An Improved & Modified Method For Channel Estimation In Mobile Wireless Systems Using Ma-Lmmse Algorithm

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Abstract: In this paper an improved channel estimation algorithm for wireless channel is proposed. The importance of the OFDM is the multi-carrier modulation which means each signal/sub-carrier is modulated simultaneously and are overlapped to each other. To increase the performance of the advance wireless system, the channel estimation is an important technology in time-varying channel. For that the different modulation technique is used in OFDM, such as BPSK, QPSK, 16 QAM, 64 QAM and for the estimation at the receiver the pilot insertion techniques such as LS (Least Square) Method and LMMSE (Linear Minimum Mean Square Error) Method is used. The LS and LMMSE technique is used at receiver the estimation is done by using the Pilot Sequences. On the basis of traditional LMMSE, an improved method named MA-LMMSE is proposed, which is the modified version of conventional LMMSE method. The major advantage of the pilot sequences it allows high accuracy in wireless channel with simplicity. The aim of this paper is to examine the different method of channel estimation for reducing the ICI and ISI phenomena and also eliminate the Doppler effects and increase the performance.

Keywords: OFDM, Channel estimation, Pilot Sequences, LS, LMMSE, MA-LMMSE, BPSK, QPSK, QAM.

I. INTRODUCTION

Channel estimation is an important technique especially in mobile wireless network systems where the wireless channel changes over time, usually caused by transmitter and/or receiver being in motion at vehicular speed. Mobile wireless communication is adversely affected by the multipath interference resulting from reflections from surroundings, such as hills, buildings and other obstacles. In order to provide reliability and high data rates at the receiver, the system needs an accurate estimate of the time-varying channel. Furthermore, mobile wireless systems are one of the main technologies which used to provide services such as data communication, voice, and video with quality of service (QoS) for both mobile users and nomadic. The knowledge of the impulse response of mobile wireless propagation channels in the estimator is an aid in acquiring important information for testing, designing or planning wireless communication systems.

Channel estimation is based on the training sequence of bits and which is unique for a certain transmitter and which is repeated in every transmitted burst [3]. The channel estimator gives the knowledge on the channel impulse response (CIR) to the detector and it estimates separately the CIR for each burst by exploiting transmitted bits and corresponding received bits. Signal detectors must have knowledge concerning the channel impulse response (CIR) of the radio link with known transmitted sequences, which can be done by a separate channel estimator. The channel estimator is shown in fig 1.

The channel estimation method based on OFDM technique. Orthogonal frequency division multiplexing can accommodate high data rate in the mobile wireless systems in order to handle multimedia services. It is important to understand the OFDM technology because the channel estimation is an integral part of OFDM system.

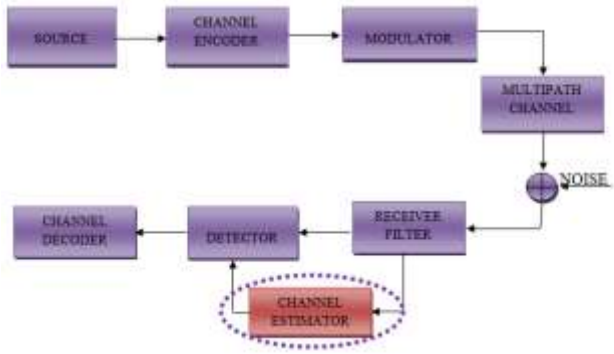

Figure 1: Block Diagram of Channel Estimator in OFDM

OFDM technology can be used effectively to avoid the effect of frequency-selective fading and narrowband interference from parallel closely spaced frequencies in mobile networks. One of the desirable features of OFDM is its robustness to the multipath induced intersymbol interference. On the other hand due to the frequency selective fading of the dispersive wireless channel, some sub channels may face deep fades and degrade the overall system performance. In order to compensate the frequency selectivity, techniques such as error correcting code and diversity have to be used [4]-[6].

Doppler shift is caused by the relative motion between the transmitter and receiver. It is considered as Doppler shift in the environment of single-path while Doppler spread in the environment of multipath. For OFDM system, the orthogonality between subcarriers is destroyed by Doppler spread. The greater the relative motion is the stronger the orthogonality is destroyed. Doppler Spread cannot ignore in the scenario [7]. So it is increasingly important to solve the Doppler frequency-spread in high-mobility environment.

