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ANALYSIS OF LS AND MMSE CHANNEL ESTIMATION TECHNIQUES UNDER VARYING MOBILITY FOR LTE DOWNLINK SYSTEM

D. MARIE JENIFER[1], Mrs. B. SHOBA[2]

[1,2]Department of Electronics and Communication Engineering,

Rajiv Gandhi College of Engineering and Technology, Puducherry, India

ABSTARCT

The Long Term Evolution (LTE) is the present extension of the third generation mobile communication system that produces high improvement in data rate, spectral efficiency and coverage. Since downlink is repeatedly an important factor in coverage and capacity feature, special observation has been given in choosing technologies for LTE downlink. Channel estimation is a main technique at receiver end in sequence to combat the reaction of noise or interference on the transmitted information. This project analyses two channel estimation techniques namely Least Square (LS) and Minimum Mean Square Error (MMSE) for LTE at low and high mobility conditions.

Keywords: LTE, Channel Estimation, LSE and MMSE

I. INTRODUCTION

Due to the ever growing need of wireless and mobile communication services, new standards have been introduced to warranty very high quality of service and data rates as well as spectral efficiency. Third Generation Partnership Project (3GPP) is Release 8. It promises data transfer rates of 100 Mbps. In addition, it also provides high spectral efficiency, coverage, speed and low latency.

LTE use two links uplink and downlink. Downlink data transmission uses Orthogonal Frequency Division Multiple Access (OFDMA) and uplink data transmission uses Single Carrier FDMA (SC-FDMA). Advantage of SC-FDMA is the low Peak to Average Power (PAP) ratio over OFDM. Requirements for LTE are Peak data rate, 100 Mbps for Downlink and 50 Mbps for Uplink within 20 MHZ bandwidth.

LTE Downlink uses physical signals and physical channels. Physical signals are Reference signals and synchronization signals. Reference Signals represent channel estimation and Synchronization Signals represent cell detection, timing and frequency offset estimation. Many types of physical channels are used. Mainly used are Physical Downlink Shared Channels (PDSCH), Physical Broadcast Channel (PBCH), Physical Control Format Indicator Channel (PCFICH) and Physical Downlink Control Channel (PDCCH).

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II. SYSTEM MODEL

A) LTE Downlink Reference Signal Structure

In LTE downlink structure, one radio frame consists of 20 sub frames, where each such frame is divided into two slots [5]. Each slot has 7 OFDM symbols in normal cyclic prefix (CP). The number of subcarriers in each OFDM symbol depends on the number of resource blocks used. A physical resource block is defined as N_{symb}^{DL} consecutive OFDM symbols in the time domain and N_{SC}^{RB} consecutive subcarriers of 15 KHz each in the frequency domain. A physical resource block thus consists of N_{symb}^{DL} x N_{SC}^{RB} resource elements, corresponding to one slot in the time domain and 180 KHz in the frequency domain [5].

Resource elements used for reference signal transmission on any of the antenna ports in a slot shall not be used for any transmission on any other antenna port in the same slot and set to zero. Fig 1 illustrates the resource elements used for reference signal transmission according to the above definition in one sub frame with 12 subcarriers. The notation R_0 is used to denote a resource element used for reference signal transmission [10].

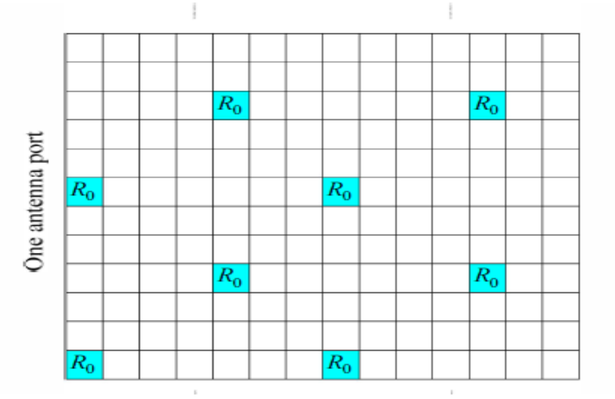

Fig 1 Mapping of LTE Downlink Reference Signals

B) LTE Frame Structures

LTE frame structures are classified as Type 1 and Type2. Type 1 frame structure is relevant to FDD and Half duplex FDD and optimized to coexist with 3.8 Mcps UTRA systems. A type 2 frame structure is applicable to TDD and supports both 5 ms and 10 ms downlink to uplink switch point tendency to recur at intervals. For 5 ms switch periodicity to special sub frame exists in both half frames and 10 ms special sub frame exists in the first half only.

Switching points has 1 ms sub frame consisting of DWPTS, UPPTS and GP. Base station synchronization is achieved by FDD (Asynchronous/ Synchronization) and TDD (Synchronous).

