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Performance Analysis of Least Mean Square and Recursive Least Square Channel Estimation Techniques under Multipath Fading Environmental Conditions

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***Abstract*—In practical scenario the transmission of signal or data from source to destination is very challenging. As there is alot of surrounding environmental changes which influence the transmitted signal. The ISI, multipath will corrupt the data and this data appears at the receiver or destination. Due to this time varying multipath fading we use different channel estimation filter at the receiver to improve the performance. Here we are estimating the different channel estimation techniques under different channel conditions. The two algorithms we used here are LMS and RLS for AWGN and Rayleigh channels under MATLAB platform.**

***Keywords:*--LMS (Least Mean Square), RLS (Recursive Least-Squares), AWGN (Additive White Gaussian Noise), Rayleigh Fading Channel**

I. INTRODUCTION

The data or information is sent from transmitter, which passes through the medium which is called as channel. During the transmission of information it undergoes intersymbol interference(ISI), distortion in signal frequency and phase and the distorted signal is received at the receiver [1].

Estimation is the approx calculation of output signal compared with the input signal of transmitter. The variation or difference between both transmitted and received signals are due to transmission medium we are using. The various equalization techniques are used to minimize the error existing between the transmitted and received signal. In previous works [12], comparative study of channel estimation algorithms under different channel scenario for QPSK modulation technique is been compared. Estimation algorithms used are (LMS, RLS) in vehicle to vehicle (V2V/VTV) communication and Intelligent Transport Systems (ITS) is proposed.

II. LITERATURE SURVEY

Jones et al. [3] with the help of LMS algorithm identified system for adaptive filters. Haykin [2] proposed a system with FIR filter models using adaptive filter algorithms and their applications. Rontogiannis et al[4] has proposed a parametric strategy for assessing the unknown multipath channel impulse response (CIR) in a semi-blind way. A methodology for assessing the model parameters in view of test covariance from information disturbed by discrete time measurement noise has been proposed for large scale fading channels in remote correspondence frameworks in[5]. In the downlink of DS-CDMA system RAKE receiver is used for suppressing intra cell interference[6]. Wei et al. [7] based on modified kalman filter algorithm(MKFA) proposed new kind of RAKE receiver which considers the characteristics of noise time variable statistics and channel gain factor. These factors enhance the track performance and convergence rate of the algorithm.

III. CHANNEL ESTIMATION

For the channel estimation to equalize the filter output we use some adaptive algorithms at the receiver or destination. In this channel estimation model we used LMS and RLS algorithms.

A. LMS Algorithm

LMS algorithm is the simplest of all other algorithms. It uses the available data and creates gradient vector for estimation. For the minimum Mean Square Error (MSE) it automatically adjusts its weight taps of the filter in accordance with the estimation error [8].

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Input : Random Process $x($
Weight of Filter : $(w_0, w_1, w_2, \ldots \ldots w_{k-}$
Filter Output : $Y(k) = w^H x($ (1)

Error signal : $e(k) = d(k) - y($ (2)
$d($ is desired output
The weights can be adjusted as,
$w_{k+1} = w_k + \mu x(k) e^*($ (3)

B. RLS Algorithm

To reduce the estimation error the RLS Algorithm is used instead of LMS Algorithm. To minimize the linear least squares cost function of input signal, it recursively checks the filter coefficients [9].
RLS Algorithm for kth order RLS Filter can be summarized as,

= Order of Filter
= Forgetting factor
= initial value $k($
Initialization : $w_k =$
K(0) = δ^-
Where is the Identity matrix
For k = 0,1,2…
Filter Weight can be updated as,
$w(k) = w(k-1) + \alpha(k) g($ (4)
Where ,
$\alpha(k) = d(k) - w(k-1$ (5)
$g(k) = P(k-1) z(k) \{\lambda + x^T(k) P(k-1) x(k)\}$ (6)
$P(= \quad \lambda^{-1} P(k-1) - g(k) x^T(k) \lambda^{-1} P(k -$ (7)
And,

$$x(k) = \begin{bmatrix} x(n) \\ x(n-1) \\ \cdot \\ \cdot \\ \\ x(n-p) \end{bmatrix} \quad (8)$$

IV. CHANNEL

In the practical environment while sending data from transmitter, there is a lot of disturbance and which corrupts the signal and also strength of the signal decreases or varies at the receiver due to multipath fading. Due to this fading the Bit Error Rate (BER) of the signal increases.
Here we are using AWGN and Rayleigh fading channels.

