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Channel Estimation in Mobile Wireless Systems & Comparisons Using Different Techniques

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***Abstract*— 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 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. The major advantage of the pilot sequences it allows high accuracy in wireless channel with simplicity. In dissertation the channel estimation in wireless channel and the comparison is done, the comparison is in between the different modulation technique is used and the estimation method is used at the receiver. In wireless communication the aim is to transmitted error free signal. The huge quantity of data/signal is transferred over the channel. The effect on data/signal caused due to the Doppler's effect and fading in mobile wireless, due to which the inter carrier interference and inter symbol interference is occurred in the signal which is transmitted. This ordinary difficulty occurs in the wireless system. The technique required to contest in multipath transmission to minimize the above difficulty. Orthogonal Frequency Division Multiplexing (OFDM) technique is used. The importance of the OFDM is the multi-carrier modulation which means the each signal/sub-carrier are modulated simultaneously and are overlapped to each other. The aim of the dissertation 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.**

***Index Terms*— Wireless Channel, Modulation BPSK, QPSK, 16 QAM, 64 QAM, LS and LMMSE method.**

I. Introduction

Channel estimation is an essential technique mainly used in wireless system. Due to the motion of the transmitter or receiver the wireless channel is change according to time. From the surrounding the communication between the transmitter and receiver is affected, the signal/data is not recovered accurately at the receiver. From the surrounding, such as the building, poles, hills and other obstacles, the signal is distorted which cause the interference in multipath signal. For the time-varying channel the highly precise channel estimation required at the receiver. The accuracy at the receiver is required more because it is main technology for the transmission of data such as data, voice and video etc. Such type of signal/data required high quality of service (QoS) at the receiver which is movable or mobile.

In channel estimation the Pilot Sequences are inserted in between the data/symbols which are transmitted [1]. The pilot sequences are the unique sequence or bits which are append in between the data/symbol and at the receiver the signal is recovered with help of the sequences which are transmitted, by using pilot sequences the accuracy of the system is improved. For the high data rate to support the multimedia transmission the Orthogonal Frequency Division Multiplexing (OFDM) technique is used. Figure 1 shows the channel estimation block diagram.

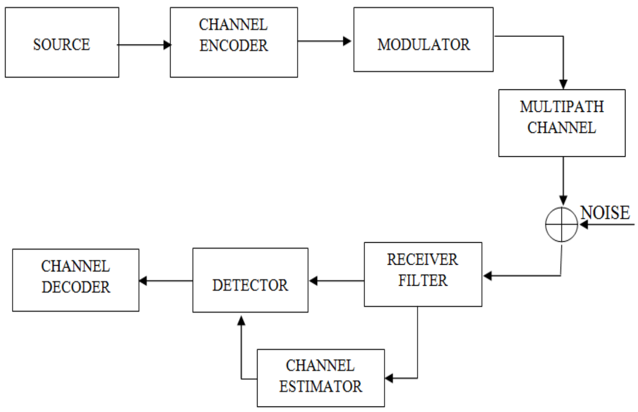

Figure 1 Block diagram of Channel Estimator

A. Orthogonal Frequency Division Multiplexing (OFDM)

In Orthogonal Frequency Division Multiplexing, the channel estimation is an important part of the OFDM and it is essential to empathize OFDM technology. For the high data rate transmission and to manage the multimedia services, in OFDM the high data rate accuracy can be achieved. The effect of the frequency-selective fading and narrowband interference of signal, which are transmitted over the wireless channel the effect of it can be avoid or minimize by using the OFDM technology. One of the advantageous characteristic of the OFDM is its robustness, were the inter-symbol-interference (ISI) and inter-carrier-interference (ICI) is induced in the multipath signals. The error correcting and diversity in OFDM is used for the

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minimization such above errors which occurred in the signal [2]-[4].

In Orthogonal Frequency Division Multiplexing the each signal/sub-carrier which are transmitted over the channel, are orthogonal to each other and they are overlapped to each other and they didn't interfere to each other, it is the main feature of the OFDM. The inter carrier interference (ICI) and inter symbol interference (ISI) is occurred in the signal, if there is no orthogonality in between the signal the signals are overlapped to each other and the data which is transmitted is lost. It is the vital technology of OFDM and it is used in many wireless standards. Figure 2 the concept of OFDM signal, in which the concept of saving the bandwidth is shown by using the OFDM.

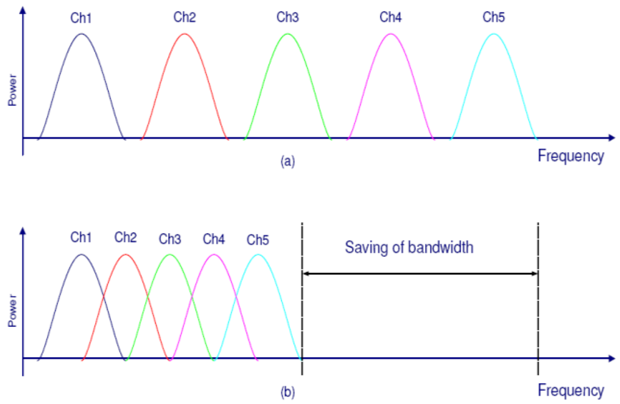

Figure 2 Concept of OFDM Signal: (a) conventional multicarrier technique (FDM) and (b) orthogonal frequency division multiplexing technique.