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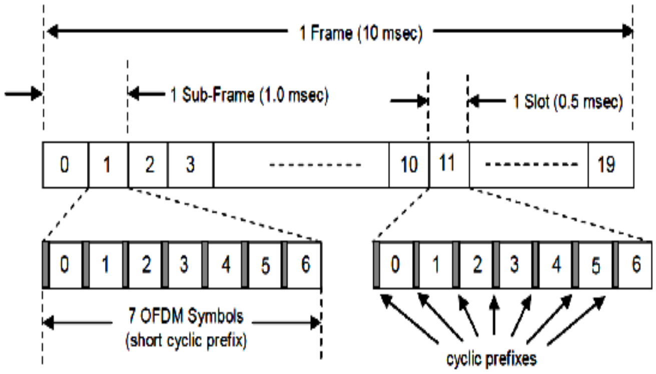

Fig. 2 LTE frame structure

c) Physical Resource Element

Resource grid

- Resource Block (RB) is 12 Subcarriers
- Subcarrier Spacing is 15KHz / 7.5 KHz
- Number of symbols / slots is 7(NCP), 6(ECP).

Ch.BW (MHZ)	1.4	3	5	10	15	20
RB	6	15	25	50	75	100

Table 1 Bandwidth Vs RB

Resource Element Groups (REG)

- Basic RE mapping for downlink control information
- Mapping in the first slot in a sub frame
- 1 OFDM Symbol:
    - 2 REG (K= 0…5, K= 6..11)
- 2 OFDM Symbol:
    - 3 REG (K= 0…3, 4..7, 8..11).

III. CHANNEL ESTIMATION

Channel Estimation is most important part of the system. The LS channel estimator is used in calculating the channel estimates from pilot symbols. The received signal vector is transformed into frequency domain before the LS channel estimation. The LS channel estimate can be filtered with an MMSE filter. The channel impulse response result from the LS or MMSE estimator has to be transformed into frequency domain for the detector with the second fast Fourier transform (FFT).

Cell Specific Reference Signal Generation is

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$$\eta_{l,n_s} = \frac{1}{\sqrt{2}}\left(1 - 2.c(2m)\right) + j\frac{1}{\sqrt{2}}\left(1 - 2.c(2m+1)\right)$$

$$m = 0,1,\ldots,2N_{RB}^{max,DL} - 1, \quad (1)$$

where n_s is slot number within a radio frame and l is OFDM symbol number within a slot, c(i) is pseudorandom sequence with

$$C_{init} = 2^{10}.(7.(n_s+1) + l + 1).(2.N_{ID}^{cell} + 1) + 2.N_{ID}^{cell} + N_{CP} \quad (2)$$

$$N_{CP} = \begin{cases} 1 \; for\ normal\ cp \\ 0 \; for\ extended\ cp \end{cases}$$

N_ID_1= 0 to 167 Physical Layer Identity Group and N_ID_2 = Physical Layer Identity

UE Specific Reference Signal Generation is

$$r(m) = \frac{1}{\sqrt{2}}\left(1 - 2.c(2m)\right) + j\frac{1}{\sqrt{2}}\left(1 - 2.c(2m+1)\right), \quad (3)$$

$$m = 0,1,\ldots,12N_{RB}^{PDSCH} - 1$$

where N_{RB}^{PDSCH} is bandwidth in resource blocks corresponds to PDSCH transmission and c(i) is pseudorandom chain with

$$c_{init} = \left(\left\lfloor\frac{n_s}{2}\right\rfloor + 1\right).(2N_{ID}^{cell} + 1).2^{16} + n_{RNTI} \quad (4)$$

A) Channel estimation techniques for LTE Downlink system

Two techniques of channel estimation is Least Square Error and Minimum Mean Square Error. LSE procedure is easy to implement but has high BER and MMSE procedure is highly complex but has low BER.

- Least square

Least square is the lowest distance linking the received signal and original signal. This estimation procedure is simple and easy to implement.

The least square channel estimator for subcarriers on which pilot symbols is given by[9]

$$\widetilde{H}_{P.Ls} = X_P^{-1} Y_P \quad (5)$$

Where $\widetilde{H}_{p,Ls}$ is LS estimation channel frequency response, X_p^{-1} is transmitted symbols and y_p is received symbols

- Minimum Mean Square Error

The MMSE channel estimator is designed to minimize the estimation MSE. The MMSE channel estimation employs the channel statistics is given by[3]

$$H_P^{MMSE=} R_{HH_P}\left(R_{H_PH_P} + \sigma_\mu^2 (XX^H)^{-1}\widetilde{H}_{P,Ls}\right. \quad (6)$$

Where R_{HHP} cross correlation matrix between all subcarriers and the subcarriers with reference signals and $R_{H_PH_P}$ is autocorrelation matrix of the subcarriers with reference signals. .The high complexity of MMSE estimator (6) is due to the inversion matrix lemma. Every time data changes, inversion is needed. The complexity of this estimator can be reduced by averaging the transmitted data.

