ANALYSIS OF COMPARATIVE PERFORMANCE OF CHANNEL ESTIMATION IN LTE+ SYSTEMS

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ABSTRACT

Estimation of the channel is carried out to analyze channel impairments on signal by either imparting pilot tones in to all of the OFDM symbols with the defined period or pilot tones will be inserted into every OFDM symbols. The consideration of slow fading channel has been done to develop the pilot channel-based block estimation. The Inter symbol interference is the effect of extension of channel impulse response over multiple symbol periods which is resulted due to high bit rate data transmission. For mitigating the ISI, multiuser systems implementation with various channels like AWGN, Rayleigh's channel environment has been presented in the paper. The results obtained shows that DDCE channel estimation with 4-QAM modulated data gives better SER performance improved by 6.6%. Similarly BER analysis of soft decision coded data proves to be efficient as compared with hard decision coded data. In case of channel tap parameter variation also the MMSE estimation proves to be better than the LSE estimation.

Keywords: *Digital Communication, Time Domain Analysis, Time-Varying Channels*

Introduction

Multiuser techniques has been much used in wireless systems because of its high bandwidth performance data rate transfer capability and its robustness to delay offered by the multipath effect in wireless communication systems. Its usage is found out in various wireless LAN protocols such as the American IEEE802.11a and the European HIPERLAN/2 counterpart, and in wireless multimedia networks such as Japanese Broadband Access Networking Multimedia. Before the demodulation of transmitted signal, a dynamic channel approximation is expected as the radio channel is frequency-selective and time varying for wideband mobile communication systems [1]. Channel calculation can be done either by injecting pilot frequencies into all modulated symbol subcarriers for a given time or by inserting pilot tones into each Modulated symbol.

Channel calculation can be done either by injecting pilot tones into symbol subcarriers for a given time or by introducing pilot frequencies into each Symbol duration. Under the hypothesis of a slow fading channel, the first one, the block style pilot channel estimate, was developed. Also with the equalizer of decision feedback, this means that the role of channel transfer does not change very easily. The channel estimation may be based on Least Square (LS) or Minimal Mean-Square (MMSE) for this block-type pilot arrangement. For the same mean square error of channel estimation over LS estimation, the MMSE approximation shown to provide 10-15 dB gain in signal-to noise ratio (SNR)[2]. In [3], a low-rank approximation is extended to linear MMSE while using the channel's frequency similarity to eliminate the important complexity disadvantage of MMSE. The other, pilot channel estimation based on combo type, is already initiated to fulfill its need for equalizing when another channel change even in one OFDM block.

The comb-type pilot channel estimation comprises of methodologies to approximate the channel at pilot frequency bands and to interpolate the channel. For comb-type based channel approximation, the estimation of the channel at the pilot frequencies may be based on LS, MMSE or Least Mean Square (LMS). It has been shown that MMSE does even better than LS. We've also implemented the equalizer of decision feedback for all sub-channels, followed by regular pilots of the block type. We by measuring bit error rate, the performances of all systems have been compared by having modulation schemes as 16QAM, QPSK, DQPSK and BPSK in multipath fading of Rayleigh and fading based AR channels as channel models. Section II describes the Multiuser system based on channel estimation implanting the pilot tones estimation schemes. In section III, pilot arrangement in the block type channel approximation is presented. In section IV estimation scheme of channel at pilot tones is addressed. Section V addresses and represents the simulation results while section VI presents the conclusion.

