STUDY AND IMPLEMENTATION OF LTE 3GPP BASEBAND TRANSCEIVER BASED MULTIWAVELET SIGNALS FOR DIFFERENT CHANNEL ESTIMATION ALGORITHMS [+]

Mohammed Aboud Kadhim [*]

Abstract :

Long Term Evolution (LTE) is a radio platform technology that will permit operators to attain even higher peak throughputs than evolved High-Speed Packet Access (HSPA+) in higher spectrum bandwidth. Time-domain based channel estimation for orthogonal frequency division multiplexing (OFDM) based Discrete Multiwavelet Transform (DMWT) system with pilot-data multiplexed scheme is investigated in this work. Starting with the analysis of channel estimation processes, current the Minimum Mean Square Error (MMSE) and Least Square (LS) estimators and compromising between performances in different Stanford University Interim SUI channel scenarios. The simulation presented by Matlab Simulink results show that MMSE method achieves better BER performance than the (LS) method.

Keyword: (LTE) 3GPP, OFDM, MMSE, LS, 16-QAM.

دراسة وتنفيذ جهاز الإرسال والاستقبال LTE 3GPP المبني على اشارات متعددة المويجات بعدة حسابات مختلفة لقنوات التخمين

محمد عبود كاظم

المستخلص :

التطور على المدى الطويل الذي هو (LTE) هو منصة التكنولوجيا الراديوية التي من شأنها أن تسمح لمستعمليه من تحقيق الذروة الانتاجية حتى أعلى من تطورت وصول الحزم عالية السرعة (+ HSPA) في أعلى عرض نطاق ترددي للطيف.

مجال الوقت المستند على قناة التخمين لمضاعفة الانقسام الترددي (OFDM) والمبني على تحويل الاشارات متعددة المويجات مع نظام المضاعفة التجريبية للبيانات نفذ في هذا العمل .ابتداء من عمليات التحليل الحسابي لقنوات التخمين عرض في هذا العمل نموذجان الاول الحد الادنى لمتوسط مربع الخطا (MMSE) والثاني اقل مربع خطا (LS) وقد تمت المقارنة بين اداء هذين النظامين بمختلف الظرووف البئية لقناة جامعة ستانفورد المؤقتة. برنامج المحاكاة المستعمل في هذا العمل هو Simulink Matlab النتائج توضح انه طريقة الحد الادنى لمتوسط مربع الخطا (MMSE)) تحقق اقل مستويات للخطا من طريقة اقل مربع خطا (LS).

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[*] Lecturer / Institute of Technology / Baghdad / Middle Technical University

1. Introduction :

Work on LTE began at 3GPP in 2004, with an official LTE work article to begin in 2006 and a finished 3GPP Release 8 requirement in March 2009. Early distributions of LTE start, in last 2009. In the past few years, there has been increasing demands for accessing the internet over the mobile devices [1].The wireless communication manufacturing has been motivated hard to describe a novel air interface for mobile communications to deliver a framework for great mobility broadband services and increase the whole system capacity; decreasing latency; and getting better spectral efficiency and cell-edge performance. The 3GPP LTE (Third Generation Partnership Project) aim to offer mobile voice, video and data services by encouraging low expense distribution and service models through internet friendly constructions and protocols. This technology is being considered as nominee, for the Fourth Generation (4G) of mobile networks [2]. Channel estimation is a significant subject in any OFDM-based scheme for demodulation and decoding. Usually, an OFDM waveform be able to be seen as a two-dimensional (2D) lattice in the time-frequency plane. For pilot-assisted channel estimation methodologies, where pilots mention to reference signals identified at both transmitter and receiver, this 2D lattice can be viewed as being sampled at the pilot positions, and the channel properties between pilots are estimated by interpolation. The two simple aspects of OFDM channel estimation are the alignment of pilot positions, and the design of the channel estimator to insert between the pilots. The aim in designing channel estimators is to resolve this problem with an acceptable tradeoff between complication and performance [3]. Channel estimation methods for 3GPP LTE systems have been extensively studied. In [4] brief and compared these two simple channel estimation schemes. The two important principles behind these algorithms are to decrease the computational complexity by implementing one-dimensional (1D) rather than two-dimensional (2D) channel estimators, and to progress the interpolation precision by employing second-order measurements of the selective fading channel in either the frequency or in the time dimension. In [5], they presentation low complexity partial-sampled MMSE channel estimation for compromising between complexity and performance. They decreased MMSE channel estimation complication by partially sampling the MMSE weight matrix. It then achieves a complete comparison of the system construction when using MMSE and when using LS for each and too discusses the seamless integration of LTE technologies into the advanced 3GPP networks. It performs an exhaustive study of the air interface radio aspects same as access modes, transmission bandwidths, supported frequency bands, antenna methods; the protocol aspects and numerous other profit contain control apparatuses, Quality of Service (QoS) and security for each of them, Finlay this paper offers an summary of the rivalry in the wireless market and tasks for each of these next-generation wireless standards

