

for slow fading channels while comb-type is best suited for fast fading channels. Arrangement of pilots for comb-type and block-type channel estimation is shown in fig.2. A comb-type channel estimation has been used because of the use of the fast fading Rayleigh channel for performance analysis of the OFDM system. Equi-spaced pilot insertion is adopted because of optimum performance. The channel frequency response at pilot subcarrier is estimated by using MMSE estimator because of its superior performance as compared to least square (LS) estimator.

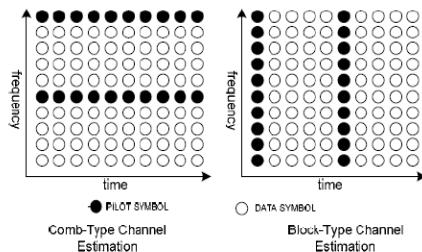


Figure 2: Arrangement of Pilots

A. Channel Estimation at Pilot Frequencies

In comb-type pilot based channel estimation, the pilot signals are uniformly inserted into $X(k)$ according to the following equation:

$$X(k) = X(mL+l)$$

$$= \begin{cases} x_p(m), l = 0 \\ \text{inf data } l = 1, \dots, L-1 \end{cases}$$

Since LS estimate is susceptible to noise and ICI, MMSE is thought about while compromising complexity. Since MMSE includes the matrix inversion at each iteration, the simplified linear MMSE estimator is suggested in. In this simplified version, the inverse is only need to be calculated once. In [13], the complexity is further reduced with a low-rank approximation by using singular value decomposition.

B. LS Estimator

The LS estimator for the cyclic impulse response g minimizes

$$(x F g) (y - x F g)^H$$

and generates the channel attenuation as bellow

$$h_{LS} = F Q_{LS} F^H x^H y$$

$$Q_{LS} = (F^H x^H F x)^{-1} \text{ and } (y - x F g)^{(H)}$$

are the conjugate transpose operations. Hence,

$$h_{LS} = x^{-1} y$$

where h_{LS} is the channel attenuation for LS

4. Proposed Interpolation Technique

The proposed interpolation technique is based on reduction of the interpolation error and channel noise associated with LS estimation. The LS estimator does not consider the channel noise during the estimation process and thus, its performance degrades. The conceptual view of the LS estimator is illustrated in Fig. 3. The nature of the Rayleigh fading channel in time domain is concentrated while distributed in frequency domain. The sample spaced channel has all the fading impulses at integer multiples of the system sampling rate and there is no energy leakage between the channel taps. The distribution of channel energy in time domain and frequency domain is shown in Fig. 4. The channel frequency response computed at data subcarriers by using 1-D interpolation techniques is subject to interpolation error.

The proposed interpolation technique illustrated in Fig. 5 consists of the following steps:

- Interpolate the channel frequency response estimate by LS estimator at the pilot subcarriers using one dimensional interpolation technique and then, take the N-point IFFT.
- Pad N-L (where L = Channel order) zeros at the end of the channel frequency response computed after the interpolation step.
- Finally, take the N-point FFT of the zero padded sequence to yield the channel frequency response at all subcarriers.

