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Enhancing Channel Estimation Performance for MIMO-OFDM in 5G Network Using Linear Minimum Mean Square Error

Chukwuka James Obagha, C.A. Nwabueze, C. N. Muoghalu

Department of Electrical and Electronic Engineering
Chukwuemeka Odumegwu Ojukwu University
Uli, Nigeria

Abstract— *In wireless networks such as the 5G, channel estimation can be used to improve reliability of communication. Channel estimation is a technique for determining the characteristics of channel and how transmitted signals are affected by it. This work presents enhanced channel estimation performance for MIMO-OFDM in 5G network using linear minimum mean square error (LMMSE) technique. It is desired to meet high quality performance at the receiver which is usually expressed in terms of bit error rate (BER). In order to achieve this, a MIMO-OFDM system with quadrature phase shift keying (QPSK) modulation for transmitting symbols over wireless channel was formulated in MATLAB. An LMMSE channel estimation algorithm was developed and implemented considering three different channel models such as additive white Gaussian noise (AWGN) channel model, MIMO simple channel model and sparse channel model, to evaluate its performance effectiveness. Simulations were conducted and the results obtained showed that the LMMSE provided BER of 0.00288 to 0.0 as the signal power, expressed in terms of SNR in dB, increases from 0 to 18 dB in AWGN channel. In simple channel and sparse channel, it yielded BER of 0.00351 to 0.000014 as the SNR increases from 0 to 18 dB and BER of 0.0036 to 0.000019 as the SNR increases from 0 to 18 dB respectively. Further performance evaluation to ascertain the superiority of LMMSE over other channel estimation schemes such as least square (LS) and minimum mean square error (MMSE) was conducted with respect to the three different channel models. Hence in AWGN channel, LMMSE yielded BER 0.00288 at 0 dB whereas LS and MMSE yielded 0.0280 and 0.0273 respectively. In simple channel, at 0 dB, LMMSE offered BER of 0.00351 while LS and MMSE provided 0.0341 and 0.0320 respectively. Also, in sparse channel, the LMMSE, LS and MMSE algorithms provided BER of 0.0036, 0.0346 and 0.0340 at 0 dB respectively. Generally, the best performance of the LMMSE was achieved in AWGN channel model but at the expense of complexity. In addition when compared with other estimators, the simulation results showed that LMMSE algorithm outperformed LS and MMSE algorithms in all the channel models for all values of SNR. Therefore, the LMMSE algorithm will offer significant gain in SNR by providing reduced bit error in wireless 5G compared with LS and MMSE.*

Keywords—5G; BER; Channel estimation; LMMSE; MIMO-OFDM

1. INTRODUCTION

The development in communication system towards satisfying increasing subscribers demand has been progressively sustained especially, in terms of improved data rate and high speed. Hence, wireless communication network has been improved over the years in terms of speed starting from 2G to more recent 5G. These networks were supported with various antenna technologies such that 2G was supported by single input single output (SISO) antenna configuration as at 2002, 3G was supported by multiple input multiple output (MIMO) as at 2009 providing speed of 348 kbps, 4G was supported by multiple input multiple output (MIMO) as at 2012 providing speed of 100Mbps, and with the 5G which is supported by massive multiple input multiple output (MIMO) as at 2020 providing speed of 10 Gbps [1].

Significant and promising improvement in performance has been achieved in modern wireless communication systems using MIMO and orthogonal frequency division multiplexing (OFDM) [2] usually called MIMO-OFDM technique. Both MIMO and OFDM are promising technologies used to achieve high rate of data transmission, improve spectral efficiency, and enhance channel robustness against the effect of multipath fading. A critical technique in MIMO-OFDM system is the channel estimation process, which is designed to reduce the effect of channel in order to recover the originally transmitted signal.

The basic operational concept of MIMO-OFDM involves the connection of more than one antenna at both the transmitter and receiver, while an OFDM scheme is implemented to divide the radio channel into orthogonal overlapping sub-channels utilizing the bandwidth of the channel. As essential technologies in wireless communication, MIMO and OFDM have been combined to achieve the required standards of 3GPP specifications and to overcome the difficulty in upgrading the 4G to 5G. The performance of wireless communication system is largely enhanced by using MIMO-OFDM technique. Several parameters of 5G such as capacity, energy, coverage, and spectral efficiency have been improved by MIMO-OFDM, while simultaneously reducing the effect of selective channel fading, multipath fading, and inter-symbol interference (ISI) [3].

In order to eliminate the unwanted effects such as multiuser interference, hardware, and propagation channel fading that are applied on transmitted data, channel estimation with a good performance is required. Conversely, an essential part of 5G is to increase communication reliability [4]. This can be achieved through channel estimation since it can offer the system necessary information to eliminate Inter-Symbol Interference (ISI) from signals and boosts accuracy of signal at the receiver [5]. Channel estimation means determining channel characteristics and how it affects transmitted symbols [6].

Since channel estimation is a core aspect of MIMO-OFDM system to achieve good quality wireless communication in 5G network [4], this paper is designed to enhance the performance of MIMO-OFDM with the aid of channel estimation algorithm.