System Model

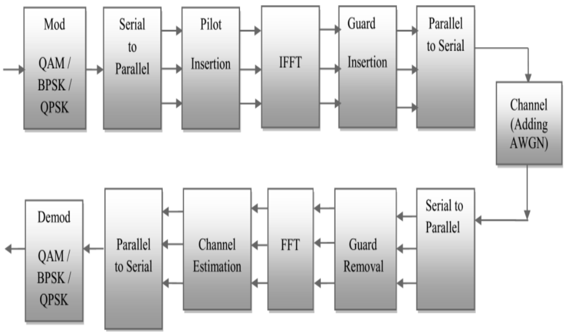

Figure 1: Multiuser system model

The transmitted signal gets mirrored from various objects in a wireless multipath environment. Several delayed versions of the transmitted signal will be seen at the receiver at various times as a consequence. This creates a distortion of the received signal. We may start using a cyclic prefix to remove the influence of inter symbol interference if just the first few specimens of the symbol are distorted. In all the zero samples transmitted next to each OFDM symbol, the cyclic prefix will be present. It does not provide any valuable information; the receiver will discard it. The duration of the reference signal should be greater than the time period of the channel, so that it does not distort the OFDM symbol themselves. Thus the results of inter symbol interference can be eliminated by removing the guard interval. Baseband OFDM model used is presented in figure 1. The value of cyclic prefix is kept longer as compared to the maximum propagation delay. It helps in maintaining the subcarrier orthogonality and absence of inter symbol interference [6]. In the system number of subcarriers used are K while L multipaths are present. The signal at the receiver is gained as:

$$\mathbf{Y = XH + N}$$

where X is K x Kmatrix. At the diagonal places of X, the transmitted signal is placed. The received signal vector is of size $K\times 1$ and N is a vector of independent identically distributed complex Gaussian noise. It is having zero mean and variance. This matrix is not at all related with channel matrix H. In this paper the Rayleigh's fading channel consideration is done. This channel is characterized by

$$h(\tau) = \sum_{i=0}^{L-1} \alpha_i \, \delta(\tau - \tau_i)$$

where τindicates the time delays of the various paths and L gives the value of number of paths. The transmitted data can be regained only if the synchronization is perfect. To obtain this, an assumption has to be made is that cyclic prefix is always larger than the assumption that the cyclic prefix is longer than the channel maximum excess delay.

Channel estimation methods

Here, we explain the channel estimation methods as follows

Least square estimator

The least square estimated channel[6] can be defined as

$$\hat{H}_{LS} = \arg\left\{\min\left\{\left(Y - \hat{H}_{LS}\right)\right\}.H\left(Y - X\,\hat{H}_{LS}\right)\right\}$$

where $\hat{H}_{LS}$representing the estimation of channel based on LS estimation.
Hence,

$$\hat{H}_{LS} = \frac{Y}{X} = H + \frac{N}{X}$$

As this algorithm is not considering any of the statistical parameters related to the channel as it is contaminated by noise, so it is the simplest algorithm. As it is contaminated by noise and not considering any channel statistical algorithms, its performance is worst.

Minimum mean square estimator(MMSE)

The MMSE estimate of the channel[7] is presented in the above equations as

$$\hat{H}_{MMSE} = F\,\hat{h}_{MMSE} = FR_{hy}R_{YY}^{-1}Y$$

where

$$R_{hy} = E\left[hY^H\right] = R_{hh}F^H X^H$$

$$R_{yy} = E\left[YY^H\right] = XFR_{hh}F^H X^H + \sigma_n^2 I_N$$

$$\hat{H}_{MMSE} = FR_{hh}F^H X^H \left(XFR_{hh}F^H X^H + \sigma_N^2 I_N\right)^{-1} Y$$

$$R_{hh} = E\left[hh^H\right]$$

where $R_{hh} = E\left[hh^H\right]$ is the channel's auto correlation matrix. The noise variance is given by σ_N^2. The DFT matrix is given by,

$$F = \left[W_K^{nk}\right] = \frac{1}{\sqrt{K}} e^{-j2\pi\frac{nk}{K}}$$

Linear Minimum Mean Square Error (LMMSE)

Application of Wiener–Hof equation is used to obtain the mean square error between actual and approximated channels. And by using this LMMSE based channel estimation [1], it is tried to minimize this mean square error.

