International Journal of Advance Research in Science and Engineering
Vol. No.6, Issue No. 09 , September 2017
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

Evaluation of Channel in Orthogonal Frequency Division Multiplexing

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ABSTRACT

Orthogonal frequency division multiplexing (OFDM) is a extraordinary case of multi-carrier transmission which can support high data rate prerequisite of multimedia based wireless systems. Since evaluation of channel is an vital part of OFDM systems, it is complex to comprehend the basis of channel evaluation techniques for Orthogonal frequency division multiplexing scheme, so that the most appropriate technique can be applied. The channel evaluation at pilot frequencies is based on LS & MMSE evaluation method by utilizing modulation scheme such as BPSK, also multi-path Rayleigh fading channel as channel model. In this paper we have implemented MATLAB simulation of OFDM to see how the Bit Error Ratio (BER) of a transmission varies when Signal to Noise Ratio (S/N Ratio) and Multi propagation effects are changed on transmission channel.

Keywords : BER, ISI, OFDM, S/N

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) has currently been functional extensively in wireless communication due to its high data rate transmission , high bandwidth efficiency capability and its robustness to multipath propagation path. It is been utilized in LAN standards such as IEEE802.11a and in multimedia wireless services such as Japanese Multimedia Mobile Access Communications. A appropriate evaluation of wireless channel is essential previous to the demodulation of OFDM signals. since the radio channel is time-varying and frequency selective for wideband communication systems [1][3].

In an OFDM scheme a large number of sub-carriers or sub channels are utilized to broadcast data information .Every sub-carriers or sub-channel is orthogonal to each other . They are narrowly spaced and have narrow band. The partition of the sub-carriers is as negligible as possible to obtain large spectral efficiency. Orthogonal Frequency Division Multiplexing (OFDM) is being utilized because of its ability to switch with multipath propagation at the receiver end, the most significant effects of multi propagation [2][8] is Inter Symbolic Interference (ISI) and Frequency selective fading. In OFDM sufficient “flat” channels are provided by the large number of narrow band sub-carriers. Therefore the problem of fading can be solved by easy equalizing. techniques for every channel. Furthermore the huge amount of carriers can provide similar data rates of a single carrier modulation at a lesser symbol rate. The symbol rate of every channel can be settle to a point that makes each symbol longer than the channel’s impulse response, this eliminates Inter symbol interference (ISI). The two

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

major drawbacks of orthogonal frequency division multiplexing are the sensitivity to frequency errors and large dynamic range of the signals being transmitted.

II. OFDM SIMULATION

Code used in this paper is for verifying the performance of LS & MMSE channel estimation technique by using BPSK Modulation scheme. The scheme of every part of the implementation can be seen in Fig 1. In the last part of the transmission, when the data is received at the receiver, a comparison of the received and transmitted data is done in order to estimate the Bit Error Ratio (BER).This paper does not explain the simulation Code but it focuses on the results which we get after simulation.