A. AWGN Channel

White Noise which is also a White Random process. A Random Process is white if it is Wide Sense Stationary (WSS)
And autocorrelation function.

$R_{xx}(\tau) = \frac{\eta}{2}\delta(\tau)$, $\delta(\tau)$ is impulse at $\tau = 0$
PSD of White Noise,
$S_{xx}(F) = \frac{\eta}{2}, \quad -\infty < F < \infty$
It is $\frac{\eta}{2}$ over entire frequency range.

Any signal is called White Noise because it is White Light
which has uniform power distribution, which is uniformly spread over a entire frequency range as it has all color components corresponding to all the frequencies.

A Random Process which has both Gaussian and White it is called White Gaussian Noise.

As in context to communication channel which is Additive White Gaussian Noise. Consider a channel

$$y(t) = x(t) + n(t)$$

Where x(t) is the transmitted signal, y(t) is the received signal and n(t) is Gaussian Noise. As we can see is the noise is getting added to the transmitted signal so it is called Additive Gaussian Noise and if the Gaussian Noise is White then this becomes Additive White Gaussian Noise. Such a communication channel which adds AWGN to transmitted Signal x(t) is termed as ``AWGN channel‖ [10].

B. Rayleigh Channel

$$F_A(a) = \int_{-\pi}^{\pi} F_{A,\phi}(a,\phi)\, d\phi$$

Where $F_A($ is marginal distribution or joint distribution with respect to `a'.

$F_A(a) = 2ae^-, \qquad 0 \le a \le$
Rayleigh Distribution of Rayleigh Fading Density.
Where, $a = \sqrt{x^2 + }$, envelope of the Fading Channel.

This distribution is known as Rayleigh Distribution which has key role in communications theory, standard model used in wireless communications channels is Rayleigh Fading Distribution.

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The Rayleigh Distribution is the probability density of Rayleigh Random Variable or Probability Density of `a ‘which is magnitude of fading coefficient given any interval the probability that magnitude lies in the interval is simply the integral of density function [11].

If the range is close to zero when magnitude of fading coefficient is fading coefficient is close to zero it means fading coefficient has very low gain which indicates the signal received significantly attenuated , so the signal power received is extremely low, such a scenario is known as ``Deep Fade Scenario''.

Deep Fade is due to received power is almost zero. This can have adverse effects on the wireless communication systems because of the received signal power is zero then essentially there is no signal is received or in essence the received signal cannot be distinguished from noise and this is the problem in wireless communication channel

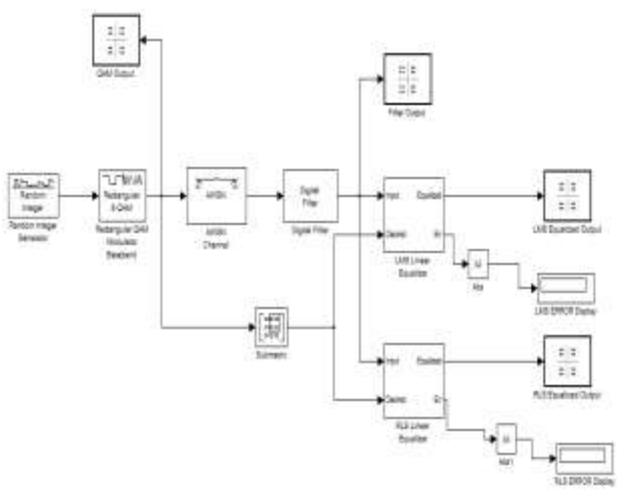

Fig 1: Block Diagram of AWGN Channel Model

In this paper we have simulated for different channels (AWGN, Rayleigh) using adaptive filters (LMS,RLS) and modulation technique used is QAM. Constellation diagram of input signal is shown in Fig 2.