2. Literature review of related works

Enormous efforts and work have been directed towards studies designed to improve various channel estimation techniques so as to enhance wireless communication system performance regarding reducing computational complexity. In this section, the papers reviewed are previous studies designed specifically to perform channel estimation. In order to estimate and recover the channel state together with transmitted signal, deep neural network (DNN) model trained offline from simulated data was used applied to online data for channel estimation and equalization in MIMO-OFDM system under noisy and faded channel scenario [7]. The channel models used were Additive white Gaussian Noise (AWGN) and Rayleigh fading. Ha et al. [8] applied Deep Learning (DL) algorithm to aid Least Square Estimation (LSE) method for 5G network. The DL algorithm was implemented in a MIMO system with multipath channel profile employed for simulation of 5G network subject to severe Doppler Effect. A scheme to address the problem of complex channel matrix dimension that depends on the number of Base Station (BS) antennas and consumes most of the scarce radio resources was developed in order to achieve efficient Channel State Information (CSI) acquisition with reduced pilot overhead in massive MIMO systems was presented in [9]. Performance comparison of channel estimation in MIMO, MISO, and SISO OFDM based systems was conducted for the block type and the comb type pilot arrangement in addition to various interpolation schemes considering the following performance metrics bit error rate (BER) and mean square error (MSE) [6]. The study revealed that systems performance improved from SISO to MIMO as the number of antennas increases while OFDM helped in interference elimination and bandwidth efficiency improvement. A hybrid technique that combined Chimp optimization algorithm and CatBoost algorithm called Chimp-based CatBoost channel estimation (CbCBCE) was proposed to determine and reduce channel parameters for uninterrupted communication [10]. Three different types of models were separately developed to address types of interference in single-cell and multiple cell systems in [11]. Taking advantages of Space Time Block Code (STBC) encoder, a solution based on block type pilots that do require interpolation technique, which transforms the process of channel estimation into a set of linear operations and thereby reduce complexity was developed and applied for channel estimation over AWGN-Rayleigh fading channel in MIMO-OFDM systems [12]. A DL bidirectional long short-term memory (BiLSTM) recurrent neural networks technique, which is a pilot dependent estimator was applied for CSI estimation in 5G wireless MIMO-OFDM communication systems [13]. Considering the benefits of STBC as a scheme that uses partial diversity of multiple transmitters and receivers in space to improve the OFDN system capacity and data rate, a variable pilot aided channel estimation technique with different orders of modulation for spectrum efficiency was introduced by Wu et al. [14]. Least Square (LS) and Minimum Mean Square Error (MMSE) algorithms were used to carry out channel estimation in MIMO-OFDM system [15]. The estimation was achieved using pilot-assisted block type training symbols. The performance of the system was evaluated in terms of BER plotted against SNR in AWGN channel model using BPSK, QPSK and 16-QAM modulation techniques. The simulation analysis of the system using LS and MMSE algorithms revealed that MMSE outperformed LS.

3. Methodology

3.1 System Model

In a MIMO system, there are many transmission endpoints and reception endpoints, which results in complex communication channel. Generally, channel estimation process consists of three main steps namely, mathematical model of channel, a signal known by both transmitter and receiver that is transmitted over the channel, and comparison of received signal with the original signal by the receiver in order to extract the properties of the channel and the noise added to the transmitted signal in the channel. Figure 1 is a 2×2 MIMO system, characterized by multipath fading channel between the transmitter side and the receiver side. The structure of the channel estimation schemes (CES) is represented with block diagrams shown in Fig. 2.

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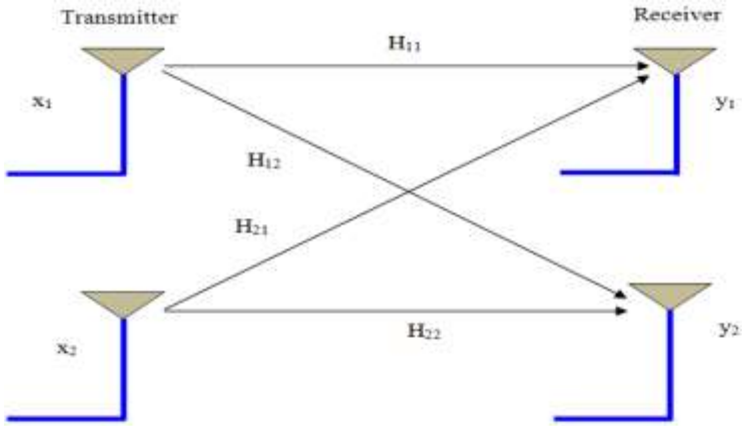

Fig. 1. *MIMO system configurations*

Consider a 2×2 MIMO system shown in Fig. 1 such that there are two signals received from s single antenna. Since different frequency signals can be affected differently by channel, therefore channels estimation needs to be performed for each frequency channel. Now, for the received signals y_1 and y_2, the following holds.
A pilot signal is sent to the receiver by the transmitter and this is expressed as follows:

$$y_1 = H_{11}x_1 + H_{21}x_2 + n_1$$
$$y_{21} = H_{12}x_1 + H_{22}x_2 + n_2$$

(1)

where x_1 and x_2 are the orthogonal transmitted pilot signals from the transmit antenna T_{X1} and T_{X2} respectively. Also, y_1 and y_2 are the received pilot signals on the receive antenna R_{X1} and R_{X2}. Since the transmitted pilot signal passed through wireless channel that is prone to noise, it will be corrupted by noise n_1 and n_2, which are the noise components on receive antenna R_{X1} and R_{X2} respectively.

