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2x2 MIMO OFDM Systems for Adaptive Channel Estimation technique

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***Abstract*— In this paper analysis of least squares (RLS) algorithm and LMS algorithm is proposed for multiple input multiple output (MIMO) orthogonal frequency division multiplexing (OFDM) systems. These two algorithms are used as adaptive channel estimation techniques. CE methods uses adaptive estimator which are able to update parameters of the estimator continuously, so that the knowledge of channel and noise statistics are not necessary. This LMS CE algorithm requires knowledge of the received signal only. So by designing this we are going to analyze the terms of the mean squares error (MSE), and bit error rate (BER) on mat lab software. Simulation results demonstrated that, the LMS CE method has better for MIMO OFDM systems. In addition, the utilizing of more multiple antennas at the transmitter and/or receiver provides a much higher performance compared with fewer antennas.**

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***Keywords*— MIMO; LMS; OFDM.**

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) is a special form of multi-carrier transmission technique in which a single high rate data stream is divided into multiple low rate data streams. These data streams are then modulated using subcarriers which are orthogonal to each other. In this way the symbol rate on each subchannel is greatly reduced, and hence the effect of intersymbol interference (ISI) due to channel dispersion in time caused by multipath delay spread is reduced.

Guard interval can also be inserted between OFDM symbols to reduce ISI further. The orthogonality between subcarriers can be maintained, even though the signal passes through a time-dispersive channel by cyclically extending the OFDM symbols into guard interval. The main advantages of OFDM are its multipath delay spread tolerance and efficient spectral usage by allowing overlapping in the frequency domain. Another significant advantage is that the modulation and demodulation can be done using inverse Fast Fourier Transformation (IFFT) and Fast Fourier Transformation (FFT) operations, which are computationally efficient. In an OFDM transmission system, each subcarrier is attenuated individually under the frequency-selective and fast fading channel. The channel performance may be highly fluctuating across the subcarriers and varies from symbol to symbol [1]. If the same fixed transmission scheme is used for all OFDM subcarriers, the error probability is dominated by the OFDM subcarriers with highest attenuation resulting in a poor performance. Therefore, in case of frequency selective fading the error probability decreases very slowly with increasing average signal-to-noise ratio (SNR) [2].

II MIMO OFDM SYSTEM

Multiple antennas can be used at the transmitter and receiver,an arrangement called a multiple-input multiple-output(MIMO) system.A MIMO system takes advantage of the spatial diversity that is obtained by spatially separated antennas in a dense multipath scattering environment. MIMO systems may be implemented in a number of different ways to obtain either a diversity gain to combat signal fading or to obtain a capacity gain. Generally, there are three categories of MIMO techniques. The first aims to improve the power efficiency by maximizing spatial diversity. Recently, multiple input multiple output (MIMO) channels have been introduced to achieve high data speed requisite by the next-generation communication systems [3]. The use of MIMO channels provides higher spectral efficiency versus single input single output (SISO), single input multiple output (SIMO), and multiple input single-output (MISO) channels, when the available bandwidth is inadequate. Furthermore, the diversity gain of the MIMO channels is nearly of second order when channel matrix has full rank. Consequently, by employing MIMO channels, not only the mobility of the wireless communications can be increased but also the algorithm can be more robust against fading, which makes it efficient for the requirements of the next-generation wireless services such as wireless local area networks (WLANs), worldwide interoperability for microwave access (WiMAX), wireless fidelity (WiFi), cognitive radio, and 3rd generation partnership project (3GPP) long term evolution (LTE) [4].

In SISO flat channels, channel estimation (CE) and its precision do not have a drastic impact on the performance of the receiver. Whereas in outdoor MIMO channels, the precision and speed of convergence of the channel estimator can drastically affect the performance of the receiver [5]. In SISO communications, the channel estimators may or may not use the training sequence or not. Although the distribution of the training symbols in a block of data affects the performance of systems [4], but due to simplicity, it is conventional to use the training symbols in the first part of each block. If the training sequence is not used, the estimator is called the blind channel estimator. A blind channel estimator uses information latent in statistical properties of the transmitting data [5]. In full-rank MIMO channels, the use of an initial training data is mandatory, and without it, the channel estimator does not converge [4], [6].

