Performance Analysis Of LMS Channel Equalizer For Sinc Pulse And Rectangular Pulse Low Pass Channels

Saurabh Shah, Ved Vyas Dwivedi, Jaymin Bhalani

Abstract: In Digital Communication System, the requirement of high-speed data transmission achieved through the channel is most important. But in transmission, the data flow rate is reduced due to the Inter Symbol Interference (ISI). For removing this ISI, we require a Channel equalizer. In this paper, we used the Least Mean Square (LMS) equalizer technique. LMS technique shows the convergence of weights with sampling instant and also compare the eye diagram before and after the adaptive equalizer. The adaptive LMS equalizer reduced the ISI and gives better performance.

Keywords: Channel Equalization, Eye Diagram, ISI, LMS Equalizer, Mean Square Error, weight adaption, Step size delta.

1 Introduction

Digital Communication system [1] has required high data rate for transmitting the information. In the transmission process, the digital system suffers from Inter Symbol Interference (ISI) [2]. ISI may arise due to the phenomenon of multipath propagation. For removing this ISI, no. of channel estimation and channel equalization techniques are designed. One of the best ways to reduce ISI is channel equalization [4]. Mostly we used an Adaptive linear transversal equalizer [6] structure. So for the requirement of high-speed data with low ISI, we design an LMS equalizer. In this paper, the LMS equalization technique is used to equalize the multipath transmission channel, also eliminate the ISI and reduce the mean square error (MSE) [8].

2 Channel Equalizer

Equalization is the process of removing ISI and noise effects from the unknown channel. Mainly equalizer is located at the receiver end of the channel. Commonly used equalization techniques are of two types:

- Linear Equalizer
- Non-Linear Equalizer

Using the linear equalizer we can easily reduce the ISI because they are highly efficient in channel equalization and simple to execute. Mostly the linear equalizers are imagined applying the linear transversal filter structure.

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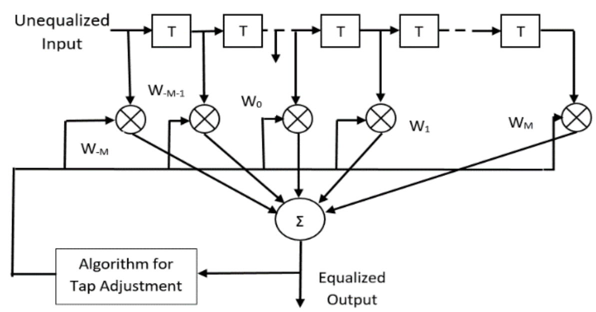

Figure 1: *Linear Transversal Equalizer*

Here the no. of equalization tap is 2M + 1 and the symbol duration is T. Here the input to the equalizer is Y(t) then the equalizer output is given by,

$$Y_{eq}(t) = \sum_{-M}^{i=M} w_i Y(t - iT) \qquad (1)$$

Here w_i are weights of the equalizer tap constructed on the optimization criterion.

For optimizing the equalizer tap weights mainly two principles are used:

1. Peak Distortion Principle (Zero Forcing Equalizer [3], [5])
2. Mean Square Error (MSE) Principle (LMMSE equalizer and LMS equalizer)

Linear equalizer based on weight adaptation is mainly used the adaptive channel equalizer [7].

3. LMS Equalizer

The automatic synthesis approach is used in LMS equalizer. Zero forcing equalizer to solve the N equation simultaneously to minimize the error between the equalized signal and the reference signal. Whereas in LMS solve the coefficients gradually to adjust to converge of a filter to minimize the error. Using the approximation of a gradient calculation solve the filter convergence of the quadratic equation which gives mean square error. Only adjusting the adaptive step size Δ reduces the mean square error in gradient techniques which is the attractiveness of this approach. The training sequence of each sample period adjusted the filter tap weight during the process. Finally, minimize the MSE when the filter arrives in this configuration. The Method of Steepest Descent using traditional optimization technique gives the stochastic gradient optimization algorithm.

Steepest Descent Method:
In this method, the weight vector is

$$w[n+1] = w[n] + \frac{\Delta}{2}\,[(-\nabla\,(E\,\{\,\epsilon^2\,[n]\})] \qquad (2)$$

here, $\epsilon\,[n]$ error, n is iteration number and step size Δ.