$$h_{LMMSE} = R_{hy} R_{YY}^{-1} Y$$

whereR_{hy} gives cross-correlation matrix as

$$R_{hY} = E\left[hY^H\right] = R_{hh} X^H$$

The received signal autocorrelation is given by

$$R_{YY} = E\left[YY^H\right] = XR_{hh}X^H + \sigma_N^2 I$$

The estimation value based on the LMMSE is given by

$$h_{LMMSE} = R_{hh}\left[\left\{R_{hh} + \sigma_N^2\left(XX^H\right)^{-1}\right\}\right]^{-1} h_{LS}$$

Awareness of the channel frequency correlatio n and the operational SNR is needed for LMM SE channel estimation. The inverted matrix for accurate calculation can be adjusted as the runn ing SNR differs. From this point of view, the c alculation of the LMMSE channel requires mat rix inversion and multiplication in an effective implementation.

Decision Directed Channel Estimation (DDCE)

Training symbols adaptations done for CE and the re-modulated Symbols which are detected [10,11,12]. The CE of previous symbols is used in these CE schemes to detect data from recent projections, during which the newly detected data is used to estimate the current channel. Data identification in DDCE can be accomplished either by hard or soft decision making. Where bitwise detection for soft decision is taken and a particular constellation is compelled for hard decision[13]. An MSE term for M-ary phase shift keying (MPSK) DFT based DDCE schemes for the LTE-downlink system is proposed in[14]. The simulation findings from this system are contrasted with realistic systems based on downlink criteria for long-term evolution-advanced (LTE-A). In addition, a new soft DDCE technique is proposed in[15], which estimates the channel of interfering signals dependent on demodulation reference signal (DM-RS) utilising virtual pilot signals (VPS) for multiuser MIMO-OFDM. Reliable data tones are selected from the required and interfering signals as VPS in this algorithm, after which CE efficiency is increased by using the iterative detection and decoding (IDD) system. The proposed algorithm demonstrates superior efficiency improvements for both SUD and MUD over traditional methods that implement either single user detection (SUD) or multiuser detection (MUD), such as traditional MMSE. It should be remembered that there are many pilot-based (or non blind) CE techniques of captivatingresults.

Results and Conclusions

Simulations of MATLAB were performed to test the OFDM device efficiency. Various parameters are listed in this discussion those are considered for the system implementation. The system performance was analysed based on various parameter changes and in following subsections those are presented.

A. Decision Directed Channel estimation Performance analysis

The SER vs SNR performance of the DDCE algorithm with the m- QAM modulation method changes is shown in the Figure 2 to 7.

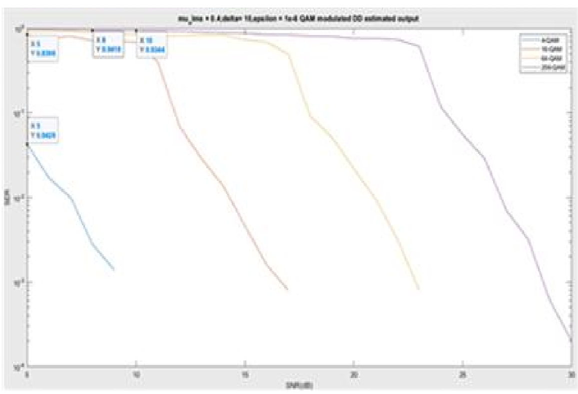

Figure 2: DDCE performance with stepsize of 0.4 with m-QAM modulations

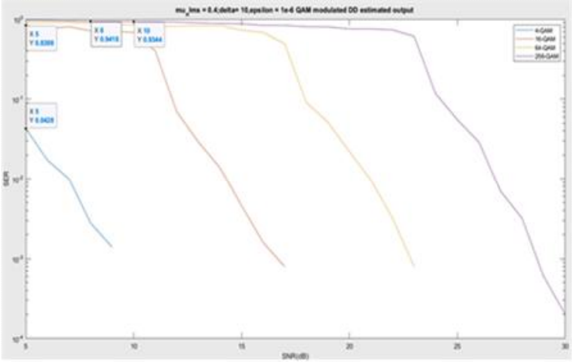

Figure 3: DDCE performance with stepsize of 0.4 with changed delta & m-QAM modulations