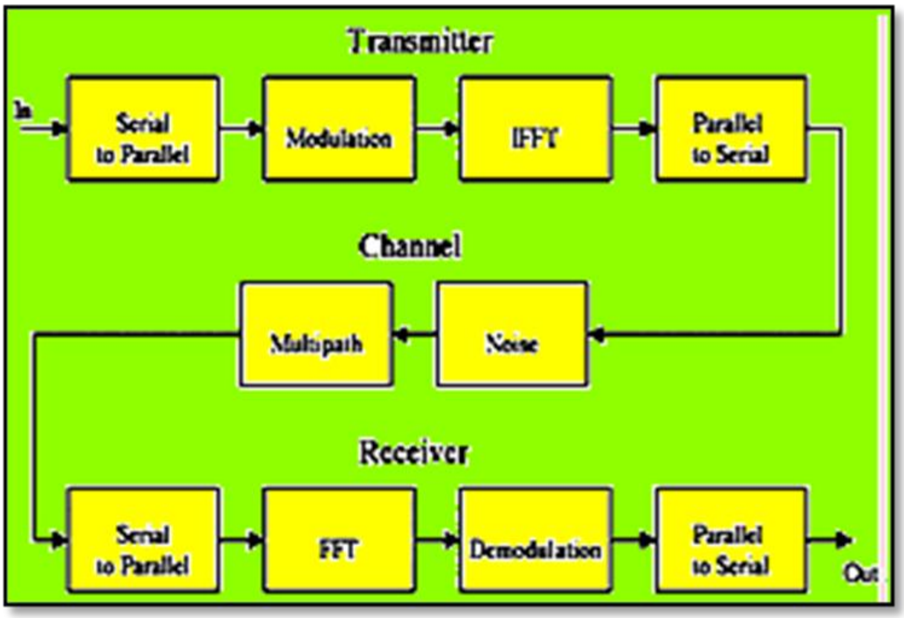

Fig.1: BASIC OFDM SYSTEM

IV. ESTIMATION OF CHANNEL

The two essential channel estimations techniques in OFDM systems are illustrated in Figure 2. The first arrangement is the block-type pilot channel estimation, is developed under the supposition of slow fading channel, and it is performed by inserting pilot tones into all subcarriers of OFDM symbols within a specific period [6][4].The second arrangement is , comb-type pilot channel estimation is introduced to satisfy the need for equalizing when the channel changes from one OFDM block to the subsequent one. It is thus carried out by introducing pilot tones into certain subcarriers of each symbol, where the interpolation is required the approximate the conditions of data subcarriers [10] [14].

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ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

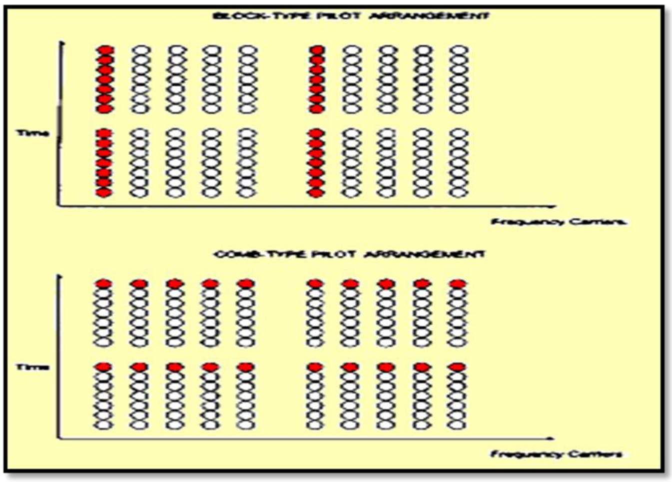

Fig.2: Pilot arrangement.

In block-type pilot-based channel estimation, as shown in Figure 2, OFDM channel evaluation symbols are transmitted periodically, and all of the subcarriers are utilized as the pilots. As the LS estimate is vulnerable to ICI and noise , MMSE is proposed while compromise complexity. Since matrix inversion is included in MMSE at each iteration [3][12].

3.1 LS Estimator

The LS estimator diminishes the parameter ($\bar{Y}$ -$\bar{H}$)^{H} ($\bar{Y}$ -$\underline{X}$ $\bar{H}$) where (•)^{H} means the conjugate transpose operation. It is shown that the LS estimator of $\bar{H}$ is given by [1][13].

$$\hat{H}_{LS}=\underline{X}^{-1}Y=[(X_K/Y_K)]^T \quad (1)$$

3.2 MMSE Estimator

The MMSE estimator utilizes the second -order statistics of the channel conditions to minimize the mean -square error .Denoted by $\underline{R}_{gg}$, R_{HH}, R_{YY} the auto covariance matrix of $\bar{g}$, $\bar{H}$ and $\bar{Y}$,respectively and $\underline{R}_{gy}$ the cross covariance matrix between $\bar{g}$ and $\bar{Y}$ [11][8].Also denoted by σ^2_N the noise variance $E\{(|\bar{N}|^2\}$.Assume the channel vector $\bar{g}$ and the noise $\bar{N}$ are uncorrelated it is derived that

$$R_{HH}= E\{\bar{H}\bar{H}^{H}\} = E\{(\underline{F}\bar{g})(\underline{F}\bar{g})^{H}\}= \underline{F}\underline{R}_{gg}\underline{F}^{H} \quad (2)$$

$$\underline{R}_{gY}= E\{\bar{g}\bar{Y}^{H}\}=E\{\bar{g}(\underline{X}\underline{F}\bar{g}+\bar{N})^{H}\}= \underline{R}_{gg}\underline{F}^{H}\underline{X}^{H} \quad (3)$$

$$R_{YY}=E\{\bar{Y}\bar{Y}^{H}\}= \underline{X}\underline{F}\underline{R}_{gg}\underline{F}^{H}\underline{X}^{H}+\sigma^2_N\underline{I}_N \quad (4)$$