In place of actual value, the instantaneous values are used in LMS algorithm which is explanation of the steepest descent method.

$$w[n+1] = w[n] + \Delta\,\epsilon\,[n] * Y_i[n] \qquad (3)$$

here, $Y_i[n]$ = [Y((n - M)Y), …,Y(0),…,Y((n + M)T) $]^T$ is the tap inputs. Using the equalized output calculated the error, $\epsilon\,[n]$.

$$\epsilon\,[n] = A_n - y_{eq}[n] \qquad (4)$$

Using the error equation (4) and output of the tap weight in equation (3), we design a LMS algorithm,

$$y_{eq}(n) = w[n]^H\,Y_i[n] \qquad (5)$$

$$\epsilon\,[n] = A_n - y_{eq}[n] \qquad (6)$$

$$w[n+1] = w[n] + \Delta\,\epsilon^*\,[n]\,Y_i[n] \qquad (7)$$

This algorithm using block diagram as shown in figure 2.

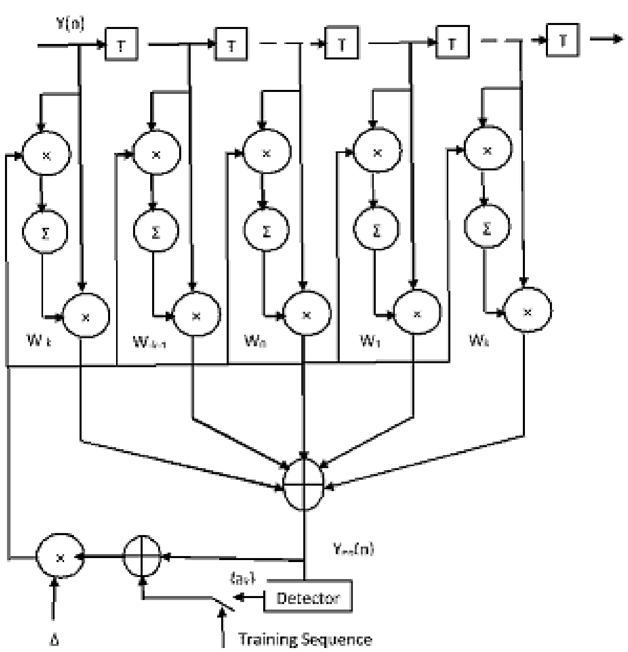

Figure 2: *The Adaptive LMS equalizer.*

4 SIMULATION

[1] LMS equalizer with Rectangular pulse Low Pass channel

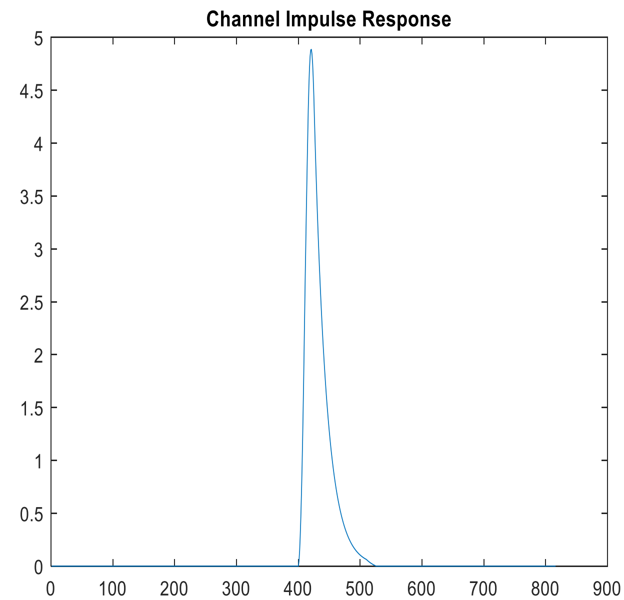

Figure 3: *Channel Impulse Response of Rectangular low pass filter*

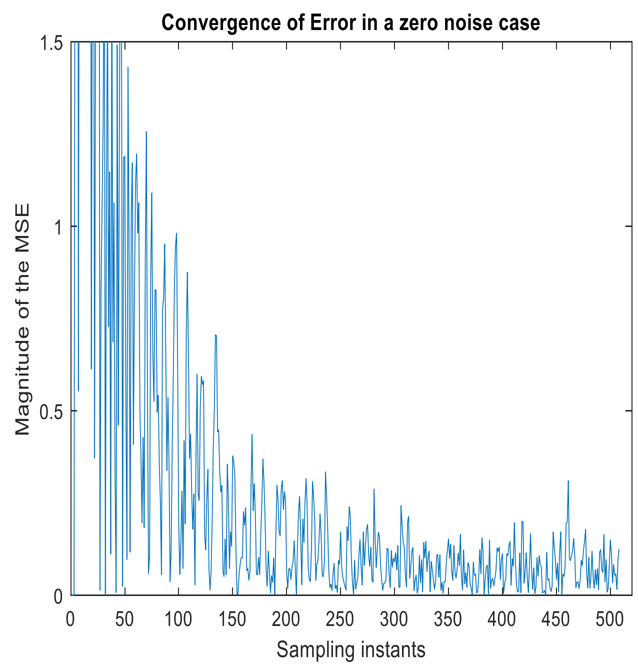

Figure 4*: Convergence of Error*

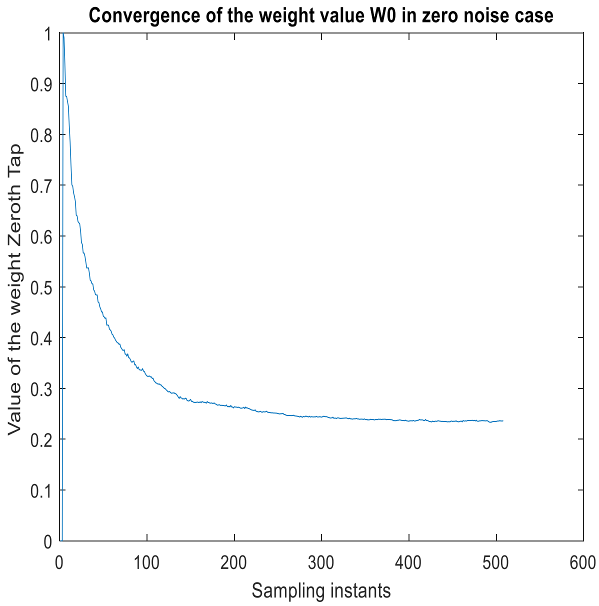