2. Estimation algorithms :

An estimation algorithm is a branch of statistical signal processing. It deals with problem of estimating parameters based on the measured data. The purpose of the estimation theory is to develop an estimator, preferably an implementable one that can be used in practice. The estimator takes the measurement data as inputs and produces estimated values of the parameters [6, 7].

$$Y = xH + N \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$Y = Ah + N$ ……………………………………………………………………………(2)

Where H and h are unknown vectors. X and A are the known matrices. Y is the measurement matrix for both. Upon this, there are two estimators mainly used for the problem of channel estimation, namely Least Squares (LS) and Minimum Mean Square Error (MMSE). The dependency between frequency domain Y and time domain channel response h can be interpreted as linear thus the system equation in frequency domain comes to be in mathematical terms, taking the Eq.2 as an example, the channel estimation is to find a solution $\widehat{h}$ for the equation $A\widehat{h} \approx$ Y. What LS mean is to minimize the Euclidean norm squared of the residual $A\widehat{h} -$ Y, that is [6,7],

$$\left\|A\widehat{h} - Y\right\|^2 = \left(A\widehat{h} - Y\right)^H\left(A\widehat{h} - Y\right) = \left(A\widehat{h}\right)^H\left(A\widehat{h}\right) - Y^H A\widehat{h} - \left(A\widehat{h}\right)^H Y + Y^H Y \quad \text{……..(3)}$$

The minimum is found at the zero of the derivative with respect to $\widehat{h}$ **,** then

$$2A^H A\widehat{h} - 2A^H Y = 0 \Rightarrow A^H A\widehat{h} = A^H Y \quad \text{………………………………………(4)}$$

Therefore, $\widehat{h}$ will be given by

$$\widehat{h} = (A^H A)^{-1} A^H Y \quad \text{…………………………………………………………(5)}$$

Under the condition that the A has full column rank. The term $(A^T A)^{-1} A^H$ is called pseudo-inverse of matrix A sometimes denoted by $A^{\dagger}$. MMSE estimator aims to approach optimal result by exploit the statistical dependence between the measured data and the estimated parameter. Eq.1 is chosen to be an example, where h is to be estimated. On purpose of minimizing the Mean Square Error according to [6, 8], the estimated channel impulse response will be given by $(MSE)\ E\left[\left(h - \hat{h}_{MMSE}\right)^2\right]$

$$\widehat{h} = R_{hY} {R_{YY}}^{-1} Y \quad \text{……………………………………………………………(6)}$$

Where R_{hY}, R_{YY} are the cross covariance matrix between h and Y and the auto covariance matrix of Y with [6, 8],

$$R_{hY} = E[hY^H] = E[h(Ah + N)^H] = R_{hh} A^H \quad \text{…………………………………(7)}$$

$$\begin{aligned} R_{YY} &= E[YY^H] = E[(Ah + N)(Ah + N)^H] \\ &= E[Ah(Ah)^H + AhN^H + N(Ah)^H + NN^H] \\ &= AR_{hh}A^H + \sigma_n^2 I \quad \text{…………………………………………………(8)} \end{aligned}$$