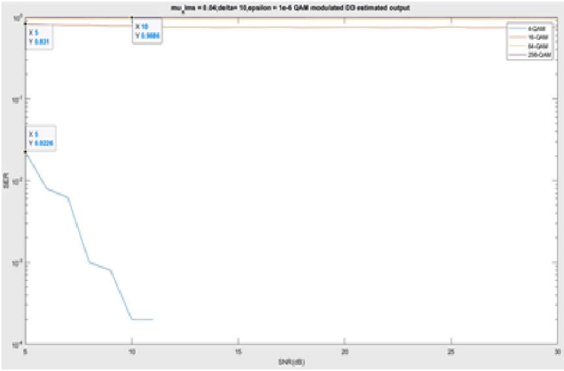

Figure 4: DDCE performance with stepsize of 0.04 with m-QAM modulations

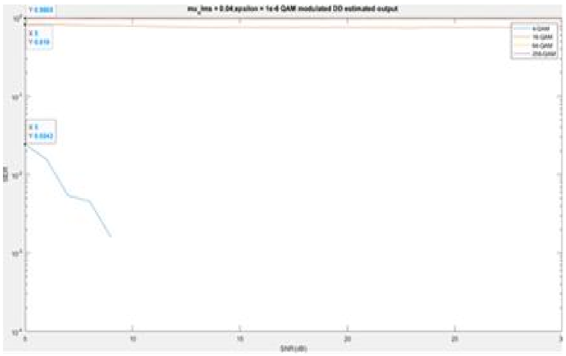

Figure 5: DDCE performance with stepsize of 0.04 with changed delta & m-QAM modulations

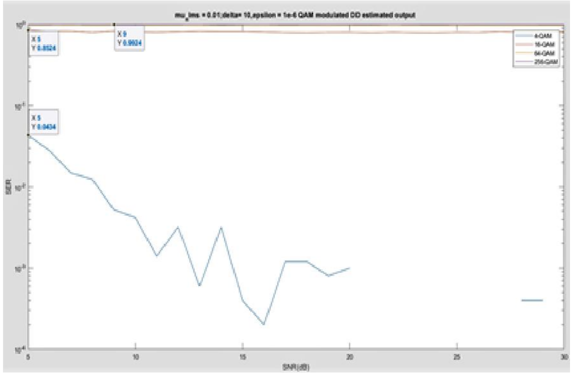

Figure 6 : DDCE performance with step size of 0.01 with m-QAM modulations

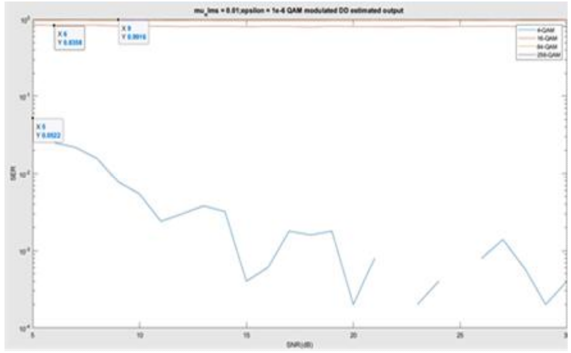

Figure 7: DDCE performance with stepsize of 0.01 with changed delta & m-QAM modulations

And its comparative result analysis is provided in table 1 below. From table 1 it can be commented that for higher modulation order the consistent estimation performance is seen. As m-order increases for modulation process, the SER value also increases irrespective of LMS step size or delay parameter changes. With specific modulation order, if step size decreases automatically the SER value decreases. In this system irrespective of the step changes, for 4 QAM based system shows 6.6% improvement and for all higher order modulation based system, performance is increased by 0.88%.