Orthogonal Frequency Division Multiplexing (OFDM)

Orthogonal frequency division multiplexing can accommodate high data rate in the mobile wireless systems in order to handle multimedia services. It is important to understand the OFDM technology because the channel estimation is an integral part of OFDM system. OFDM technology can be used effectively to avoid the effect of frequency-selective fading and narrowband interference from parallel closely spaced frequencies in mobile networks. If there is no orthogonality in the channel, inter-channel interference (ICI) can be experienced. With these vital

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advantages, OFDM technology has been widely used by many wireless standards such as WLAN, WMAN, and DVB [8]. In OFDM scheme, complex filters are not required and time-spreading can be used without any complications in OFDM scheme.

Orthogonal Frequency Division Multiplexing (OFDM) is one of the promising applications, which reduces the multipath fading and makes complex equalizers unnecessary [9]. The concept of using parallel-data transmission and frequency division multiplexing (FDM) was first published in the mid of 1960s. The basic idea was to use parallel data and FDM with overlapping subchannel to avoid the use of high-speed equalization to combat impulsive noise and multipath distortion and fully utilize bandwidth.

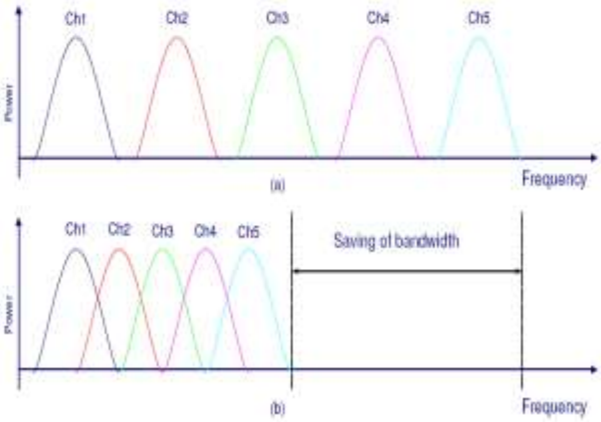

Figure 2: Concept of OFDM Signal: (a) conventional multicarrier technique (FDM) , and (b) orthogonal frequency division multiplexing technique.

In Figure 2, we can observe the difference between non-overlapping multicarrier modulation technique and overlapping modulation technique. From figure 2(b) it is very clear that by using overlapping modulation technique we can save much more bandwidth than the non-overlapping one [9]. Weinstein and Ebert [10] applied the discrete Fourier transform (DFT) to parallel data transmission system as part of the modulation and demodulation process. In multicarrier transmission, bandwidth divided in many non-overlapping subcarriers but not essential that all subcarriers are orthogonal to each other as shown in figure 3 [9].

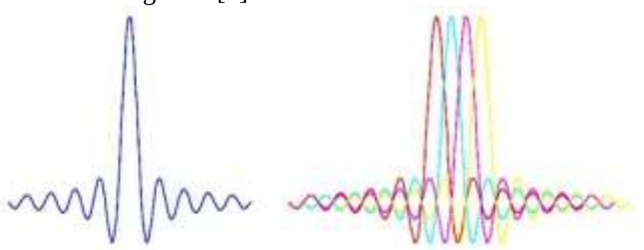

Figure 3: Spectra of (a) an OFDM sub-channel (b) an OFDM Signal

Orthogonal frequency-division multiplexing (OFDM) is a key technique in the mobile applications of 3G/4G system due to its capability of high rate transmission and robustness to inter-symbol-interference (ISI). It could combat the frequency selective fading effectively because of narrow bandwidth of each subcarrier. Furthermore, its implementation is low-complexity because the signal processing architectures need only IFFT, FFT and simple frequency-domain equalization. However, these advantages no longer exist when the channel response varies rapidly in time-domain because of the mobility of user equipment.

II. METHODOLOGY

In OFDM the concept of parallel data and FDM with overlapping sub channels to avoid the use of high-speed equalization to combat impulsive noise and multipath distortion and fully utilize bandwidth. The working of OFDM is shown in figure 4.

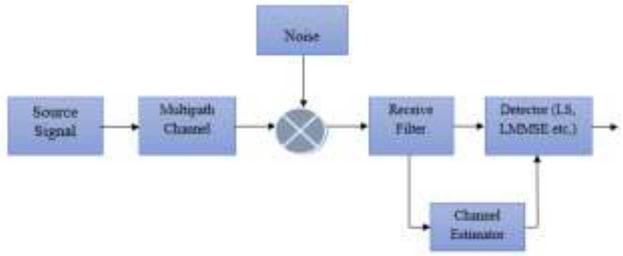

Figure 4: Block diagram of Channel Estimator

Channel and Signal Model

The method of channel estimation in which the Pilot Sequence are added after the signal is modulated and before the signal is transmitted. At the receiver pilot sequences are removed and the signal is extracted from the received signal.