$R_{hh} = E[hh^H]$ is the auto-covariance matrix of h and σ_n^2 denotes the noise variance

$E|n_k|^2$ These two quantities are expected to be identified at the estimator then Eq.4 be able to be rewritten as [6, 8].

$$\hat{h} = R_{hh}A^H(AR_{hh}A^H + \sigma_n^2 I)^{-1}Y$$
$$= R_{hh}(R_{hh} + \sigma_n^2(A^H A)^{-1})^{-1} A^{\dagger}Y \quad \ldots\ldots (9)$$

3. System model :

The system model of LTE 3GPP baseband transceiver based multiwavelet signals that used for simulation in this paper is shown in Fig.1. The simulation was applied using Matlab Simulink. The LTE transceiver structure is divided into three main sections: transmitter, channel, and receiver:

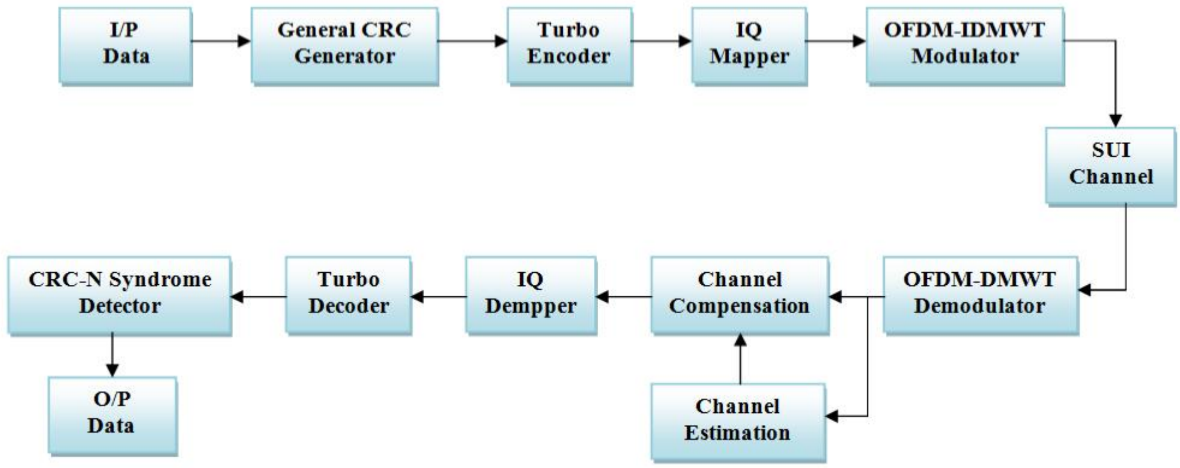

Figure (1): The Proposed LTE 3GPP Baseband Transceiver Based Multiwavelet Signals

In this paper, we construct the LTE transceiver compatible to the 3GPP LTE requirement [1-3], which is shown in Figure 1. In the transmitter end, we proceed the pseudo noise (PN) binary sequence generator to generate random binary sequence, and then the transmitter in the physical layer starts with the resource data which are in the form of transport blocks (see Figure 1). In each, one transport block will be moved first to the channel coding part which consists of two CRC encoders and one Turbo encoder. Similar to [9], an encoder of Cyclic Redundancy Check (CRC) is employed at the beginning of channel coding. The channel coding system for PDSCH adopts Turbo coding, which is a type of strong channel coding. The performance of Turbo codes be able to be close to the theoretical Shannon capacity limits. As in [9], the construction of the Turbo encoder is a Parallel Concatenated Convolutional Code (PCCC) with two 8-state constituent encoders and one Turbo code internal interleaver. The theoretical structure of a Turbo encoder in [9]. As clarified in Figure 1, the modulation system used is the 16-QAM coding rate (1/2) with gray coding in the constellation map the binary sequences to the quadrature amplitude modulation (16-QAM) symbols. Following, the synchronization signals are added after symbol mapping to make transmitter and receiver synchronized. This method converts data to the agreeing value of constellation, which is a complex word (with a real and an imaginary part). The bandwidth (B =(1/T_s)) is divided into N similarly spaced subcarriers at frequencies (kΔf), k=0,1,2,...,N-1 with Δf=B/N and, T_s , the sampling interval. At the transmitter, information bits are collected and mapped into complex symbols. In this system, 16-QAM with constellation