Given the channel H_{ij} from i^{th} transmit antenna T_{Xi} to jth receive antenna R_{Xj} with i and $j \varepsilon \{1,2\}$. The channel matrix is expressed as follows:

$$H = \begin{bmatrix} H_{11} & H_{12} \\ H_{21} & H_{22} \end{bmatrix}$$

(2)

It should be noted that 2×2 MIMO system is used to describe the wireless communication in this context because it is more simplified. Also, the process of channel estimation remains the same in MIMO system except that increasing the number of antennas results in increase in number of received signals from a single source.

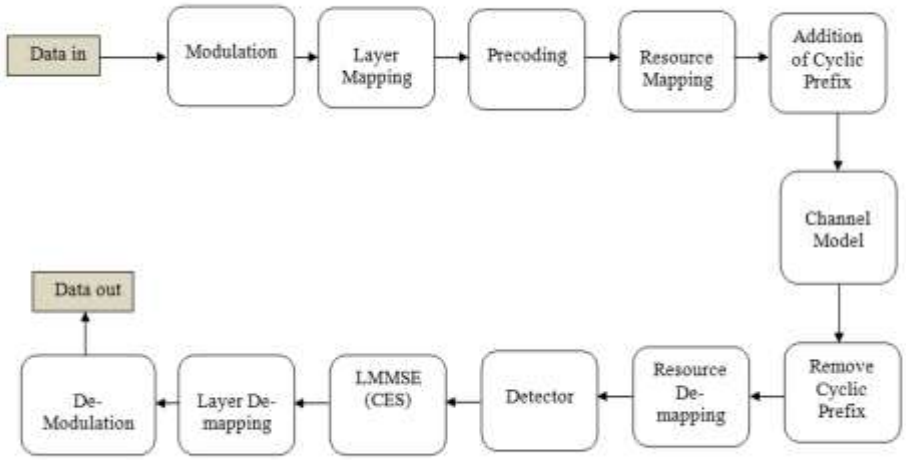

Fig. 2. *Proposed system block diagram*

3.2 Channel Model

In this paper, three types of channel models were considered to evaluate the performance of channel estimation technique. These channel models include:

- Additive White Gaussian Noise (AWGN) channel model: In this scheme, the MATLAB communication toolbox provides AWGN channel function, which serves to introduce noise that imitate the typical noise in a practical or real wireless communication environment. A simple structure for the process is shown in Figure 3.4 and the mathematical expression for the channel is given by (3).

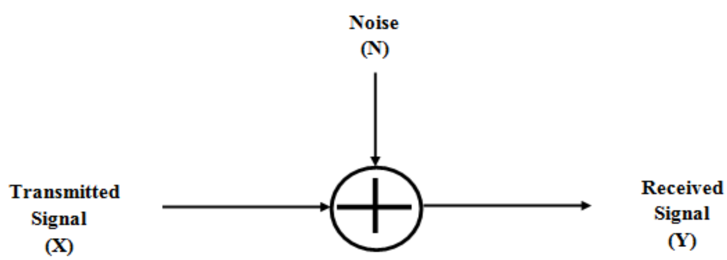

Fig. 3. *Generalized AWGN channel model*

$$Y = X + N \tag{3}$$

where Y is the received signal, X is the transmitted signal, and N is the additive white Gaussian noise (AWGN).

- MIMO simple channel model: In this case, correlation is added to one receive antenna per each phase of transmission by the channel. The mathematical description of simple channel is given by:

$$Y = H_{SC} X + N \tag{4}$$

where H_{SC} is the simple channel gain with correlation coefficient matrix given in (5), which is multiplied by the transmitted signal during transmission [4].

$$H_{SC} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{5}$$

- MIMO sparse Channel model: In this model, correlation is added to one or two receive antennas for every phase of transmission by the channel. The mathematical definition of the channel is given by:

$$Y = H_{SPC} X + N \tag{6}$$

where H_{SPC} is the sparse channel gain with correlation coefficient matrix given in (7), which is multiplied by the transmitted signal during transmission [4].

$$H_{SPC} = \begin{bmatrix} 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$
(7)

It can be seen that both the MIMO simple channel and MIMO sparse channel models incorporate the AWGN in addition to their channel matrices.

3.3 Channel Estimation Scheme

In channel estimation, data signal or training signal, or both, can be employed. The channel estimation scheme considered in this work is linear minimum mean square error (LMMSE) technique. Considering feedback block diagram in Figure 3.4, the minimum mean square error (MMSE) channel estimation technique estimates the channel H given by [16]:

$$J(\hat{H}) = E\{\| e \|^2\} = E\{\| H - \hat{H} \|^2 \qquad (8)$$

where $J(\hat{H})$ is the mean square error (MSE) of the channel estimate, $E\{\| e \|^2\}$ is the mean square error value, e is the error (e), and $\hat{H}$ is the channel estimate.