IV. SIMULATION RESULTS

The performance of LS and MMSE channel estimators are simulated in terms of Bit Error Rate (BER) and Signal-to-Noise Ratio (SNR) for Rayleigh fading with mobility.

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PARAMETER	VALUE
Bandwidth	20MHz
Number of subcarriers	2048
Subcarrier spacing	15KHz
Number of RB	10
Modulation scheme	QPSK, 16 -QAM
Channel model	Rayleigh

Table 2 Simulation Parameter

Fig 3 shows the simulation plot of BER Vs SNR for LS and MMSE channel estimation techniques. It is seen that channel estimation at low mobility is better than high mobility.

Fig 4 shows the simulation plot of BER Vs SNR for LS and MMSE channel estimation technique under the effect of Rayleigh fading. It is seen that BER performance of LS and MMSE channel estimation for high mobility is better than low mobility, but computationally LS is less complex compared to MMSE. This estimation procedure is simple and easy to implement. But it has high bit error rate. MMSE gives less BER compared to LS, hence it is better technique. But it has higher computational complexity.

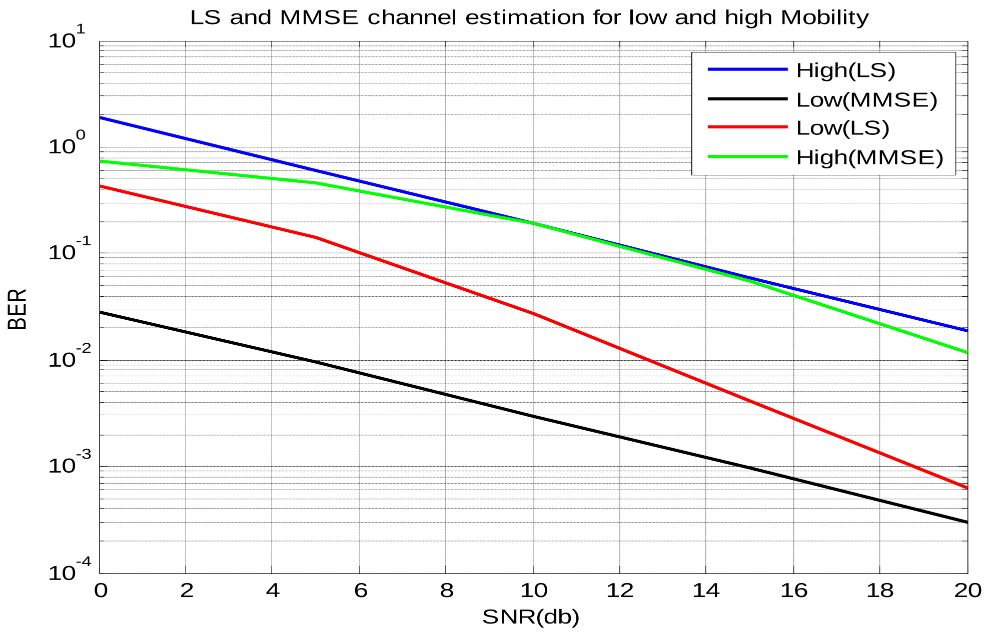

Fig 3 BER vs SNR plot of LS and MMSE Channel Estimation (QPSK)

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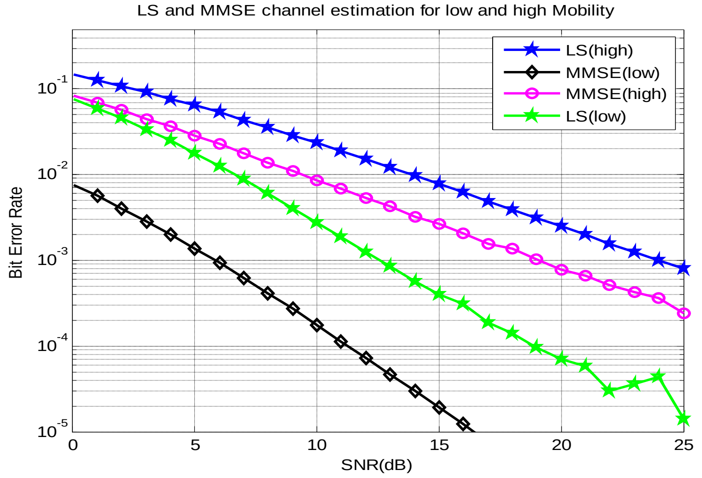

Fig 4 BER vs SNR plot of LS and MMSE Channel Estimation(16-QAM)

V. CONCLUSION

LTE downlink channel is estimated under Rayleigh fading by using LS and MMSE estimation techniques under low and high mobility. From the simulation results, it is concluded that MMSE gives less BER compared to LS for fading channel and also for with mobility. LS is simple technique, whereas MMSE is complex because it includes auto correlation and cross correlation functions. Channel Estimation technique offers a considerable improvement of the performance of Downlink LTE system. It makes the estimation more efficient and reduces the complexity of transceiver.

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