System	Parameter changed	4QAM	16QAM	64QAM	256QAM
Mu_lms=0.4, epsilon= 1e-6	Delta= 15	0.0418	0.8028	0.9078	0.9502
	Delta= 10	0.0428	0.8398	0.9418	0.9344
Mu_lms=0.04 epsilon= 1e-6	Delta= 15	0.0242	0.819	0.9868	-
	Delta= 10	0.0226	0.831	0.9881	-
Mu_lms=0.01 epsilon= 1e-6	Delta= 15	0.0522	0.8358	0.9916	-
	Delta= 10	0.0434	0.8524	0.9924	-

Table 1: SER variation observed at SNR=5db with delay and stepsize change parameter w.r.t. m-QAM system DD estimation output

B) BER estimate performance for hard decision and soft decision Viterbi decoders in AWGN and Rayleigh channel

During this implementation the system parameters used were M-QAM modulation, number of Symbols Per Frame were 1000. Trelliscode[171] [133]coding was used with the test data length=32 and coding rate of rate = ½. The obtained results are presented from figure 8 to 13 and summarised in table 2 presented below.

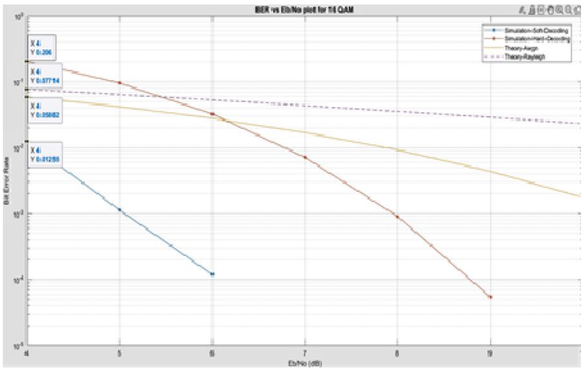

Figure 8: BER vs Eb/No for 16 QAM

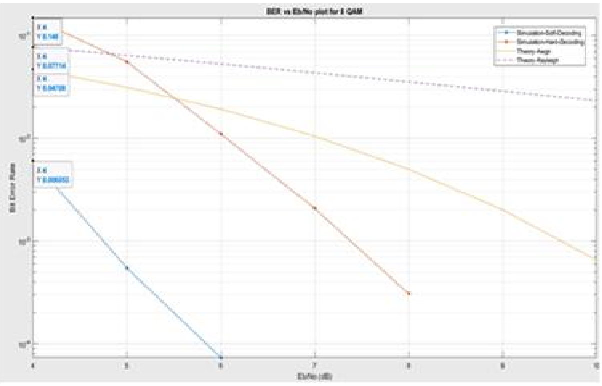

Figure 9: BER vs Eb/No for 8 QAM

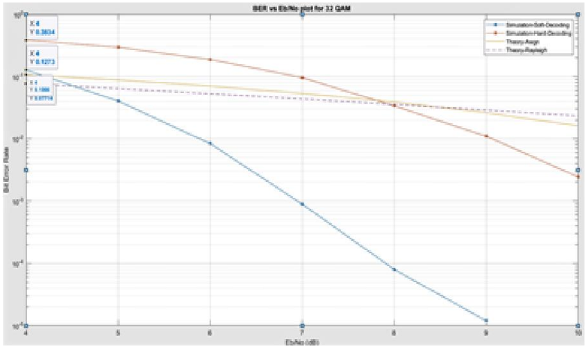

Figure 10: BER vs Eb/No for 32 QAM

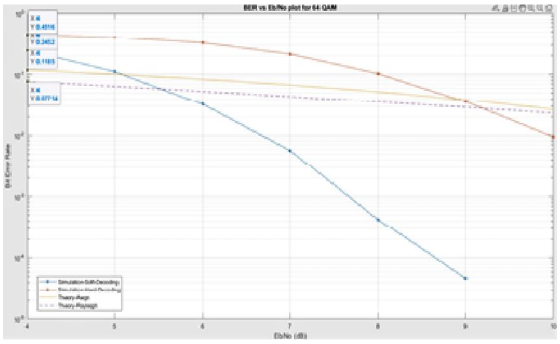

Figure 11: BER vs Eb/No for 64 QAM

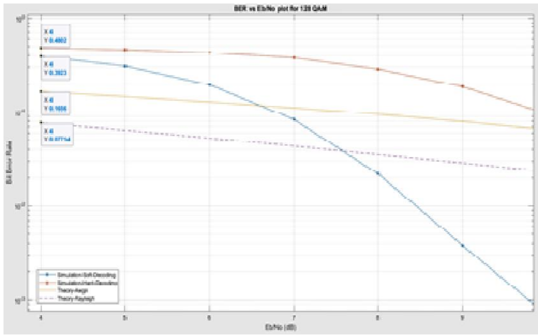

Figure 12: BER vs Eb/No for 128 QAM