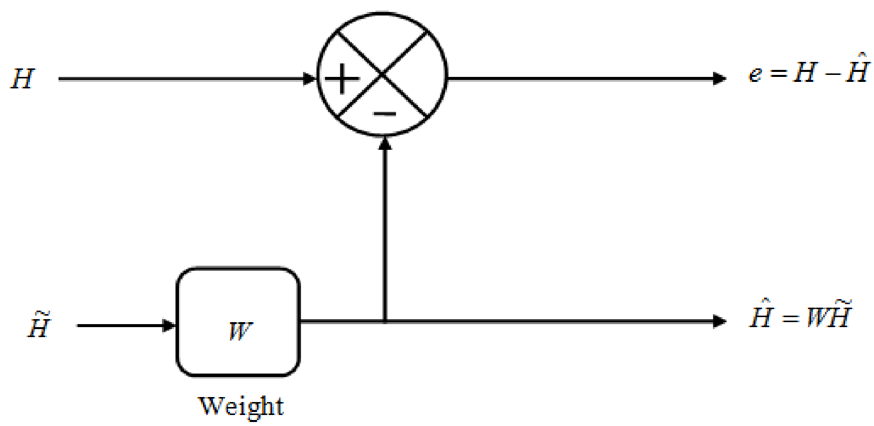

Fig. 4. *Minimum mean square error*

Subsequently, from Fig. 4, $\tilde{H}$ is the least square (LS) channel estimate is multiplied by weight matrix W. Hence, this ensures that MMSE channel estimation technique determines an improved (linear) estimate with respect to weighting matrix in such a way the MSE described by (8) is minimized [16]. Assuming orthogonality, the principle states that the estimation error vector e is orthogonal to $\tilde{H}$, hence the expression [16]:

$$\begin{aligned} E\{e\tilde{H}^H\} &= E\{(H - \hat{H})\tilde{H}^H\} \\ &= E\{(H - W\tilde{H})\tilde{H}^H\} \\ &= E(H\tilde{H}^H) - WE(\tilde{H}\tilde{H}^H) \\ &= R_{H\tilde{H}} - WR_{\tilde{H}\tilde{H}} = 0 \end{aligned} \qquad (9)$$

where $\tilde{H}^H$ is the Hermitian transpose of the least square (LS) channel estimate $\tilde{H}$, $R_{H\tilde{H}}$ and $R_{\tilde{H}\tilde{H}}$ are the same as the expression R_{AB}, which is the cross-correlation matrix of $N \times N$ matrices A and B (that is $R_{AB} = E[AB^H]$) such that $\tilde{H}$ is given by [17]:

$$\tilde{H} = X^{-1}Y = H + X^{-1}Z \qquad (10)$$

Expressing (4) in terms of W gives:

$$W = R_{H\tilde{H}} R_{\tilde{H}\tilde{H}}^{-1}$$
(11)

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where $R_{\tilde{H}\tilde{H}}$ stands for the autocorrelation matrix of $\tilde{H}$ defined as:

$$
\begin{aligned}
R_{\tilde{H}\tilde{H}} &= E\{\tilde{H}\tilde{H}^H\} \\
&= E\{X^{-1}Y(X^{-1}Y)^H\} \\
&= E\{(H + X^{-1}Z)(H + X^{-1}Z)^H\} \\
&= E\{HH^H + X^{-1}ZH^H + HZ^H(X^{-1})^H + X^{-1}ZZ^H(X^{-1})^h)\} \\
&= E\{HH^H + E\{X^{-1}ZZ^H(X^{-1})\} \\
&= \mathrm{E}\{\mathrm{HH^H}\} + \frac{\sigma_Z^2}{\sigma_X^2} I
\end{aligned}
$$

(12)

and also $R_{H\tilde{H}}$ represents the cross-correlation matrix between the actual channel vector and temporary channel estimate vector in frequency domain. The MMSE channel estimate can be described by [16]:

$$
\begin{aligned}
\hat{H} &= W\tilde{H} = R_{H\tilde{H}} R_{\tilde{H}\tilde{H}}^{-1} \tilde{H} \\
&= R_{H\tilde{H}} \left(R_{HH} + \frac{\sigma_z^2}{\sigma_x^2} I \right)^{-1} \tilde{H}
\end{aligned}
$$

(13)

where $E\{HH^H\}$ is the power of the transmitted signal, σ is the Gaussian additive channel noise with variance, and I is an identity matrix. Thus, from (13), the linear MMSE (LMMSE) can be expressed in a simplified form as in [18]:

$$
\hat{H}^{LMMSE} = R_{H\tilde{H}} \left(R_{HH} + \frac{\beta}{SNR} I \right)^{-1} \tilde{H}
$$

(14)

where β is a scaling factor and depends on the signal constellation. It is one for QPSK modulation and SNR is the average signal to noise ratio.