$C_{16-\mathrm{QAM}}$ is supposed for the symbol mapping. $\mathrm{N_c}$ and is the number of sub-carriers carrying data. N is the multicarrier size. Therefore, the number of virtual carriers is N-$\mathrm{N_c}$. We adopt that half of the virtual carriers are on both ends of the spectral band [10]. Which contains of the OFDM modulator and demodulator. The training frame (pilot sub-carriers frame) are injected and sent prior to the information frame. This pilot frame is used to generate channel estimation, which is used to atonement for the SUI channel models effect on the signal. To modulate spread data symbol on the orthogonal carriers, an N-point Inverse multi-wavelet transform IDMWT is used, as in conventional OFDM. Zeros are inserted in some bins of the IDMWT to compress the transmitted spectrum and decrease the adjacent carriers' interference noise. The added zeros to some sub-carriers limit the bandwidth of the structure, though the system without the zeros pad has a spectrum that is spread in frequency. The adding of zeros to some sub-carriers means not all the sub-carriers are used; only the subset ($\mathrm{N_c}$) of total subcarriers ($\mathrm{N_F}$) is used. Thus, the number of bits in OFDM symbol is equal to $\log_2$ (M)* $\mathrm{N_c}$. Orthogonality between carriers is usually, damage when the transmitted signal is passed through a SUI channel models. In Multi-wavelet setting, GHM multi-scaling and multi-wavelet function coefficients are 2×2 matrices, and through transformation step they necessity multiply vectors (instead of scalars). This means that multi-filter bank needs 2 input rows [11]. The goal of preprocessing is to associate the given scalar input signal of length N to a sequence of length-2 vectors in order to start the study algorithm, and to reduce the noise interference effects. In the one dimensional signals the "repeated row" structure is convenient and influential to implement. If the number of sub-channels is satisfactorily large, the channel power spectral density can be supposed virtually flat within each sub-channel. In these types of channels, multicarrier modulation has long been known to be optimum when the number of sub-channels is large. The size of sub-channels necessary t approximate optimum performance depends on how fast the channel transfer function differs with frequency. The calculation of DMWT and IDMWT for 256 point as in [12]. After this, the data converted from the parallel to the serial form are fed to the SUI channel models further information about SUI channel models in [13]. The receiver achieves the same operations as the transmitter, but in a reverse order. Assume that the timing offset is perfectly estimated. Take a discrete multi-wavelets transform (DMWT) operator the received signal for transform the time-domain signal into the frequency-domain signal. Also, multiwavelet OFDM contains operations for synchronization and compensation for the harsh SUI channel models.

4. Simulation and Results :

In this part the simulation of the suggested LTE 3GPP baseband transceiver based multiwavelet signals and comparing when using the channel estimation LS and the channel estimation MMSE is performed, beside the BER performance of the system observed in SUI channel models.