The multipath time-varying channel model is considered in which the impulse response is expressed as:

$$H(n) = \frac{1}{\sqrt{N_p}} \sum_{p=0}^{N_p-1} \alpha_p e^{j\frac{2\pi}{N} f_{D_p}} \delta(n-\tau_p)$$

Where, α_p, f_{Dp} and τ_p are the complex amplitude, normalized Doppler shift and time delay for the pth multipath arrival respectively.

For an OFDM signal the transmitted signal is expressed as:

$$X(n) = \frac{1}{N} \sum_{i=0}^{N-1} d_i e^{j\frac{2\pi}{N} in}$$

Where, d_i is BPSK-modulated signal carried by the ith subcarrier, N is the number of subcarriers. After the modulation of OFDM, the pilot sequences are added to the signal and then transmitted.

The received signal can be expressed as:

$$\boldsymbol{Y(n) = H(n)\, X(n) + W(n)}$$

Where, Y(n) is the received signal, X(n) is the transmitted signal, H(n) is the impulse response and W(n) is the additive white Gaussian noise (AWGN).

The received signal is derived from the convolution of the input signal and channel impulse response. After removing the pilot sequences, the received signal can be expressed as:

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$$Y(n) = \frac{1}{N\sqrt{N_p}} \sum_{p=0}^{N_p-1} a_p e^{j\frac{2\pi}{N} f_{D_p} n} \sum_{i=0}^{N-1} d_i e^{j\frac{2\pi}{N} i(n-\tau_p)} + W(n)$$

Proposed Modified Adaptive Linear Mean Minimum Square Error (MA-LMMSE)

The LMMSE channel estimator is designed to minimize the estimation MSE. In this proposed MA-LMMSE the estimation process additionally involves comparison of new samples with previous one & rest of the phenomenon is same as MMSE, which makes this technique adaptive. Since, modification is required in correlation matrix & receiver circuitry, hence it is named MA-LMMSE. The LMMSE estimate of the channel responses given as:

$$H_P^{LMMSE} = R_{HH_P}\left(R_{H_PH_P} + \frac{\beta}{SNR} I_P\right)^{-1} H_P^{LS}$$

Where, β = Scaling Factor
Ip = Identity Matrix

R_{HH_P} represents the cross-correlation matrix between all sub-carriers and the subcarriers with reference signals. $R_{H_P H_P}$ represents the auto-correlation matrix of the sub-carriers with reference signals. The high complexity of LMMSE estimator is due to the inverse matrix. Every time data changes, inversion is needed. The complexity of this estimator can be reduced by averaging the transmitted data. Then, the estimation can be done more accurately.
The detailed flow chart of the proposed algorithm is gives an idea of the complete process of OFDM system design is included, since channel estimation is a block of OFDM system. Channel estimation is performed at the receiver end for accurate prediction of the received signals from noisy environment. This includes the estimation of original signal form detected signal from the channel, which contains noise.

PROPOSED ALGORITHM

Step 1: Specify various simulation parameters like mapping schemes, modulation types, maximum SNR & information symbols being transmitted.

Step 2: Generate modulated symbols using modulator. In this work 16-QAM & 64-QAM modulation is taken, since at higher SNR these modulation performs better, than other techniques, like BPSK, QPSK etc.

Step 3: Generate random channel matrix coefficients using Rayleigh fading or Rician fading model. Generate random AWGN noise matrix.

Step 4: The modulated signal is rehashed from serial to parallel & orthogonal training (pilot) symbols are generated. Perform IFFT. After this parallel to serial rehashing, guard & cyclic extension is added. Then this signal is converted into digital to analog before transmission.

Step 5: At the receiver first received analog signal is rehashed into digital form for further processing, then removal of guard & cyclic extension is performed. After serial to parallel rehashing, FFT is performed.

Step 6: Calculate training data output & blind information data output using orthogonal training symbols, channel coefficients matrix & noise coefficients matrix.

Step 7: Apply proposed estimation technique which is the modified adaptive version of Adaptive LMMSE technique. We define this method as Modified Adaptive Linear Minimum Mean Square Error (MA-LMMSE).

Step 8: Arrange the estimated matrix of channel.

Step 9: Apply demodulation to calculate received information symbols.