Assume $\underline{R}_{gg}$ thus (R_{HH}) and σ^2_N are known as end receiver in advance, MMSE estimator of $\bar{g}$ is given $\hat{g}_{MMSE}= R_{gY}R_{YY}^{-1}\bar{Y}^{HH}$ note that $\bar{g}$ is not Gaussian , $\hat{g}_{MMSE}$ it is not essentially a minimum mean-square error estimator, [7][10]but it is still the best linear estimator in the mean-square error sense. At last, it is intended that

$$\begin{aligned}\hat{H}_{MMSE}&= \underline{F}\hat{g}_{MMSE}\underline{F}[(\underline{F}^{H}\underline{X}^{H})^{-1}\underline{R}_{gg}^{-1}\sigma^2_N+XF]^{-1}\bar{Y}\\ &=\underline{F}\underline{R}_{gg}[(\underline{F}^{H}\underline{X}^{H}\underline{X}\underline{F})^{-1}\sigma^2_N+\underline{R}_{gg}]\underline{F}^{-1}\hat{H}_{LS} \quad (5)\\ &=\underline{R}_{HH}[\underline{R}_{HH}+\sigma^2_N(\underline{X}\underline{X}^{H})^{-1}\hat{H}_{LS}\end{aligned}$$

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ISSN (O) 2319 - 8354
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IV. OFDM SYSTEM PARAMETERS

The System parameters utilize are the Hyperlan/ 2 parameters of the European standard and observe how they influence an OFDM system. For wireless LAN transmissions in the 5.2 GHz frequency band Hiperlan/2 standard makes use of OFDM modulation along with TDMA access scheme to competently exploit the channels which are time dispersive with frequency selective fading.

System Parameters
Sampling rate $F_0 = 1/T = 20$ *MHz*
Carrier central frequency $f_c = 5.2$ *GHz*
FFT size $N = 64$,
Useful symbol part duration $TU = 64T = 3.2\mu s$,
Cyclic prefix duration $TCP = 16T = 0.8\mu s$
Symbol interval $T_S = T_U + T_{CP}$ $,80T = 4.0$ μs
Number of data sub-carriers $N_{SD} = 48$
Number of pilot sub-carriers $NSP = 4$
Total sub-carriers $N_{ST} = N_{SD} + NSP = 52$
Sub-carrier spacing $F = 1/TU = 0.3125$ *MHz*
Nominal bandwidth $B = N_{ST}F = 16.25$ *MHz*
Data symbol constellations :BPSK

Table.no.1 System parameters

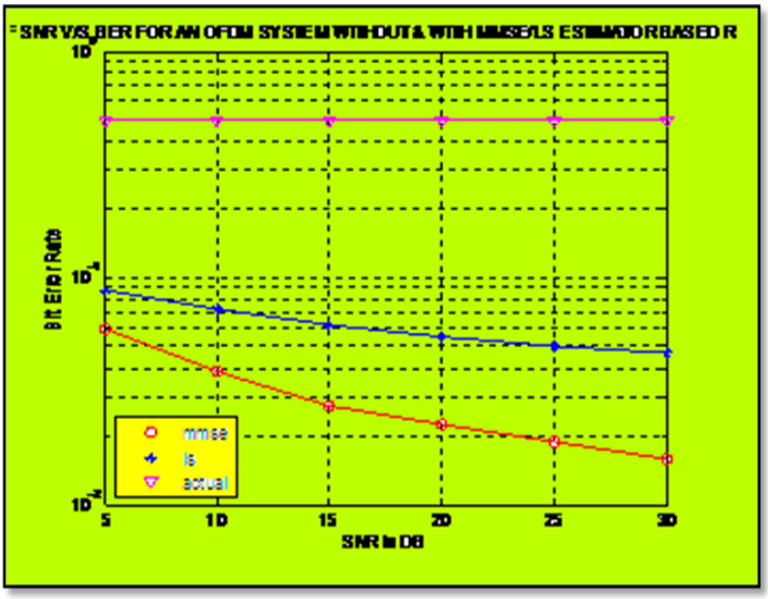

Fig.3: SNR v/s BER for an OFDM system without & with MMSE/LS estimation based receiver using BPSK modulation scheme

V.CONCLUSION

The OFDM system can be efficiently evaluated by utilizing these estimators, giving us certain knowledge about the evaluated channel statistics. In addition the complexity of MMSE is large as compared to LS estimator. The above results of simulation are done by using 64 subcarriers in OFDM system. We can also see the effect of implementing the estimators such as the LS & MMSE in the OFDM system. The above results show us the SNR VS BER plot for with and without MMSE/LS based receiver using BPSK modulation scheme.

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

VI. ACKNOWLEDGEMENTS

I would like to thank Dr. R.S Kawitkar, Professor in Dept. of E&Tc engineering Sinhgad College of engineering, Pune for his valuable guidance and time to time suggestions.

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