Table (1): the Parameters of LTE Transceiver

Parameter	Assumption
Subcarrier frequency in a Resource block	180KHz
Sub-frame duration	0.5ms
Sampling Frequency	3.84MHz
Transmission Bandwidth	2.5 MHz
Sub-carrier spacing	15KHz
Sampling Frequency	3.84MHz
DMWT Size	256
Modulation type	16-QAM
Data rate	108 Mbps
Channel estimation	Perfect
Receiver decoder type	Soft sphere detection (SSD)
Number of iterations	1000
Channel coding	Turbo
Channel type	SUI Channel

4 .1 Performance of SUI-1 channel :

When using channel estimation (LS) and channel estimation (MMSE) it can be shown that for BER=10^{-3} the SNR required for (MMSE) is about 2.925 dB while in (LS) the SNR about 3.6 dB from Figure 2 it is found that the when using (MMSE) outclasses significantly other scheme for this channel model. It be able to be concluded that the with (MMSE) is more important than the other schemes in this channel that have been assumed.

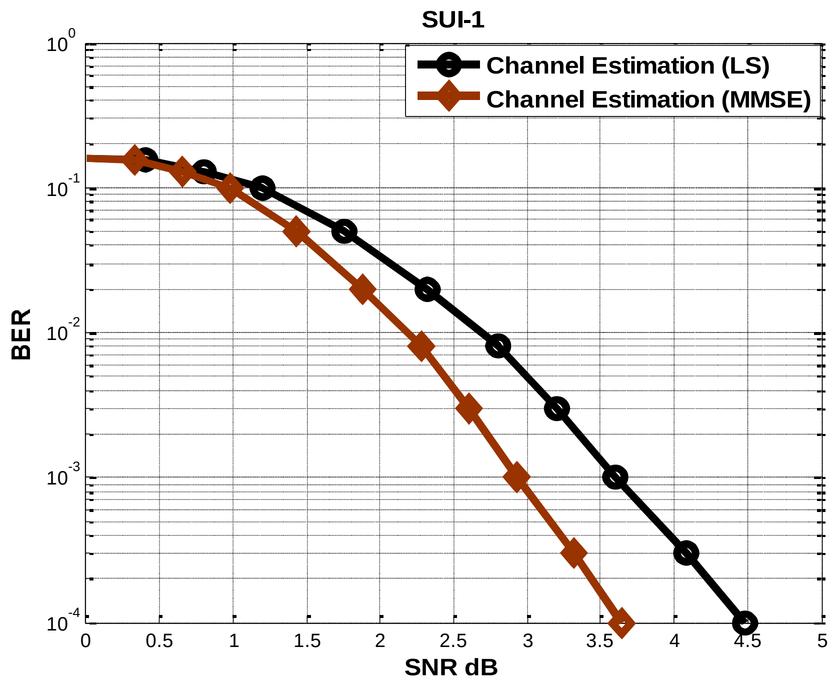

Figure (2): BER performance of the proposed LTE 3GPP Baseband Transceiver Based Multiwavelet Signals in SUI-1 channel model

4 .2 Performance of SUI-2 channel :

In this simulation case some powerful results were obtained. With channel estimation (LS) and channel estimation (MMSE) it can be realized that for BER=10^{-3} the SNR necessary for (MMSE) is about 4.95 dB though in (LS) the SNR about 5.85 dB from Figure 3 it is found that the when using (MMSE) outperforms significantly other scheme for this channel model. It can be concluded that the with (MMSE) is more important than the other systems in this channel that have been assumed.