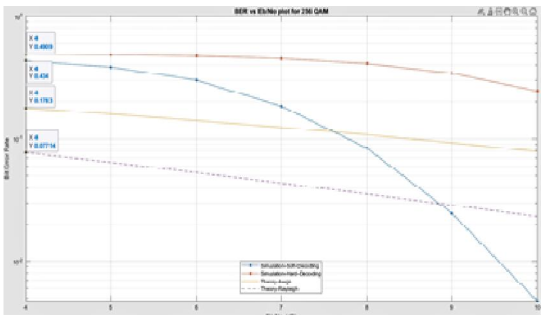

Figure 13: BER vs Eb/No for 256 QAM

	8QAM	16QAM	32QAM	64QAM	128_QAM	256QAM
Harddecision	0.148	0.206	0.38	0.45	0.39	0.49
Soft decision	0.0060	0.01255	0.1273	0.24	0.48	0.43
AWGN	0.047	0.058	0.1066	0.11	0.16	0.17
Rayleigh	0.077	0.077	0.077	0.077	0.077	0.077

Table 2: BER Vs Eb/N0 plot with Eb/N0=4db with different estimation methods

Comparative result analysis of the table 2 is presented in next statements If hard decoding estimation as compared to other estimation methods the BER value associated with any modulation method is greater. In case of soft decoding estimation as compared to other estimation methods the BER value associated with any modulation method is smallest. Rayleigh's channel based BER estimation is constant eventhough modulation order is changed. AWGN channel based BER estimation go on increasing with the modulation order increases. So SOFT decoding BER estimation proves to be more efficient.

C) LS and the MMSE estimators performances comparison based on the channel tappings variation

Due to the channel delay changes also the estimation gets hampered. The effect of channel tap i.e. delay element changes has been presented in figure 14 to 17. The result summarization is done in following statements.