Step 10: Calculate BER using transmitted symbols & received symbols. Plot SNR vs BER as a performance analysis criterion, which is used as to measure the performance.

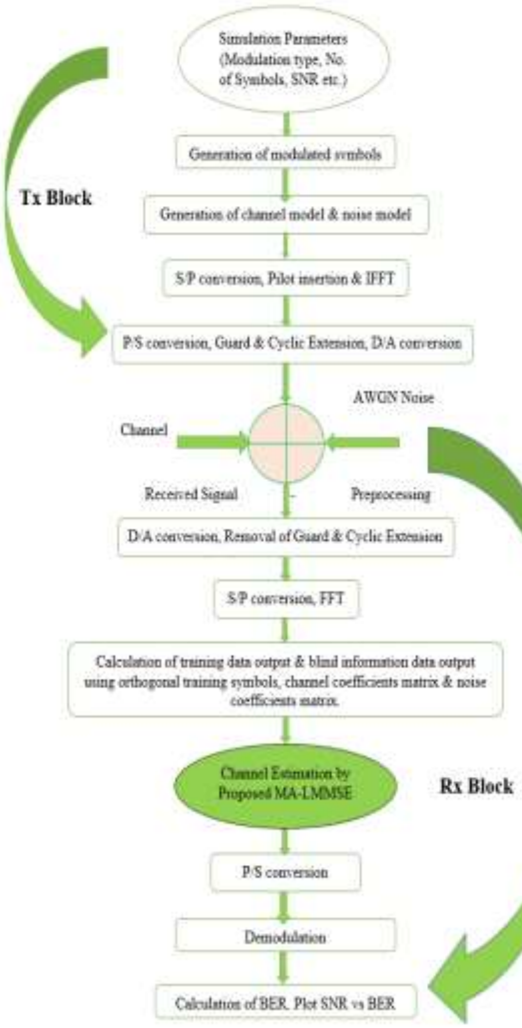

Figure 5: Detailed Flow Chart

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III. SIMULATION RESULTS

The MATLAB/SIMULINK Communication tool box is used for implement the proposed model. In the channel estimation technique, Proposed Modified Adaptive Linear Mean Minimum Square Error (MA-LMMSE) method is designed on pilot sequence arrangement. The received signal which is receive at the receiver end which contain the pilot sequences, in which the number of bits are changed is estimated and detect the error in the signal. By which the Doppler diversity and the intersymbol interferences is reduced and the estimation could improve the BER performance.

Parameters	Specifications
FFT Size	64, 128, 256, 512
Number of Active Carriers	64
Guard Type	Cyclic Extension
Cyclic Prefix Size	8, 16
Modulation Type	BPSK, QPSK, 16-QAM, 64-QAM
Channel Model	Rayleigh Fading / Rician Fading
Beta (β)	17/9
SNR Range	0 to 10 dB

Table 1: Simulation Parameters

Selection of Modulation Technique

We have performed the simulation with BPSK, QPSK, 16-QAM & 64-QAM for selection of best modulation technique first.