One of the important technique in the OFDM is the Multi-Carrier-Modulation technique, it is important because for the high rate of transmission the data bit stream is divided into N parallel data bit stream and this N parallel bit stream are modulated of N orthogonal sub-carrier. The each sub-carrier is orthogonal to each other and having the different frequency when they are transmitted by which the sub-carrier are didn't overlapped to each other. When the single carrier is transmitted, the signal is modulate by the single carrier an transmitted by doing this, the bandwidth required for the transmission is much greater in the basic communication system and by using OFDM the bandwidth required for the transmission is much lesser than the single carrier modulation, the bandwidth is save much more in OFDM. For making the OFDM more efficient the Fast Fourier Transformation (FFT) and Inverse Fast Fourier Transformation (IFFT) is applied to modulation and de-modulation of sub-carrier. The IFFT is implemented at the transmitted side in which the frequency domain signals are converted into time domain signal. FFT is implemented at the receiver side in which the time domain signal is again converted into frequency domain. The OFDM become more efficient by implementing the FFT. The main advantage of the OFDM is to achieve the high spectral efficiency and several flat fading channels by converting frequency selective fading channel [5-6]. In Figure 3 shows the spectrum of an OFDM signal in which each sub-channel are orthogonal to each other and the each having the same null-point so, they does not interfere to each other.

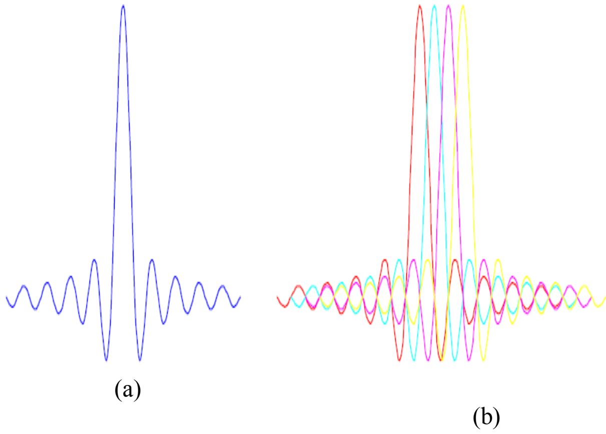

Figure 3 Spectra of an OFDM, (a) OFDM Sub-Channel (b) OFDM Symbol

In this paper the Least Square Method (LS) and Linear Minimum Mean Square Error Method (LMMSE) is used for the channel estimation and different modulation technique is used for the modulation such as BPSK, QPSK, 16 QAM and 64 QAM and the comparison of the estimation method and the modulation method is done.

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.

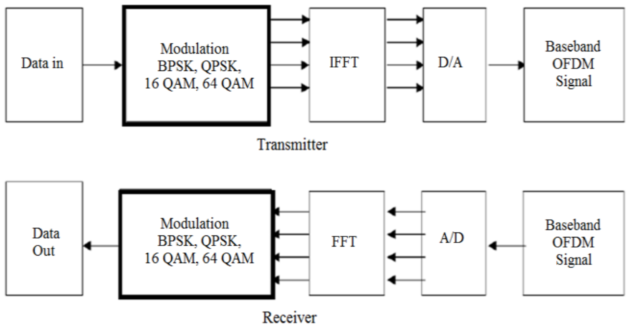

Figure 4: Block diagram of noise-corrupted LS Estimator

A. Channel Estimation

The estimation technique is preferred among many channel estimation technique. A modified and improved Linear Minimum Mean Square Error (LMMSE) and Least Square (LS) method is used. The channel estimation is designed on pilot sequence arrangement, shown in figure 5. In which the signal is received and estimated the error occurred in the signal.

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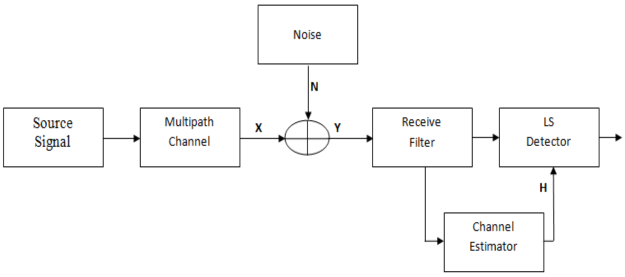

Figure 5: Block diagram of noise-corrupted LS Estimator

B. 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.

Step 1 For a transmitted signal:

1. Generate the random data.
2. Apply the modulation such as: BPSK, QPSK, 16QAM, 64QAM.
3. The modulated signal is converted as serial to parallel & Pilot signal is inserted.
4. After IFFT is performed (N=64).
5. Again parallel to serial conversion is done & Add Cyclic Prefix.
6. Finally the signal is converted into digital to analog , which represents as:

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

7. Where: N= Number of sub-carriers.

Step 2 The signal is transmitted and the Channel impulse response is:

$$h(n) = \frac{1}{\sqrt{N_P}}\sum_{p=0}^{N_P-1} \alpha_P e^{j\frac{2\pi}{N}f_{D_P}\delta(n-\tau_P)}$$

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

Step 3 The signal is received at the receiver is recovered by performing the inverse of the transmitted signal & performs the LS & LMMSE method.

