.01	0.1	0.176	0.02	0.14	0.19124	0.04	0.11	0.175334	0.06	0.1	0.190131	0.1	0.1	0.204816	0.15	0.11
10	0.010	0	0	0.095	0	0.12	0.102	0.01	0.1	0.127	0.02	0.14	0.131528	0.04	0.11	0.147909	0.06	0.1	0.156504	0.1	0.1	0.151623	0.15	0.11
12	0.001	0	0	0.075	0	0.12	0.092	0.01	0.1	0.093	0.02	0.14	0.100374	0.04	0.11	0.116908	0.06	0.1	0.11042	0.1	0.1	0.093086	0.15	0.11
14	0.002	0	0	0.057	0	0.12	0.051	0.01	0.1	0.057	0.02	0.14	0.084374	0.04	0.11	0.081187	0.06	0.1	0.083094	0.1	0.1	0.067412	0.15	0.11
16	0.001	0	0	0.029	0	0.12	0.044	0.01	0.1	0.040	0.02	0.14	0.073162	0.04	0.11	0.056845	0.06	0.1	0.061401	0.1	0.1	0.052368	0.15	0.11
18	0.000021	0	0	0.026	0	0.12	0.031	0.01	0.1	0.038	0.02	0.14	0.03913	0.04	0.11	0.031447	0.06	0.1	0.044812	0.1	0.1	0.036049	0.15	0.11
20	0.00017	0	0	0.014	0	0.12	0.019	0.01	0.1	0.020	0.02	0.14	0.021964	0.04	0.11	0.031821	0.06	0.1	0.031165	0.1	0.1	0.019137	0.15	0.11
22	0.000008	0	0	0.007	0	0.12	0.011	0.01	0.1	0.016	0.02	0.14	0.015052	0.04	0.11	0.01055	0.06	0.1	0.011312	0.1	0.1	0.010498	0.15	0.11
24	0	0	0	0.001	0	0.12	0.008	0.01	0.1	0.007	0.02	0.14	0.010094	0.04	0.11	0.006548	0.06	0.1	0.005927	0.1	0.1	0.00473	0.15	0.11
26	0	0	0	0.002	0	0.12	0.002	0.01	0.1	0.007	0.02	0.14	0.0085	0.04	0.11	0.003132	0.06	0.1	0.007597	0.1	0.1	0.002818	0.15	0.11
28	0	0	0	0.004	0	0.12	0.002	0.01	0.1	0.003	0.02	0.14	0.003379	0.04	0.11	0.007237	0.06	0.1	0.003856	0.1	0.1	0.006472	0.15	0.11
30	0	0	0	0.0003	0	0.12	0.002	0.01	0.1	0.0002	0.02	0.14	0.001791	0.04	0.11	0.001744	0.06	0.1	0.003452	0.1	0.1	0.001122	0.15	0.11

Table 5. 1×1 to 8×8 MIMO configuration simulation results, including SNR (dB), BER, and complexity (flops), along with the diversity gain value: MIMO channel (AWGN fading)

	Configuration (1×1)			Configuration (2×2)			Configuration (3×3)			Configuration (4×4)			Configuration (5×5)			Configuration (6×6)			Configuration (7×7)			Configuration (8×8)		
SNR (dB)	**BER**	**Complexity**	**DG**	**BER**	**Complexity**	**DG**	**BER**	**Complexity**	**DG**	**BER**	**Complexity**	**DG**	**BER**	**Complexity**	**DG**	**BER**	**Complexity**	**DG**	**BER**	**Complexity**	**DG**	**BER**	**Complexity**	**DG**
0	0.059	0	0	0.059	0.01	0	0.058	0.01	0	0.059	0.01	0	0.058	0.02	0	0.058	0.02	0	0.059	0.02	0	0.059	0.03	0
2	0.028	0	0	0.028	0.01	0	0.028	0.01	0	0.028	0.01	0	0.028	0.02	0	0.028	0.02	0	0.028	0.02	0	0.028	0.03	0
4	0.009	0	0	0.009	0.01	0	0.009	0.01	0	0.009	0.01	0	0.009	0.02	0	0.009	0.02	0	0.009	0.02	0	0.009	0.03	0
6	0.001	0	0	0.001	0.01	0	0.001	0.01	0	0.001	0.01	0	0.001	0.02	0	0.001	0.02	0	0.001	0.02	0	0.001	0.03	0
8	0.000147	0	0	0.000147	0.01	0	0.000147	0.01	0	0.000141	0.01	0	0.000147	0.02	0	0.000143	0.02	0	0.000145	0.02	0	0.000152	0.03	0
10	0.000003	0	0	0.000002	0.01	0	0.000004	0.01	0	0.000003	0.01	0	0.000004	0.02	0	0.000003	0.02	0	0.000004	0.02	0	0.000003	0.03	0
12	0	0	0	0	0.01	0	0	0.01	0	0	0.01	0	0	0.02	0	0	0.02	0	0	0.02	0	0	0.03	0
14	0	0	0	0	0.01	0	0	0.01	0	0	0.01	0	0	0.02	0	0	0.02	0	0	0.02	0	0	0.03	0
16	0	0	0	0	0.01	0	0	0.01	0	0	0.01	0	0	0.02	0	0	0.02	0	0	0.02	0	0	0.03	0
18	0	0	0	0	0.01	0	0	0.01	0	0	0.01	0	0	0.02	0	0	0.02	0	0	0.02	0	0	0.03	0
20	0	0	0	0	0.01	0	0	0.01	0	0	0.01	0	0	0.02	0	0	0.02	0	0	0.02	0	0	0.03	0
22	0	0	0	0	0.01	0	0	0.01	0	0	0.01	0	0	0.02	0	0	0.02	0	0	0.02	0	0	0.03	0
24	0	0	0	0	0.01	0	0	0.01	0	0	0.01	0	0	0.02	0	0	0.02	0	0	0.02	0	0	0.03	0
26	0	0	0	0	0.01	0	0	0.01	0	0	0.01	0	0	0.02	0	0	0.02	0	0	0.02	0	0	0.03	0
28	0	0	0	0	0.01	0	0	0.01	0	0	0.01	0	0	0.02	0	0	0.02	0	0	0.02	0	0	0.03	0
30	0	0	0	0	0.01	0	0	0.01	0	0	0.01	0	0	0.02	0	0	0.02	0	0	0.02	0	0	0.03	0