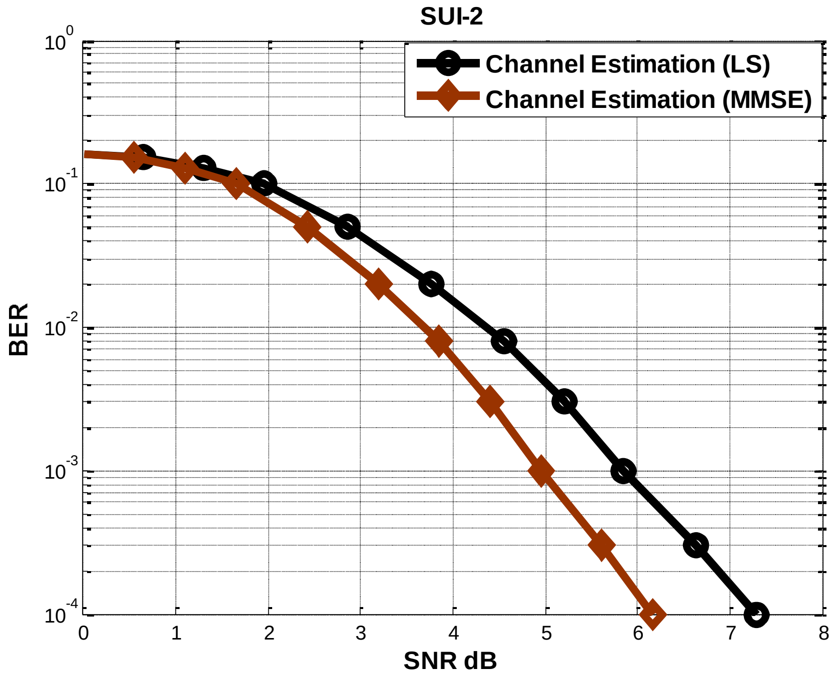

Figure (3): BER performance of the proposed LTE 3GPP Baseband Transceiver Based Multiwavelet Signals in SUI-2 channel model

4 .3 Performance of SUI-3 channel :

In the SUI-3 channel, the results are depicted in Figure 4 it can be shown that for BER=10^{-3} the SNR required for the LTE 3GPP baseband transceiver based multiwavelet signals when using (MMSE) is about 8.1 dB, while when using (LS) the SNR about 9 dB, from Figure 4 it is found that the transceiver when using (MMSE) outclasses significantly than other schemes for this channel model.

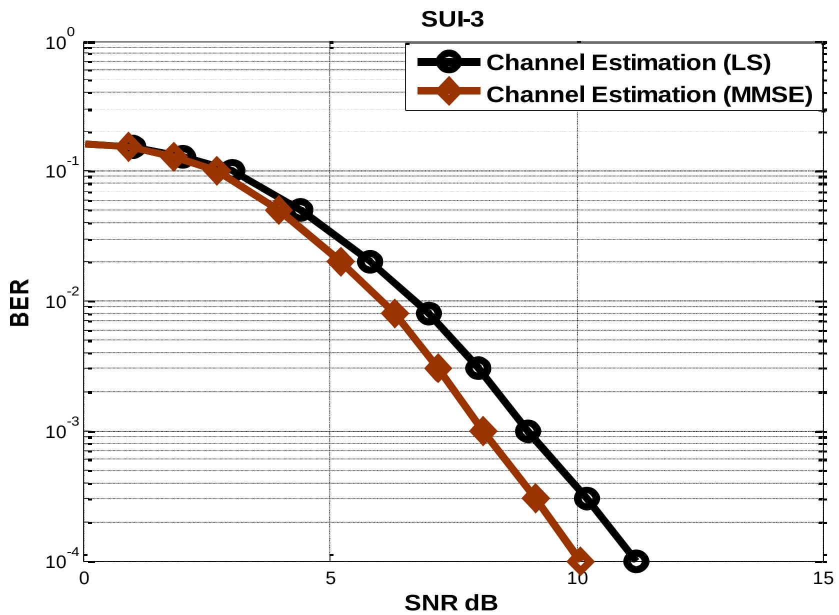

Figure (4): BER performance of the proposed LTE 3GPP Baseband Transceiver Based Multiwavelet Signals in SUI-3 channel model

4 .4 Performance of SUI-4 channel :

The simulations for SUI-4 channel the result shown in Figure 5 it can be shown that for BER=10^{-3} the SNR necessary for the scheme when using (MMSE) is about 11.7dB, while when using (LS) the SNR about 12.6dB. Also from Figure 5 it is found that the LTE 3GPP baseband transceiver based multiwavelet signals when using (MMSE) outclasses significantly than other systems for this channel model.