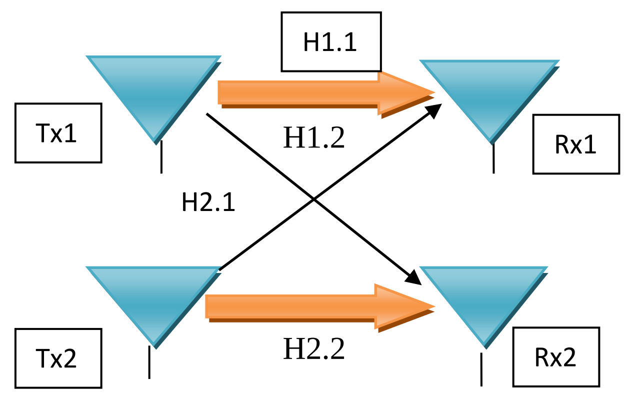

Fig-1 MIMO OFDM System with 2 Tx&2Rx

III CHANNEL ESTIMATION TECHNIQUES

There are many digital signal processing applications in which second order statistics cannot be specified. Such application includes channel equalization echo cancellation and noise cancellation. In these applications, filters with adjustable coefficients called Adaptive filters are employed. An adaptive filter is a filter that self adjusts its transfer function according to an optimizing algorithm. It adapts the performance based on the input signal. Such filters incorporate algorithms that allow the filter coefficients to adapt to the signal statics. There are different approaches used in adaptive filtering, which are Adaptive techniques use algorithms, which enable the adaptive filter to adjust its parameters to produce an output that matches the output of an unknown system. This algorithm employs an individual convergence factor that is updated for each adaptive filter coefficient at each iteration.

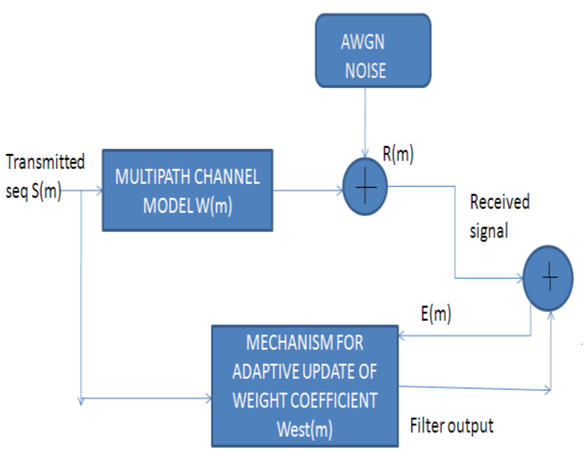

Fig 2.Idea for adaptive CE Methods

IV LMS ALGORITHM

Least mean squares (LMS) algorithms are class of adaptive filter used to mimic a desired filter by finding the filter coefficients that relate to producing the least mean squares of the error signal (difference between the desired and the actual signal). It is a stochastic gradient descent method in that the filter is only adapted based on the error at the current time. The basic idea behind LMS filter is to approach the optimum filter weights (R-1 P), by updating the filter weights in a manner to converge to the optimum filter weight. The algorithm starts by assuming a small weights (zero in most cases), and at each step, by finding the gradient of the mean square error, the weights are updated. That is, if the MSE-gradient is positive, it implies, the error would keep increasing positively, if the same weight is used for further iterations, which means we need to reduce the weights. In the same way, if the gradient is negative, we need to increase the weights. So, the basic weight update equation is:

$$w_{n+1} = w_n - \mu\Delta\varepsilon[n]$$

Where, $\boldsymbol{\varepsilon}$ represents the mean-square error. The negative sign indicates that, we need to change the weights in a direction opposite to that of the gradient slope.

LMS algorithm summary:

The LMS algorithm [6] for a pth order algorithm can be summarized as

Parameters: P = filter order

μ = step size

Initialization: $\hat{h}(0) = 0$

Computation: For n = 0, 1, 2...

$X(n) = [x(n), x(n - 1), \ldots, x(n - p + 1)]T$

$e(n) = d(n) - \hat{h}H(n)\ X(n)$

$\hat{h}(n+1) = \hat{h}(n) + \mu\ e^*(n)\ X(n)$

Convergence and stability in the mean of LMS:

As the LMS algorithm does not use the exact values of the expectations, the weights would never reach the optimal weights in the absolute sense, but a convergence is possible in mean. That is even-though, the weights may change by small amounts, it changes about the optimal weights. However, if the variance, with which the weights change, is large, convergence in mean would be misleading. This problem may occur, if the value of step-size μ is not chosen properly.

Thus, an upper bound on μ is needed which is given as

$0 < \mu < 2\lambda max$

Where λmax is an autocorrelation matrix, its Eigen values are non negative. If this condition is not fulfilled, the algorithm becomes unstable. The convergence of the algorithm [4] is inversely proportional to the eigen value spread of the correlation matrix R. When the eigen values of R are widespread, convergence may be slow. The eigen value spread of the correlation matrix is estimated by computing the ratio of the largest eigen value to the smallest eigen value of the matrix. If **μ** is chosen to be very small then the algorithm converges very slowly. A large value of **μ** may lead to a faster convergence but may be less stable around the minimum value.

Maximum convergence speed [7] is achieved when

$\mu = 2\lambda max + \lambda min$

Where λmin is the smallest eigen value of R. Given that μ is less than or equal to this optimum, the convergence speed is determined by λmin, with a larger value yielding faster convergence. This means that faster convergence can be achieved when λmax is close to λmin, that is, the maximum achievable convergence speed depends on the eigen value spread of R.