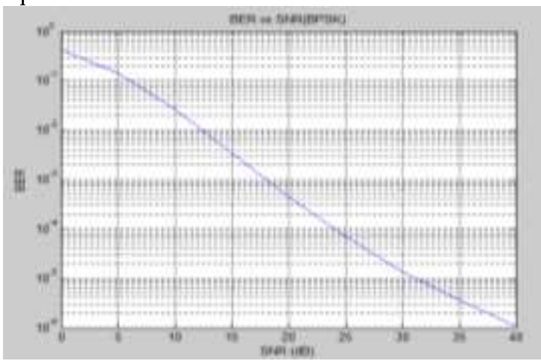

Figure 6: BER and SNR using BPSK Method

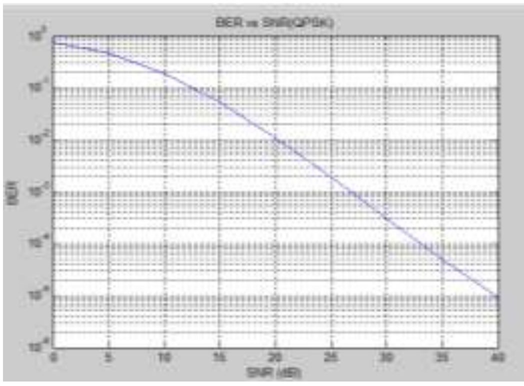

Figure 7: BER and SNR using QPSK Method

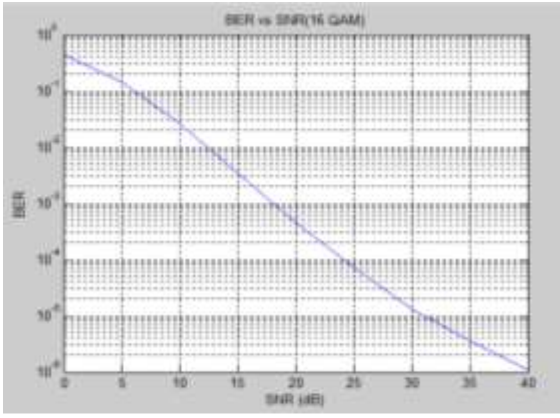

Figure 8: BER and SNR using 16 QAM Method

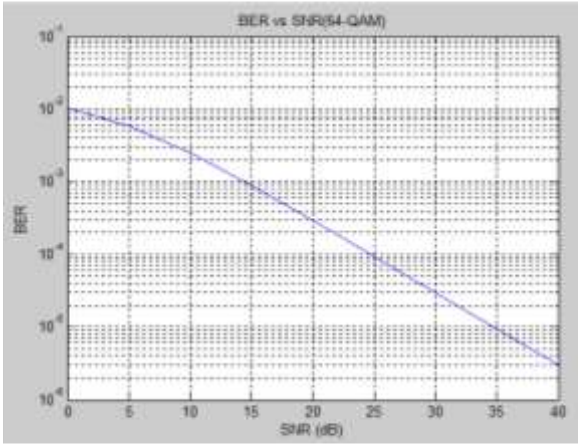

Figure 9: BER and SNR using 64 QAM Method

SNR (dB)	Bit Error Rate (BER)			
	BPSK	QPSK	16 QAM	64 QAM
0	0.2042	0.1122	0.0107	0.01
4	0.112	0.0479	0.0073	0.0032
8	0.0148	0.0182	0.0012	0.0014
12	1.80E-03	1.17E-02	5.23E-04	5.62E-04
16	2.24E-04	3.20E-03	1.41E-04	1.41E-04
20	2.29E-05	0.0013	3.16E-04	3.16E-04

Table 2: SNR vs BER for different modulation techniques

From the above table it can be seen that QAM modulation technique is better than others.

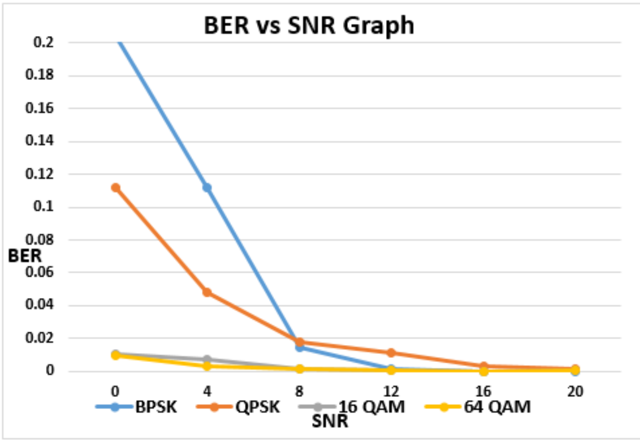

Figure 10: SNR vs BER for different modulation techniques

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Proposed MA-LMMSE with 16-QAM

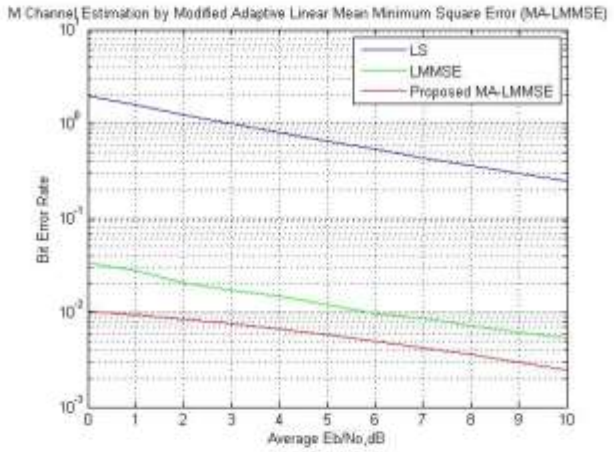
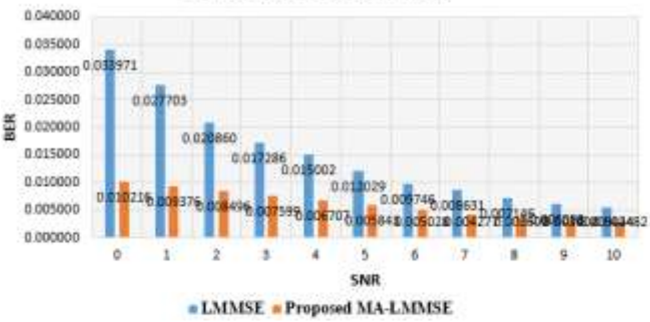