3.4 Performance Evaluation Metric

The performance analysis of the system will be carried out in terms of bit error rate (BER) since critical role is performed by channel estimation in BER performance improvement regarding noise rate. Thus, the performance metric are defined by:

$$
\mathrm{BER} = \frac{\text{Number of error bits}}{\text{Sum of the number of transmitted bits}} \tag{15}
$$

These performance metrics are affected by the presence of noise in the signal and as such, are usually evaluated at a measure of the efficiency of the system. The BER is evaluated against signal to noise ratio (SNR) expressed in decibels (dB). The SNR is often considered as a measure of signal power. It is defined as the ratio of the average signal power to noise power. The reliability level of the communication between the transmit end and the receive end is determined by the SNR [19]. Hence, the SNR of wireless communication system can be defined by:

$$
\mathrm{SNR} = \frac{\text{Signal power}, \mathrm{E_b}}{\text{Noise power}, \mathrm{No}}
$$

(16)

4. RESULTS AND DISCUSSION

In this section, the performances of the LMMSE channel estimation technique including other schemes implemented for performance comparison purpose such as least square (LS) and minimum mean square error (MMSE) methods, evaluated in terms of BER against SNR considering different simulation cases are presented. For simulation purpose in this work, the channel estimation schemes were implemented considering Additive White Gaussian Noise (AWGN) channel model, simple channel model, and sparse channel model in MATLAB environment. The simulation parameters are subcarrier spacing configuration = 0, subcarrier spacing = 15 kHz, number of OFDM symbols = 14, number of PDSCH subcarrier = 72, number of layers = 4, antenna configuration = 4×4, FFT size of 128, number of physical resource blocks = 12, interpolation = linear, and modulation technique = QPSK.

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The section is divided into three sections namely, subsection 4.1: performance analyses of LMMSE in AWGN, simple and sparse channels in terms of BER and subsection 4.2: performance comparison of LMMSE with LS and MMSE in the three channels in terms of BER using the QPSK modulation technique.

4.1 Performance Evaluation of LMMSE for BER

In this subsection the simulation results obtained from the analysis carried out in MATLAB regarding the implementation of the LMMSE algorithm in the AWGN, simple and sparse channel models in terms of the system performance determine for BER against SNR are presented as shown in Fig. 5 to 7. Also, the comparison of the various channel performance regarding LMMSE implementation is shown in Fig. 8.

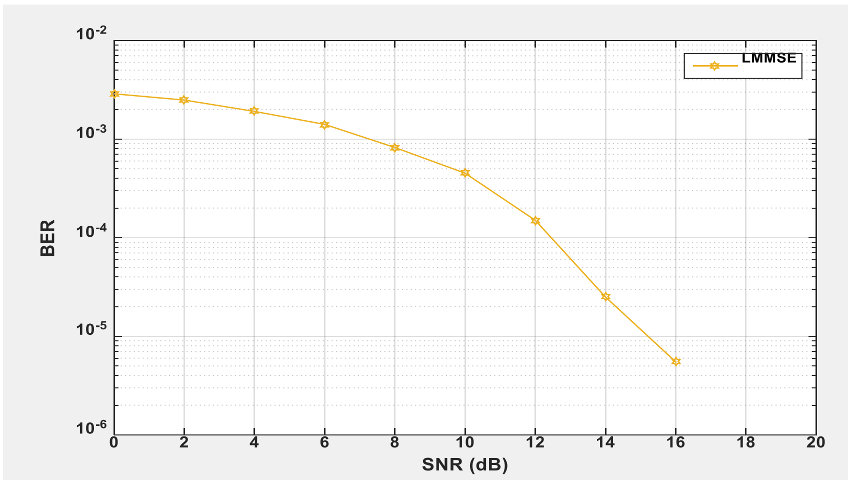

Fig. 5. *LMMSE performance for BER against SNR in AWGN channel*

The simulation curve in Fig. 5 shows the BER against SNR performance of the transmitted signal in AWGN channel, when LMMSE algorithm was implemented for channel estimation of MIMO-OFDM system. It was observed that that the BER decreases from 0.00288 to 0.0 as the signal power, expressed in terms of SNR in dB, increases from 0 to 18 dB.