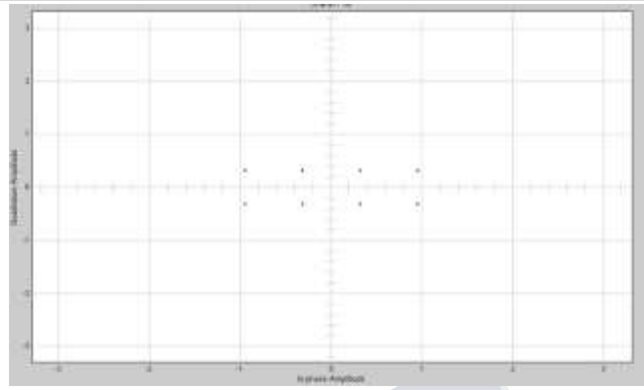

Fig 2: Transmitted Signal

B. Channel

B.1 Case 1. AWGN Channel

AWGN Channel is used in Wire line Communication where some channel noise is added to the transmitted signal. There is no effect of channel echo or multipath to the signal. The block diagram of AWGN Channel is shown in Fig 1. The noisy signal is received at the receiver is shown in Fig 3.

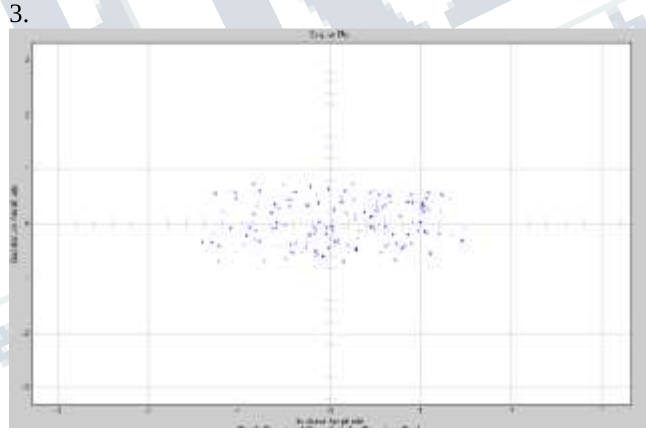

Fig 3: Received Signal at the Receiver End

The received signal is equalized using the LMS and RLS linear Equalizers in which the received signal is compared with the desired signal and equalized with respect to desired signal. The scatter plot of LMS and RLS Equalized signals are shown Fig 4 and Fig 5 respectively.

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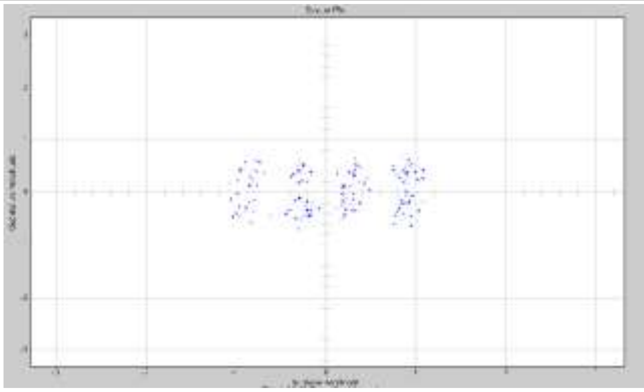

Fig 4: AWGN Channel LMS Equalized Signal

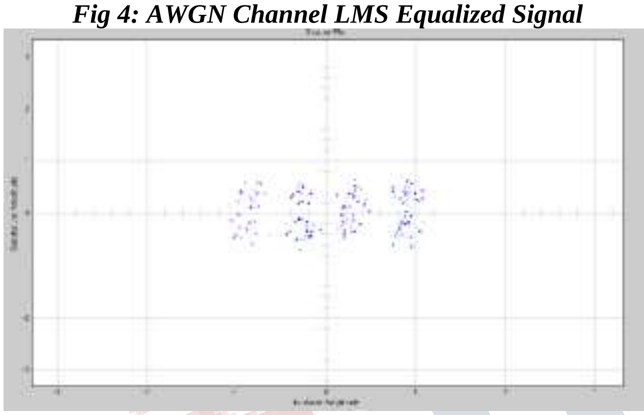

Fig 5: AWGN Channel RLS Equalized Signal

B.2 Case II: Rayleigh Fading Channel

Rayleigh Channel is used in the wireless communication in which the large amount of noise is added to the transmitted signal. This is due to its multipath reception at the receiver. The block diagram of Rayleigh Channel is shown in Fig 6.

