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Synchronization and channel estimation in OFDM using modified least minimum mean square error

[1]Dr.N.venu, [2]Vydyula Saiprasanna, [3]Athirajula Manasa
[4]Gadda Sai Jyothi
[1]Professor [2,3,4]UG Scholar
Balaji Institute of Technology & Science

Abstract:-The present work addresses channel estimation based on the Minimum Mean Square Error (MMSE) and Least Square (LS) criteria and also considers time-domain channel statistics. It presents an optimal criterion for the pilots, and corresponding optimal designs enabling complexity reductions. Using a general model for a slowly fading channel, the MMSE and LS estimators and a method for modifications compromising between complexity and performance is presented. The symbol error rate for a 16-QAM system is estimated by means of simulation results. MMSE (minimum mean square error) and LS (least square) estimators are also examined. The MMSE estimator has good performance but high complexity. The LS estimator has low complexity, but its performance is not as good as that of the MMSE estimator. Comparison is done for both types of estimators for channel estimation and the results are observed, considering the performances of channel estimators according to their behavior to symbol error rate and mean square error. Therefore, SNR of different estimators is studied corresponding to the particular SER value. OFDM-based systems are generally used in time varying frequency selective fading channels. In order to achieve the potential advantages of OFDMbased systems, the channel coefficients should be estimated with minimum error. Finally, it is concluded that modified estimators give better performance than the ordinary estimators in OFDM systems.

Keywords- (LS), 16 QAM, MMSE, OFDM

I.INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) is an alternative wireless modulation technology to CDMA. OFDM has the potential to surpass the capacity of CDMA systems and provide the wireless access method for 4G systems. OFDM is a modulation scheme that allows digital data to be efficiently and reliably transmitted over a radio channel, even in multipath environments. Signals are orthogonal if they are mutually independent of each other. Orthogonality is a property that allows multiple information signals to be transmitted perfectly over a common channel and detected, without interference.

A. GUARD PERIOD

The effect of ISI on an OFDM signal can be improved by the addition of a guard period to the start of each symbol. This guard period is a cyclic copy that extends the length of the symbol waveform. Each sub carrier in the data section of the symbol (i.e. the OFDM symbol with no guard period added, which is equal to the length of the IFFT size used to generate the signal) has an integer number of cycles. Because of this, placing copies of the symbol end-to-end results in a continuous signal, with no discontinuities at the joins. Manuscript

II. MOTIVATION

It is not possible to make reliable data decisions unless a good channel estimate is available. Thus, an accurate and efficient channel estimation procedure is necessary to coherently demodulate the received data.

III.CHANNEL ESTIMATION

Channel estimation in OFDM is usually performed with the aid of pilot symbols. Since each sub carrier is used in flat fading, the techniques from single-carrier flat fading systems are directly applicable to OFDM. For such systems PilotSymbol Assisted Modulation (PSAM) on flat fading channels involves the sparse insertion of known pilot symbols in a stream of data symbols.

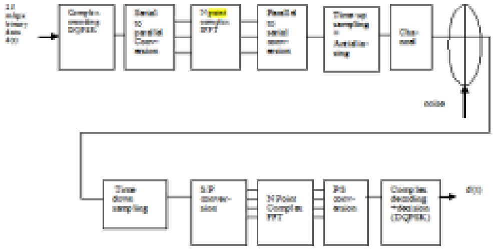
A.FEATURES OF CHANNEL ESTIMATION

Channel estimation is typically performed by sending a• pilot from the transmitter and measuring the pilot at the receiver. A sufficient amount of pilot needs to be transmitted in• order for the receiver to obtain a reasonably accurate estimate of the channel response. In the downlink of a wireless communication system, a• single pilot transmission from an access point (or a base station) can be used by a number of terminals to estimate the response of the distinct downlink channels from the access point to each of the terminals. In the uplink, each terminal needs to send a pilot• transmission separately in order to enable the access point to estimate the uplink channel from the terminal to the access point. For an OFDM system, the N sub bands may experience• different effective channels due to different effects of fading and multipath and may consequently be associated with different complex channel gains.

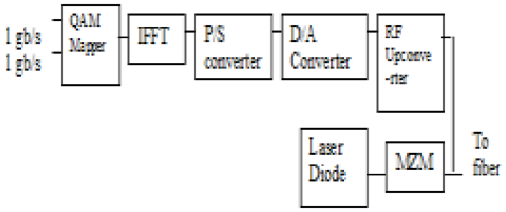
IV.OFDM GENERATION AND RECEPTION OFDM

signals are typically generated digitally due to the difficulty in creating large banks of phase lock oscillators and receivers in the analog form.

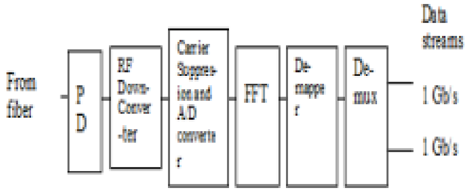
A. BLOCK DIAGRAM OF OFDM SYSTEM



B. OFDM TRANSMITTER CONFIGURATION



C. OFDM RECEIVER CONFIGURATION



V. CHANNEL ESTIMATION IN OFDM SYSTEMS

Orthogonal frequency division multiplexing (OFDM) based systems are strong candidates for an air interface of future fourth-generation mobile wireless systems which provide high data rates and high mobility. In order to achieve the potential advantages of OFDM-based systems, the channel coefficients should be estimated with minimum error. The channel estimation can be improved using more pilot symbols. However, it causes data rate reduction or bandwidth expansion. Therefore, spectrally efficient channel estimation techniques should be considered.