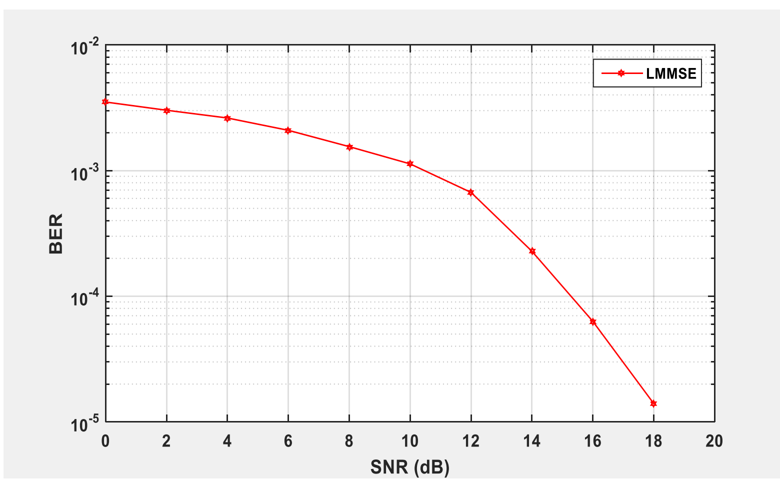

Fig. 6. *LMMSE performance for BER against SNR in simple channel*

The performance evaluation of the system in MIMO simple channel in terms of BER using LMMSE as shown in Fig. 6 reveals that the simulation curve of BER against SNR is on downward trend. It was observed using this simple channel model that the value of BER decreases from 0.00351 to 0.000014 as the SNR increases from 0 to 18 dB.

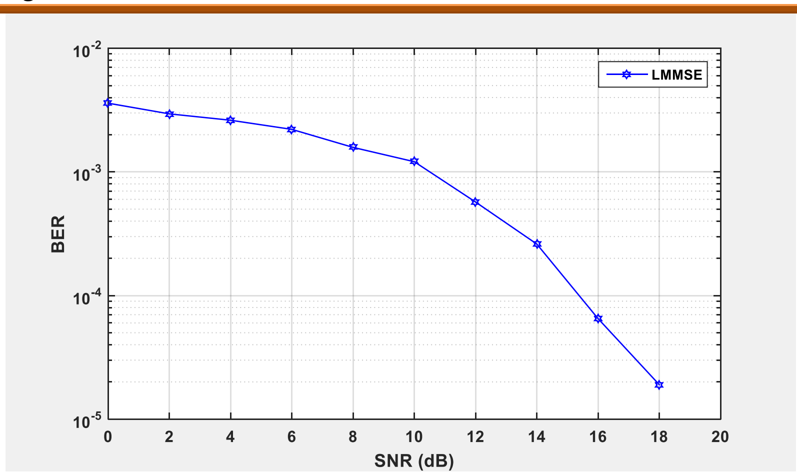

Fig. 7. *LMMSE performance for BER against SNR in sparse channel*

The simulation curve in Fig. 7 shows the performance evaluation of the LMMSE in sparse channel in terms of BER against SNR in MIMO system. It was observed from the simulation result using the sparse channel that BER of the signal decreases from 0.0036 to 0.000019 as the SNR increases from 0 to 18 dB.

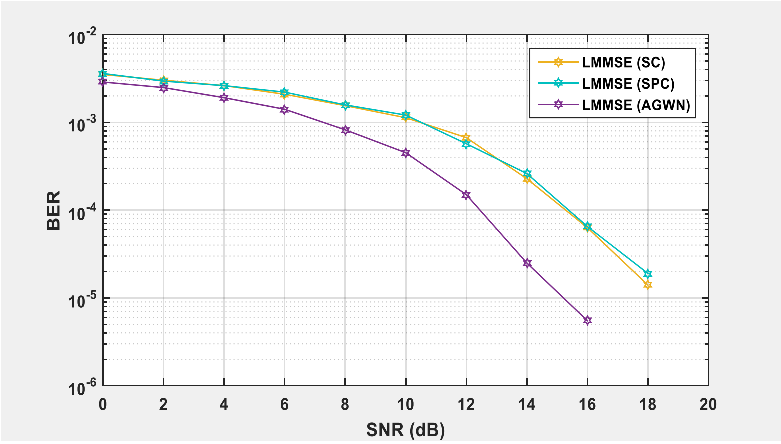

Fig. 8. LMMSE performance for BER against SNR in different channel

Figure 8 is the performance evaluation BER against SNR in simple channel (SC), sparse channel (SPC), and AWGN channel. Numerical analysis of the values of the BER for various values of SNR from 0 to 18 dB is shown in Table 1.

Table 1: Numerical analysis of BER against SNR using LMMSE in different channels

SNR (dB)	BER		
	AWGN channel	***Simple channel***	***Sparse channel***
0	0.00288	0.00351	0.0036
2	0.00249	0.00302	0.00295
4	0.00191	0.00262	0.00262
6	0.00141	0.00209	0.00221
8	0.000822	0.00155	0.00158
10	0.000451	0.00113	0.00121
12	0.00015	0.00067	0.000571
14	0.000025	0.000228	0.000261
16	0.0000055	0.0000631	0.0000651
18	0.0	0.000014	0.000019

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Looking at Table 1, it can be seen that the LMMSE offer the most efficient performance in terms of BER evaluation in AWGN channel followed by simple channel. Hence, the BER is 0.0, 0.000014, and 0.000019 at SNR of 18 dB for AWGN channel, simple channel, and sparse channel models respectively.

4.2 Performance Comparison

The simulation results obtained from the analysis carried out in MATLAB regarding the implementation of the LS, MMSE and LMMSE algorithm in the AWGN, simple and sparse channel models regarding the system performance in terms of BER against SNR are presented in this section as shown in Fig. 9 to 11.