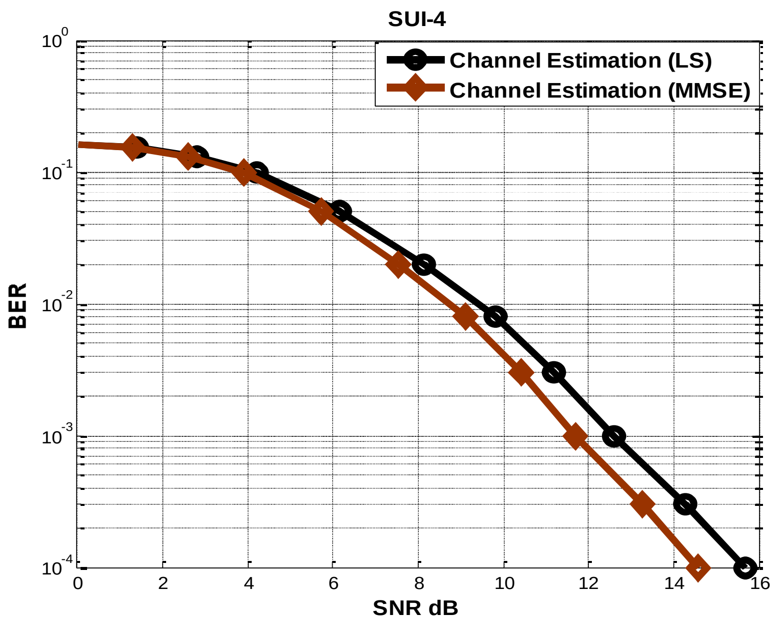

Figure (5): BER performance of the proposed LTE 3GPP Baseband Transceiver Based Multiwavelet Signals in SUI-4 channel model

4 .5 Performance of SUI-5 channel :

In this channel the system when using channel estimation (LS) and channel estimation (MMSE) it can be shown that for BER=10^{-3} the SNR necessary when using (MMSE) is about 14.63 dB though when using (LS) the SNR about 15.75 dB from Figure 6, it is found that the LTE 3GPP baseband transceiver based multiwavelet signals when using (MMSE) is best than other system for this channel model.

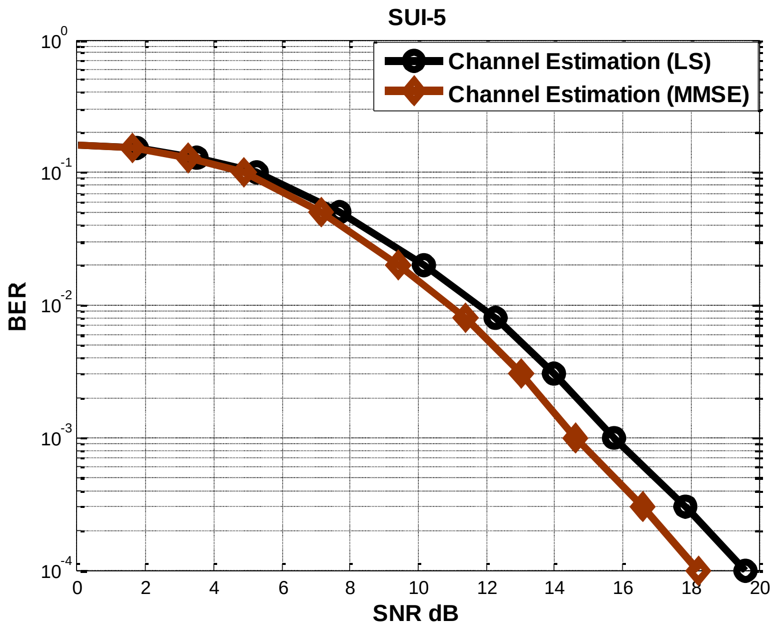

Figure (6): BER performance of the proposed LTE 3GPP Baseband Transceiver Based Multiwavelet Signals in SUI-5 channel model