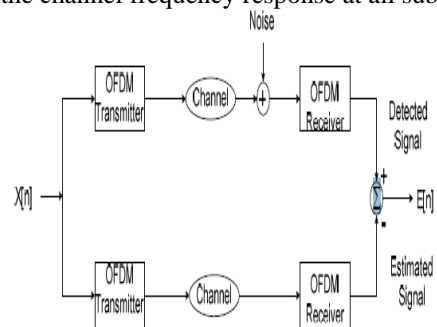


Figure 3: Conceptual View of LS estimator the

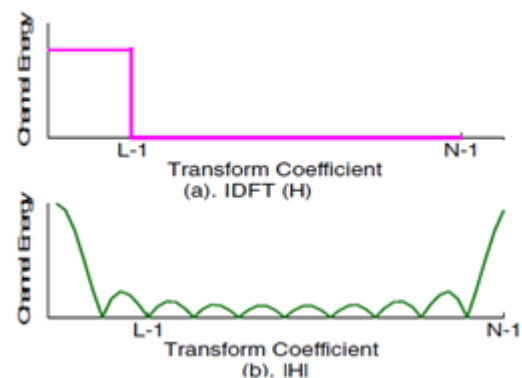


Figure 4: Channel Energy Distribution in time and frequency domain

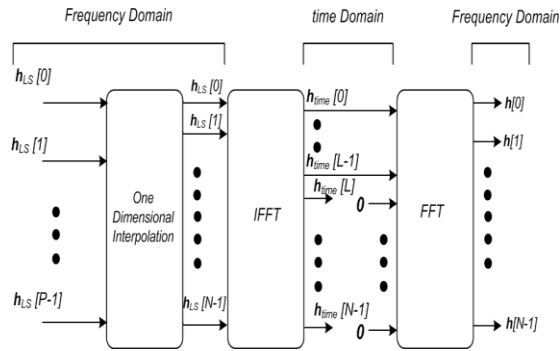


Figure 5: Proposed Interpolation Technique

5. Simulation Results

Figs. 6 & 7 illustrate the performance comparison curves of the uncoded OFDM system over Rayleigh fading channel for QPSK and BPSK modulation schemes respectively. It is clear from the Figs. 6 & 7 that the performance of the proposed interpolation technique using different one dimensional interpolation techniques is better than one-dimensional interpolation techniques. This performance improvement of the proposed interpolation over one-dimensional is because of the noise cancellation after estimating the channel frequency vector for all subcarriers. The channel frequency response computed after interpolation technique is converted into time domain and then, zeros are padded and finally, the zero padded sequence is converted into the frequency domain. The estimated frequency response has a low interpolation error as compared to the channel frequency response estimated by using onedimensional interpolation techniques.

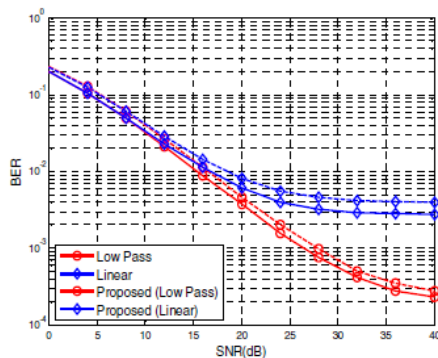


Figure 6: Performance comparison of BPSK Modulated OFDM for different Interpolation techniques

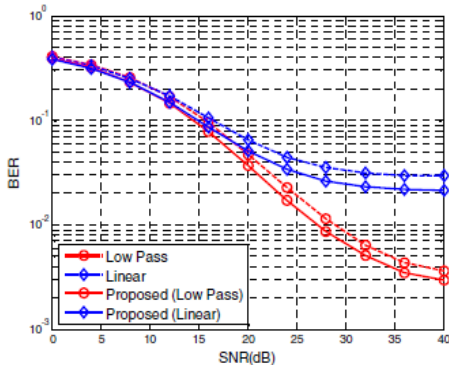


Figure 7: Performance comparison of 16-QAM Modulated OFDM for different Interpolation techniques.

The performance of uncoded OFDM with different modulation schemes for proposed interpolation technique using Low pass interpolation is shown in Fig. 8. It is clear from the Fig. 8 that the performance degradation for higher modulation scheme occurs. This degradation in BER performance is due to the nearby positioning of the constellation points for higher order modulation schemes.

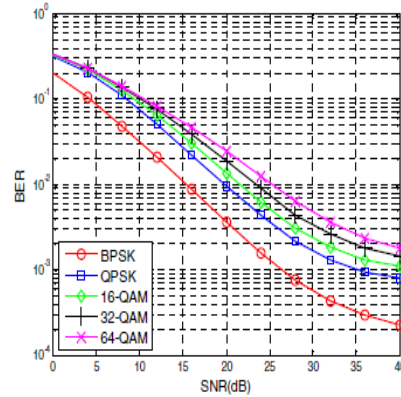


Figure 8: Performance comparison of the OFDM System with Different Modulation Schemes for Proposed Interpolation technique using Low pass interpolation

6. Conclusion

In this paper we investigated the BER performance of BPSK and QAM-modulated OFDM wireless communication systems with the implementation of LS-Interpolation-based comb-type pilot symbol-assisted channel estimation algorithm over frequency selective multi-path Rayleigh fading channel. In channel estimation, the OFDM system employed Least square estimator for the estimation of channel at pilot frequencies while different interpolation techniques are used to interpolate the channel at data frequencies. Simulation results show that the proposed OFDM system with LS channel estimator achieves good error rate performance under the BPSK and QAM modulation schemes over Rayleigh fading channel. The proposed Interpolation technique using Low-pass interpolation performs better in channel frequency response estimation than other studied interpolation algorithms and the BER performance of OFDM system with comb pilot-assisted channel estimation is less affected by Doppler frequency.

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