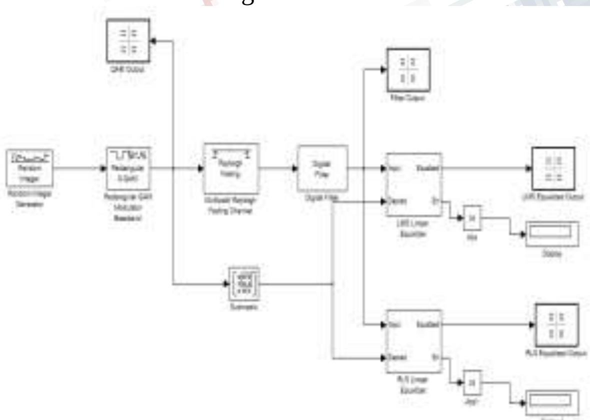

Fig 6 : Block Diagram of Rayleigh Channel Model

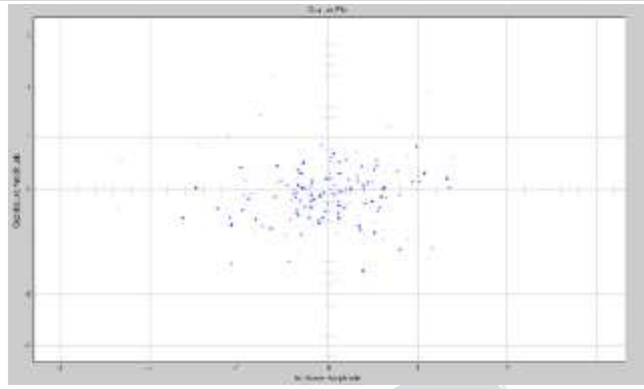

Fig 7: Rayleigh Received Signal at the Receiver End

Fig 7 shows the received signal at receiver end in Rayleigh Channel condition. LMS and RLS Linear Equalizer Outputs are shown in Fig 8 and Fig 9 respectively

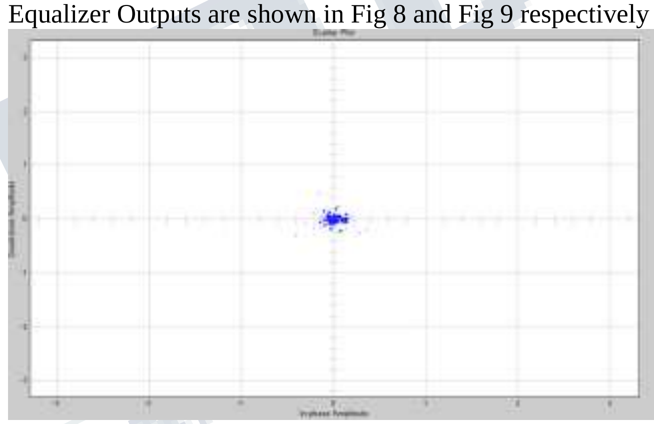

Fig 8: Rayleigh LMS Equalized Signal

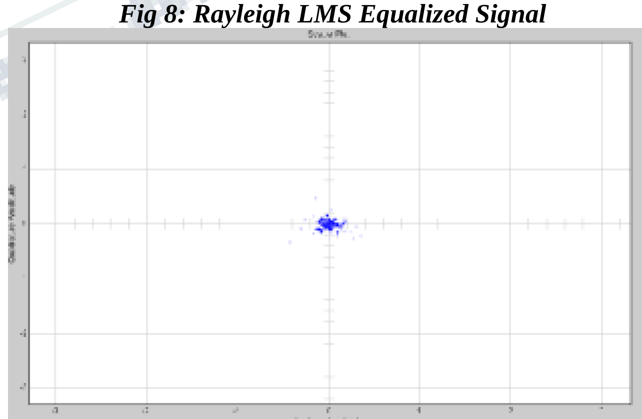

Fig 9: Rayleigh RLS Equalized Signal

VI. CONCLUSIONS

Here the different channel performances are compared by using LMS and RLS algorithms. In comparison the amount of error generated by RLS Algorithm is lesser than the LMS Algorithm.. And also the

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Vol 3, Issue 10, October 2016

mathematical computation is simple in case of LMS algorithm; hence it can be easily implemented in the system.

Channel	Mean Error		Standard Deviation	
	LMS	RLS	LMS	RLS
AWGN	1.148	1.142	0.1914	0.1919
Rayleigh Fading	1.381	1.35	0.7786	0.7811

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