VI. MMSE AND LS ESTIMATORS

There are mainly two types of estimators used in the channel estimation called minimum mean square error (MMSE) and least squares (LS) channel estimators. The MMSE estimator has good performance but high complexity. The LS estimator has low complexity, but its performance is not as good as that of the MMSE estimator. Modifications to both MMSE and LS estimators that use the assumption of a finite length impulse response are presented so that the performance of the estimators can be increased.

VII. MODIFIED MMSE AND LS ESTIMATORS

The MMSE estimator requires the calculation of an N * N matrix Q’M MSE, which implies a high complexity (when N is large.) A straightforward way of decreasing the complexity is to reduce the size of Q’M MSE. If the first L taps of g are to be taken, and set Rgg (r,s)=0 for $r,s \notin [0,L1]$, then QM MSE is effectively reduced to an L*L matrix. If the matrix T denotes the first L columns of the DFT matrix F and R’gg denotes the upper left L*L corner of Rgg, the modified MMSE estimator becomes h’M MSE=T Q’M MSE TH XH y

Where, Q’M MSE =R’gg [(TH XH XT)-1 σ n2 + R’gg]-1 [(TH XH XT)-1

Taking only the first L taps of g into account, thus implicitly using channel statistics, the modified LS estimator becomes

h’LS=T Q’LS TH XH y Where, Q’LS = (TH XH XT)-1

VIII. CHANNEL ESTIMATION SIMULATIONS

A. INGREDIENTS REQUIRED FOR CHANNEL ESTIMATION

The ingredients required for channel estimation are presented as following:

B. GENERATION OF G MATRIX

The formulas used in the simulation of generation of G matrix are given below as: s = s + (e-j π (1/N)*(K+(N-1))* τ (m)* ((sin *π τ (m)) / sin π * 1/N)* τ (m)-k)))) also g(k+1)=s/sqrt(N) Finally, G =g' Where, g' is the transpose of channel matrix G.

C. GENERATION OF H MATRIX

Now the next ingredient for channel estimation is H matrix which is derived by the given formula as G is to be used in this therefore H is given as H=fft (G) H matrix is basically a channel impulse matrix. The transfer function for channel matrix is given as H=Y/ X where Y and X are the output and input channel responses respectively.

D. NOISE

The noise is also to be considered in the channel estimation as AWGN i.e. Additive White Gaussian Noise which adds complex Gaussian noise to the channel.

E. N SEQUENCE

If the FFT of the noise is to be taken, N sequence is derived as N=fft (noise)

F. OUTPUT RESPONSE OF CHANNELY

Output response of the channel is given by the following equation Y=XFG + N

G. AUTOCOVARIANCE MATRIX

Rgg that is covariance matrix can be estimated by using the optimal linear minimum mean-squared error that is called LMMSE estimate of h for all possible linear estimators h’ becomes

h’M MSE=A h’LS

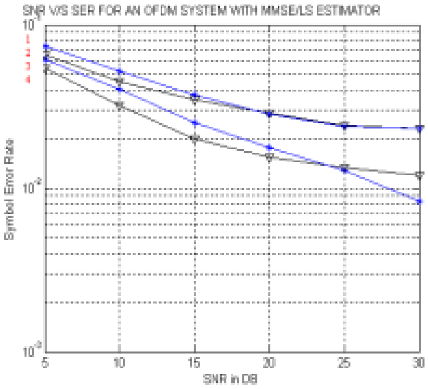
Where,

A=R’gg’ R-1gg’ = Rgg (Rgg+ σ n2 XXH)-1)-1 and Rgg is the channel autocorrelation matrix, that is, the matrix containing the correlations of the channel attenuations of the sub carriers. H.

EVALUATION OF H_MMSE

Now ingredients for channel estimation are ready and now the estimated channel response is calculated by the use of MMSE estimator that is given as H_MMSE

IX. RESULT



In Figure (i) symbol error rate at 0.106 is taken and different values of the Signal to noise ratios are seen for different type of estimators i.e. MMSE or LS and the modified versions of these estimators with tap of 10 is used. So they are called as MMSE10 and LS10 estimators and the results are shown in Table below.

Table 1: shows the Comparison of the SNR of different estimators when particular SER is taken for realization.

S.No	TYPE OF ESTIMATOR	SYMBOL ERROR RATE	SNR in dB
1	LS	0.106	10
2	MMSE	0.106	8
3	LS-10	0.106	6
4	MMSE-10	0.106	4

X. CONCLUSION

By analyzing the performance of estimators in terms of SNR when plotted against Symbol Error Rate, it is seen that MMSE estimators have good performance but high complexity. Therefore, to reduce the complexity and to become efficient modified MMSE estimator is used here with tap of 10 also called as MMSE10. Similarly, LS estimator has low complexity, but its performance is not as good as that of the MMSE estimator. Therefore to increase the performance capacity, modified LS estimator is considered called as LS10 estimator. By utilizing the result of this work, we can enhance the capacity of the wireless system dynamically and it will help to increase the performance and service factor of the particular wireless communication system

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