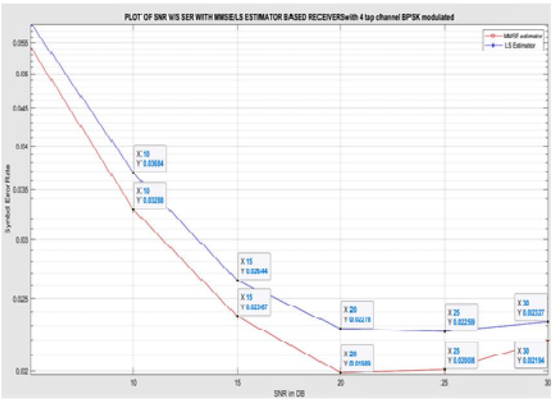

Figure 14: SER vs SNR plot of 4 tap, BPSK modulated data

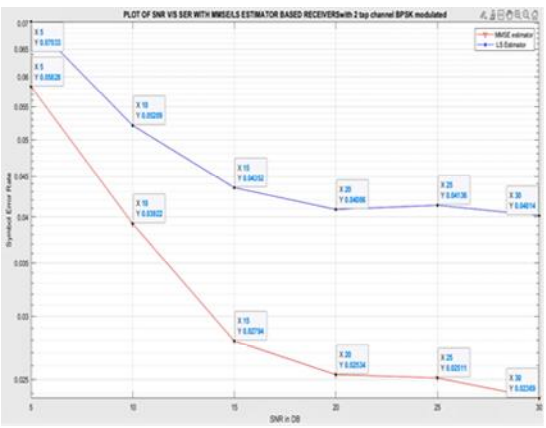

Figure 15: SER vs SNR plot of 2 tap, BPSK modulated data

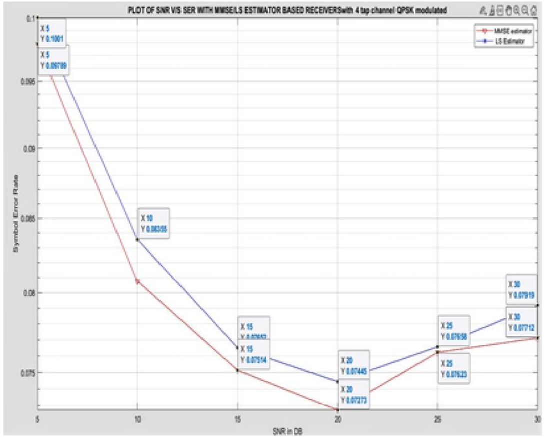

Figure 16: SER vs SNR plot of 4 tap, BPSK modulated data

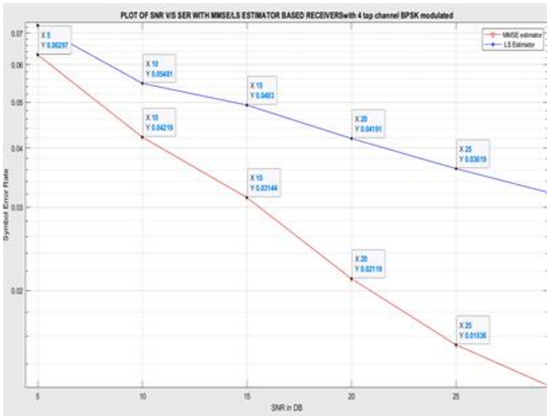

Figure 17: SER vs SNR plot of 4 tap, BPSK modulated data

SNR vs SER plot with MMSE/LSE estimator-based receivers with 4 tap channel and BPSK modulated data shows that MMSE estimator outperforms the LSE estimator. The SER value obtained for MMSE/LSE are nearly same throughout the SNR range. But for BPSK 2 tap channel system exhibits that in higher SNR region, SER values of MMSE/ LSE varies widely. But here also MMSE outperforms the LSE. In the system of 4-tap QPSK, The SER value obtained for MMSE/LSE are nearly same throughout the SNR range. But 4 tap BPSK systems, exhibits that in higher SNR region, SER values of MMSE/ LSE varies widely. But here also MMSE outperforms the LSE.

Conclusions

The key aim of this study is to test various methods of channel estimation for LTE downlink systems under different conditions of the channel. By way of simulations, we have presented the experimental findings. For high SNR values, the LS estimator is computer simple and efficient. Higher constellation mapping at high smartphone speeds will degrade its performance. For higher modulation systems and large delay ranges, the MMSE estimator may be a safer approach. Minimum square mean square error (MMSE), Linear Minimum Mean Square Error (LMMSE), proposed method, are used for the channel approximation. The application of the suggested approach is closed to the standard estimation methods. As it uses the channel autocorrelation matrix and the noise variation that was calculated in the LMMSE algorithm, to the optimal LMMSE approximation and higher than the LS. At high SNR, suggested method efficiency is much more correct. It helps in reducing MSE and BER both.

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