V. RESULTS & DISCUSSION

In this section, a MIMO-OFDM system with 2 transmitter antennas and 2 or 1 receiver ones is used for the simulation. The assumed system has a QAM modulation. The total number of subcarriers, N, is 64 or 32 .

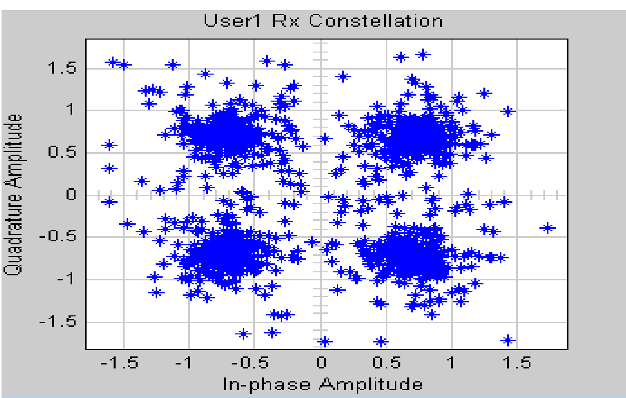

Fig 3: User 1 Rx Constellation

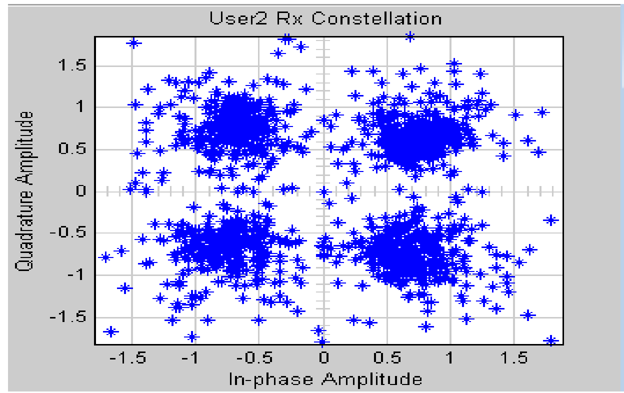

Fig 4: User 2 Rx Constellation

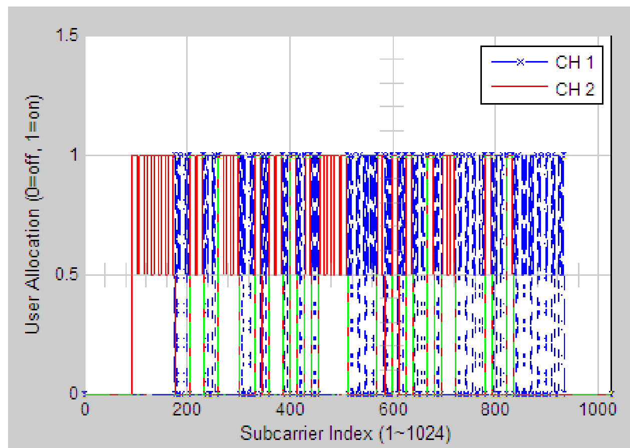

Fig 5:MIMO OFDM Carrier & its user allocation

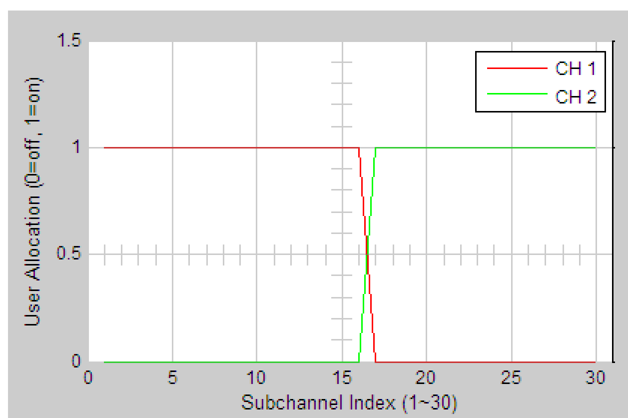

Fig 6:2X2 MIMO Channels with higher Bit Error Rate

In addition, the utilizing of more multiple antennas at the transmitter and/or receiver provides a much higher BER performance compared with fewer antennas.

VI.CONCLUSION

Recently, multiple input multiple output (MIMO) transmission has been well known as one of the most important practical technique to combat fading as well as increase the channel capacity of wireless communication systems. In this paper, LMS adaptive channel estimator are described for MIMO OFDM systems. Simulation results demonstrated that the LMS CE method has better for MIMO OFDM systems. In addition, the utilizing of more multiple antennas at the transmitter and/or receiver provides a much higher performance compared with fewer antennas.

VII. REFERENCES

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