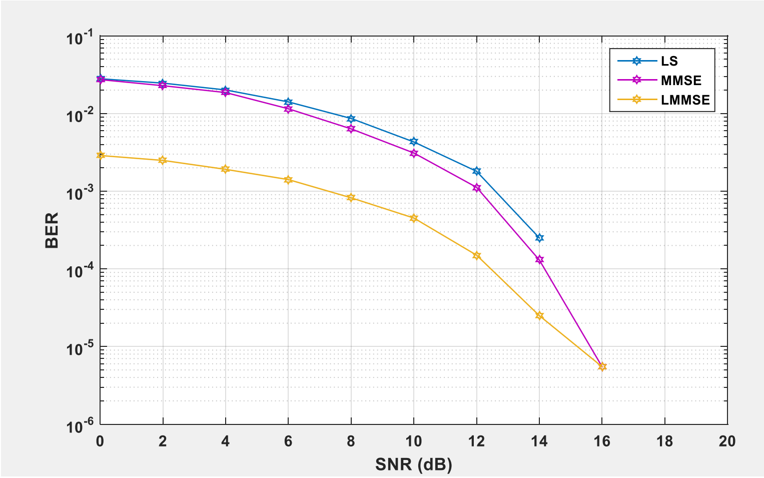

Fig. 9. *BER performance for different channel estimation algorithms in AWGN*

Figure 9 shows the resulting simulation curves from the evaluation of the performance of LS, MMSE and LMMSE schemes in AWGN channel in terms of BER plotted against SNR. The BER curves show that as the BER reduces and the SNR increases for the three algorithms. This sequential decreasing of BER against increasing SNR means that as less error is recorded in the signal, the signal strength (or power or magnitude) increases with less noise power. Table 2 is the numerical performance evaluations of the BER of the algorithms in AWGN channel.

Table 2: Numerical analysis of BER with different algorithms in AWGN

SNR (dB)	BER		
	LS	**MMSE**	**LMMSE**
0	0.0280	0.0273	0.00288
2	0.0246	0.0228	0.00249
4	0.0201	0.0186	0.00191
6	0.0141	0.0115	0.00141
8	0.00863	0.00634	0.000822
10	0.0043	0.0031	0.000451
12	0.0018	0.00112	0.00015
14	0.00025	0.00013	0.000025
16	0.0	0.0000055	0.0000055
18	0.0	0.0	0.0

Looking at Fig. 9 in addition to Table 2, it can be seen that BER curve of LMMSE shows that the algorithm outperformed the LS and MMSE schemes. This is even more obvious as shown in Table 1, where the magnitudes of BER using the LMMSE algorithm was improved with most reduced values achieved at various corresponding SNR from 0 to 18 dB.

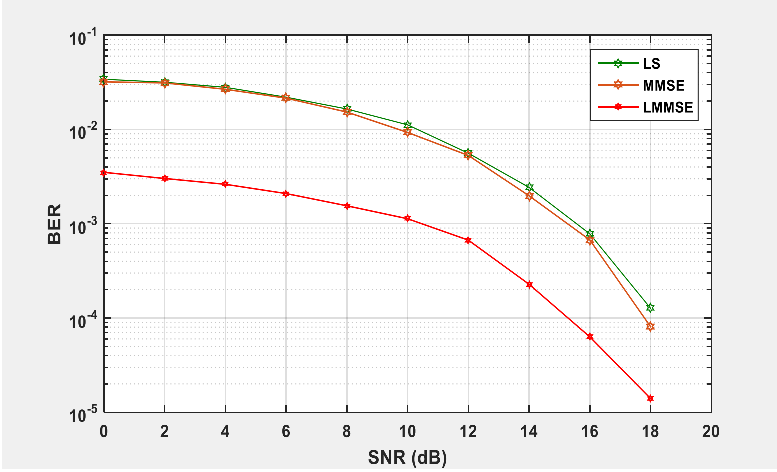

Fig. 10. *BER performance for different channel estimation algorithms in SC*

The resulting simulation curves from the evaluation of the performance of LS, MMSE and LMMSE schemes in MIMO simple channel in terms of BER plotted against SNR is shown in Fig. 10. Again, the curves show that as the BER reduces, the SNR increases for the three algorithms. Numerical evaluations of the BERs of the various channel estimation scheme are shown in Table 3.

Table 3: Numerical analysis of BER with different algorithms in AWGN

SNR (dB)	BER		
	LS	**MMSE**	**LMMSE**
0	0.0341	0.0320	0.00351
2	0.0317	0.0312	0.00302
4	0.0280	0.0267	0.00262
6	0.0220	0.0215	0.00209
8	0.0165	0.0153	0.00155
10	0.0112	0.0093	0.00113
12	0.0056	0.0053	0.00067
14	0.00243	0.00198	0.000228
16	0.000781	0.000673	0.0000631
18	0.000127	0.000081	0.000014

It can be seen as shown in Fig. 10 that BER curve of LMMSE indicates that the algorithm outperformed the LS and MMSE schemes. This is even more noticeable as shown in Table 3, where the magnitudes of BER using the LMMSE algorithm was improved with most reduced values achieved at various corresponding SNR from 0 to 18 dB.