4 .6 Performance of SUI-6 channel :

In this case, the results obtained were hopeful. The system When using channel estimation (LS) and channel estimation (MMSE) it can be seen that for BER=10^{-3} the SNR necessary for the system when using (MMSE) is about 19.35 dB though when using (LS) the SNR about 20.7 dB from Figure 7 it is found that the LTE 3GPP baseband transceiver based multiwavelet signals when using (MMSE) is improved than other scheme for this channel model

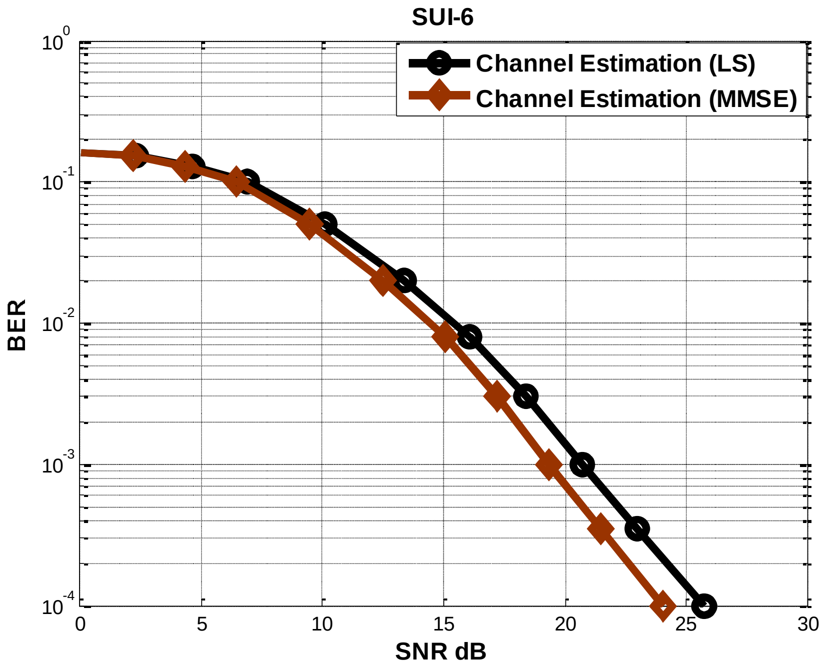

Figure (7): BER performance of the proposed LTE 3GPP Baseband Transceiver Based Multiwavelet Signals in SUI-6 channel model

A number of significant results can be taken from Table (2); In this simulation, in most situations, when using channel estimation (LS) and channel estimation (MMSE), user-channel characteristics under which wireless communications is tested or used have significant impact on the schemes overall performance. It became clear that SUI channels with larger delay spread are a bigger test to any system. The LTE 3GPP baseband transceiver based multiwavelet signals when using the channel estimation (MMSE) proved its efficiency in combating the multipath effect other than when using channel estimation (LS) on the SUI channel models.

Table (2): Comparison between results

Channel for BER= 10^{-3}	SUI-1 dB	SUI-2 dB	SUI-3 dB	SUI-4 dB	SUI-5 dB	SUI-6 dB
LS dB	3.6	5.85	9	12.6	15.75	20.7
MMSE dB	2.925	4.95	8.1	11.7	14.63	19.35

1. Conclusions :

In this paper, the simulations done with the MATLAB/Simulink software. The main role of this paper was the employment of the LTE 3GPP baseband transceiver based multiwavelet signals with channel estimation (MMSE) and (LS) was suggested, simulate and tested. Simulations delivered verified that suggested design using channel estimation (MMSE) attains much lower bit error rates and improved performance than channel estimation (LS). Proposed systems design is strong for SUI channels. From attained results in Table (2) it can be concluded, that SNR can be effectively increased using suggested channel estimation (MMSE) designed method.

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