Figure 11: Proposed MA-LMMSE Algorithm with 16-QAM

SNR (dB)	Bit Error Rate (BER)		
	LS	LMMSE	Proposed MA-LMMSE
0	1.943646	0.033971	**0.010216**
1	1.564226	0.027703	**0.009376**
2	1.255018	0.020860	**0.008496**
3	1.008713	0.017286	**0.007599**
4	0.810740	0.015002	**0.006707**
5	0.656894	0.012029	**0.005843**
6	0.540470	0.009746	**0.005028**
7	0.435856	0.008631	**0.004277**
8	0.356955	0.007146	**0.003600**
9	0.297144	0.006098	**0.003002**
10	0.248841	0.005444	**0.002482**

Table 3: Comparison of LS, LMMSE & Proposed MA-LMMSE Algorithm with 16-QAM

BER vs SNR Performance



Proposed MA-LMMSE with 64-QAM

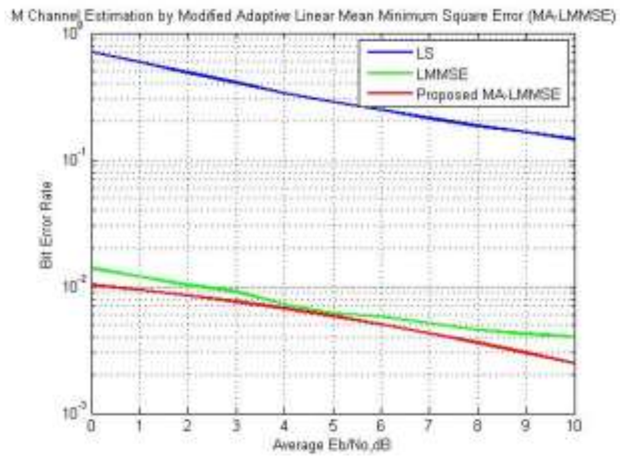
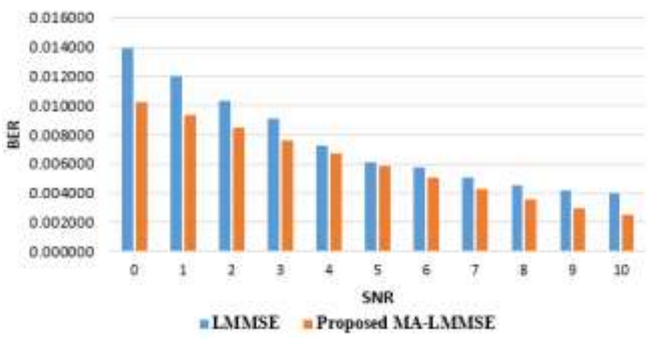


Figure 12: Proposed MA-LMMSE Algorithm with 64-QAM

SNR (dB)	Bit Error Rate (BER)		
	LS	LMMSE	Proposed MA-LMMSE
0	0.704256	0.013940	0.010216
1	0.590865	0.011985	0.009376
2	0.487698	0.010291	0.008496
3	0.406352	0.009108	0.007599
4	0.333998	0.007232	0.006707
5	0.283564	0.006154	0.005843
6	0.247296	0.005796	0.005028
7	0.212394	0.005086	0.004277
8	0.184453	0.004537	0.003600
9	0.164928	0.004224	0.003002
10	0.145026	0.004013	0.002482

Table 4: Comparison of LS, LMMSE & Proposed MA-LMMSE Algorithm with 64-QAM

BER vs SNR



IV. CONCLUSION

The channel estimation method, the OFDM transmission technique has emerged as a promising for high data rate and reliable transmission for wireless communication systems. Due to channel interference, the accuracy of channel estimation is an essential factor for a good receiver. Least Square method reduces BER but the proposed MA-LMMSE is showing best optimized performance of the system for BER as well as SNR for QAM modulation as compared to LS & LMMSE algorithm.

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