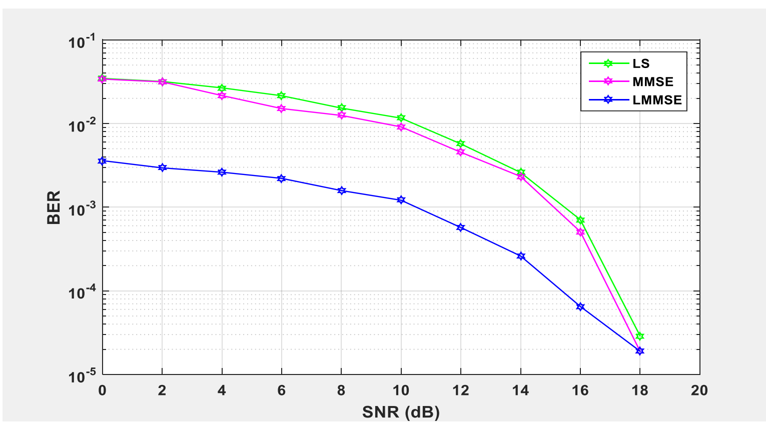

Fig. 11. *BER performance for different channel estimation algorithms in SPC*

Figure 11 shows the performance evaluation of BER against SNR for LS, MMSE and LMMSE algorithms in MIMO sparse channel. Similar trend of decreasing BER with increasing SNR can be observed. Looking at the BER curves, it can be seen that LMMSE provided the most efficient performance. This is because its BER curve indicates the most reduced number of error bits for each transmitted number of bits measured against the power of the signal (i.e. SNR in dB). Table 4 shows the numerical values of the each BER against SNR with respect to LS, MMSE and LMMSE.

Table 4: Numerical analysis of BER with different algorithms in AWGN

SNR (dB)	BER		
	LS	**MMSE**	**LMMSE**
0	0.0346	0.0340	0.0036
2	0.0318	0.0315	0.00295
4	0.0267	0.0216	0.00262
6	0.0215	0.0151	0.00221
8	0.0153	0.0125	0.00158
10	0.0116	0.00912	0.00121
12	0.00571	0.00453	0.000571
14	0.00260	0.00233	0.000261
16	0.000709	0.000510	0.0000651
18	0.000029	0.000019	0.000019

From Table 4, it can be seen that the LMMSE algorithm still offers the best performance in terms of BER for the sparse channel consideration.

4.3 Discussion

The analyses of the performance of the linear minimum mean square error (LMMSE) algorithm for channel estimation for a 4×4 MIMO-OFDM system have been carried out via simulations in MATLAB. The simulations were evaluated in terms of BER against SNR curves in three different channel models. The results from the simulations conducted as shown Figure 4.4, revealed that the best performance of the LMMSE was achieved in AWGN channel model. This should be expected because it is an ideal channel and adds less noise (or complexity) to the transmitted signal compare to simple and sparse channel models. Almost similar BER curves of LMMSE was achieved in simple and sparse channel models. In order to validate the effectiveness of the LMMSE scheme, simulation was conducted together with other estimators such as least square (LS) and minimum mean square error (MMSE) to compare their performances in terms of BER against SNR. It was observed that the BER simulation curves of the three algorithms decrease as the SNR increases. This is because increasing SNR indicates that the relative amount of noise compared to the received signal strength decreases. Hence, this leads to decrease in BER as the value of SNR increases. The BER performance of LS and MMSE estimation schemes in AWGN and simple channel models for SNR under 6 and 8 dB was almost equal respectively. Though, the plots showed that the MMSE scheme outperformed the LS as the SNR increases. Thus, in a system with low value of SNR, using MMSE which is of higher complexity would not be necessary. This is because it does not add any significant improvement to performance of the system at lower values of SNR. Generally, the simulation results showed that LMMSE algorithm outperformed LS and MMSE algorithms in all the channel models for all values of SNR in terms of BER performance. That is, the LMMSE algorithm offers a significant gain in SNR values compare with LS and MMSE. It also provides the best enhancement for BER in all cases with respect to the different channel models considered.

5. CONCLUSION

In this paper, enhancing channel estimation performance for MIM-OFDM in 5G network using linear minimum mean square error (LMMSE) technique has been presented. Channel estimation is fundamental in achieving effective wireless communication in MIMO-OFDM 5G network. The basic concept of this work was to decide on a channel estimation technique that can enhance communication between transmit and receive ends of MIMO-OFDM system. This was evaluated in terms of the performance efficiency of transmitted symbols (or number of bits), which was expressed in bit error rate (BER). Pilot-assisted channel estimation scheme was used in the study. Thus, block-type pilot configuration was utilized for channel estimation while employing QPSK modulation over different channels. The LMMSE algorithm was implemented in different channel models and it was later simulated with LS and MMSE to determine its effectiveness. The comparison analyses revealed that the performance of the channel estimation algorithms including LMMSE improves on a regular basis as the SNR increases. In terms of the simulation results obtained, it suffices to say that LMMSE outperformed LS and MMSE and would be a good scheme to enhance the BER performance of MIMO-OFDM system.

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