The signal received by the convolution of the input signal and channel impulse response is:

$$y(n) = \frac{1}{N\sqrt{N_P}}\sum_{p=0}^{N_P-1} \alpha_P\, e^{j\frac{2\pi}{N}f_{D_P^n}} \sum_{i=0}^{N-1} d_i e^{j\frac{2\pi}{N}i(n-\tau_P)} + w(n)$$

Where, w (n) is additive white Gaussian noise (AWGN).

C. Least Square (LS) Method

Least square estimation is used to minimize the square distance between the received signal and the original signal. The least square estimates (LS) of the channel at the pilot subcarriers given by the following equation:

$$H_P^{LS} = (X_P)^{-1}\, Y_P$$

D. Linear Mean Minimum Square Error LMMSE

The LMMSE channel estimator is designed to minimize the estimation MSE. 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

III. RESULT ANALYSIS

The MATLAB/SIMULINK Communication tool box is used for implement the proposed model. In channel estimation technique, a modified and improved Linear Minimum Mean Square Error (LMMSE) and Least Square (LS) 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 inter symbol interferences is reduced and the estimation could improve the BER performance.

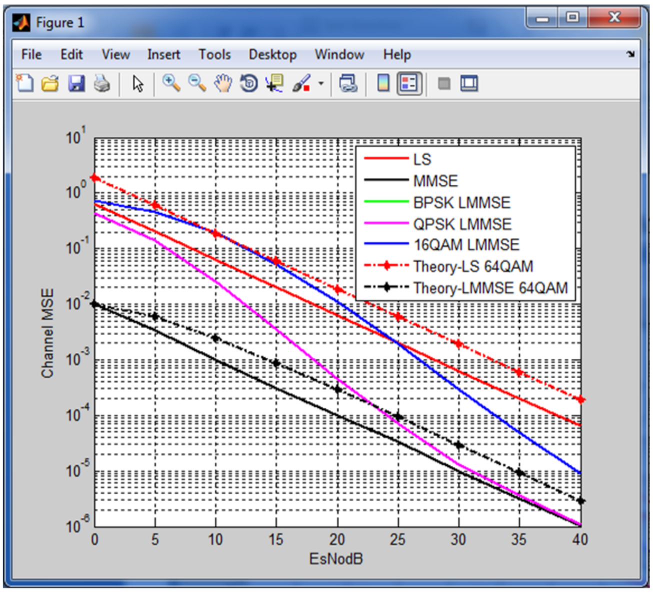

Figure 6: Comparison of BPSK, QPSK, QAM, LS, LMMSE Method

The Figure 6 is represents the comparisons of different method of modulation such as BPSK, QPSK, 16QAM, 64 QAM is used for improving the BER of the signal and estimation is done by using LS and LMMSE method. In which the BER is improved by using the 64 QAM and the signal is estimated by LMMSE as comparison to LS method. The table 1 shows the comparison in between the different modulation technique.

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SNR (dB)	BER (dB)			
	BPSK	QPSK	16 QAM	64 QAM
0	0.2042	0.1122	0.2951	0.0100
4	0.1120	0.0479	0.2512	0.0032
8	0.0148	0.0182	0.1479	0.0014
12	0.0018	0.0117	0.0200	5.623e-004
16	2.239e-004	0.0032	1.585e-004	1.413e-004
20	2.291e-005	0.0013	1.783e-005	3.162e-004

Table 1: Comparison of different modulation technique

In table 2 it represents the comparison result of the Least Square Method and Linear Minimum Mean Error Square Error Method in which the result of the LMMSE is better than the LS method.

SNR (dB)	BER (dB)	
	LS Method	LMMSE Method
0	0.316	0.0100
5	0.120	0.0016
10	0.0316	1.0000e-003
15	0.0126	1.5849e-004
20	0.0032	1.0000e-004
25	0.0012	1.5849e-005
30	3.1623e-004	1.0000e-005

Table 2: Comparison of LS and LMMSE Method

IV. CONCLUSION

In the channel estimation the OFDM transmission technique has emerged as a promising for high data rate and reliable 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 improved LMMSE is showing best optimized performance of the system for BER as well as SNR as compare theory. At the 10 dB of BER & SNR get the 98% of accuracy which is the main objective.

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