Figure 5: *Convergence of weights*

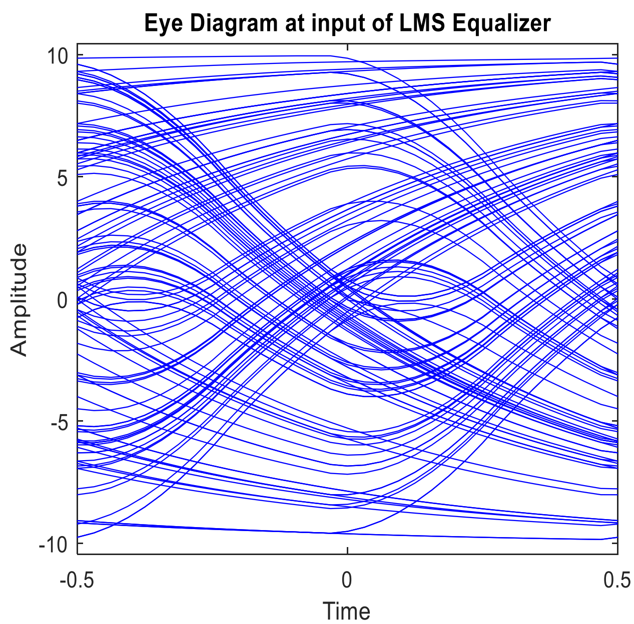

Figure 6*: Eye Diagram at input of the Equalizer*

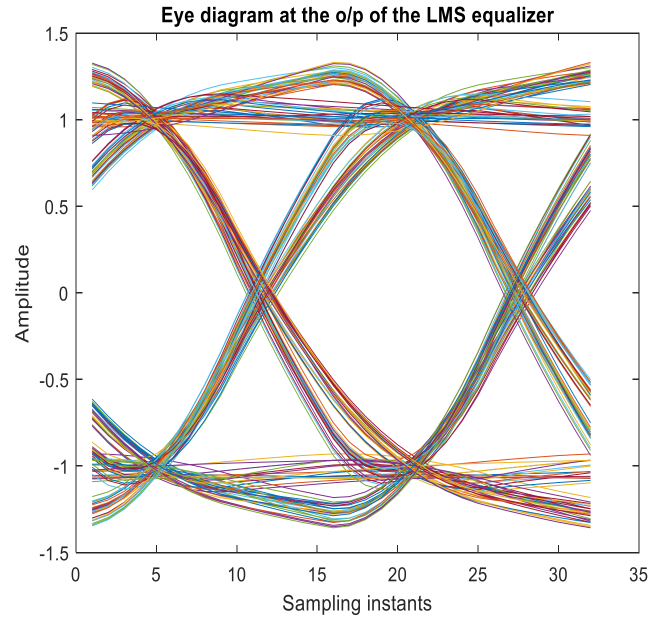

Figure 7: *Eye Diagram at the output of the Equalizer*

[2] LMS equalizer with Sinc pulse Low Pass channel

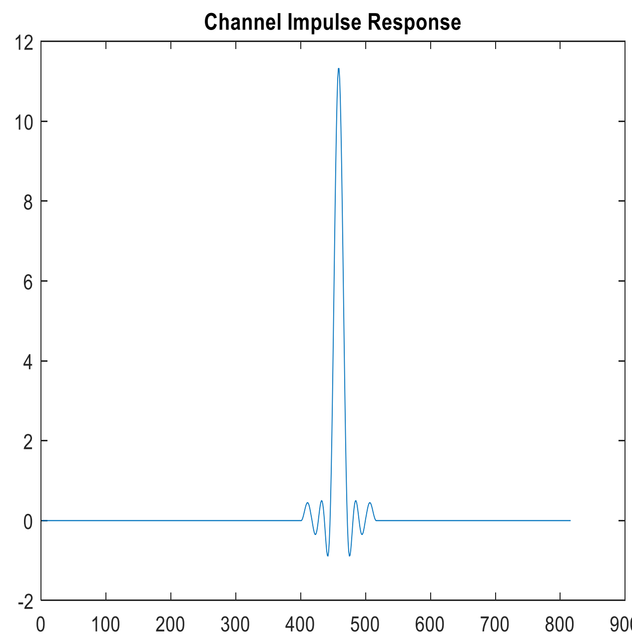

Figure 8: *Channel Impulse Response of Sinc Pulse*

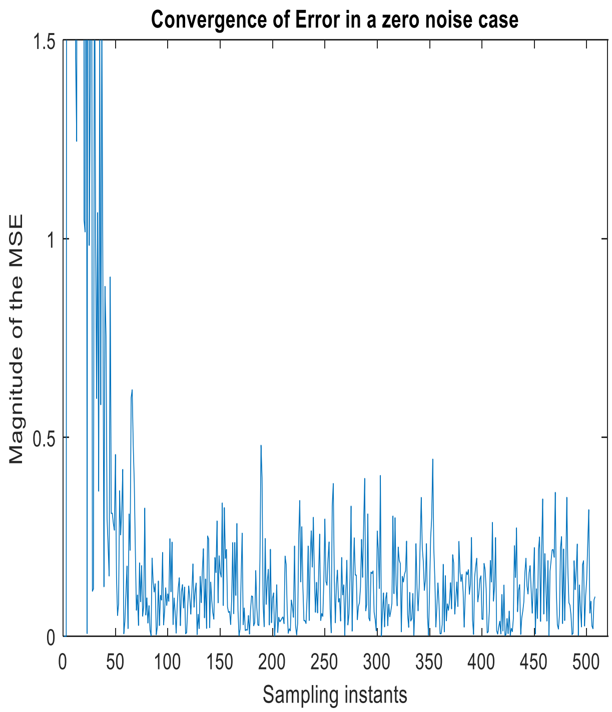

Figure 9: *Convergence of Error*

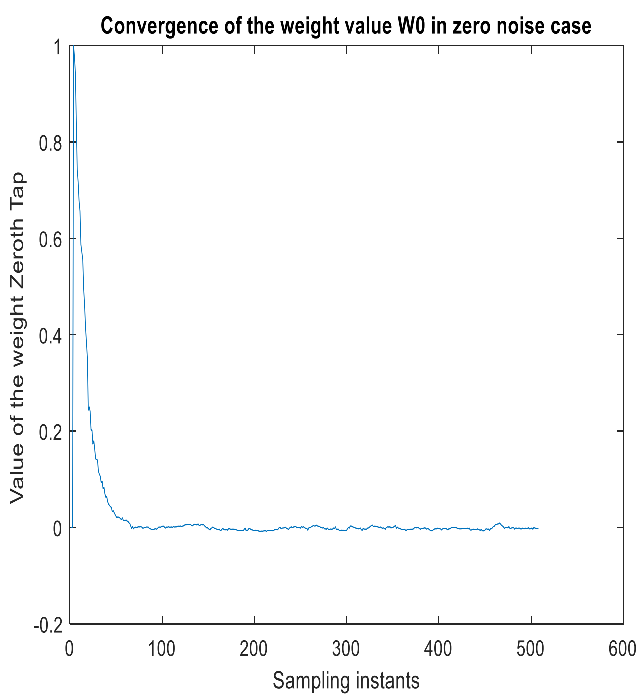

Figure 10: *Convergence of weights*

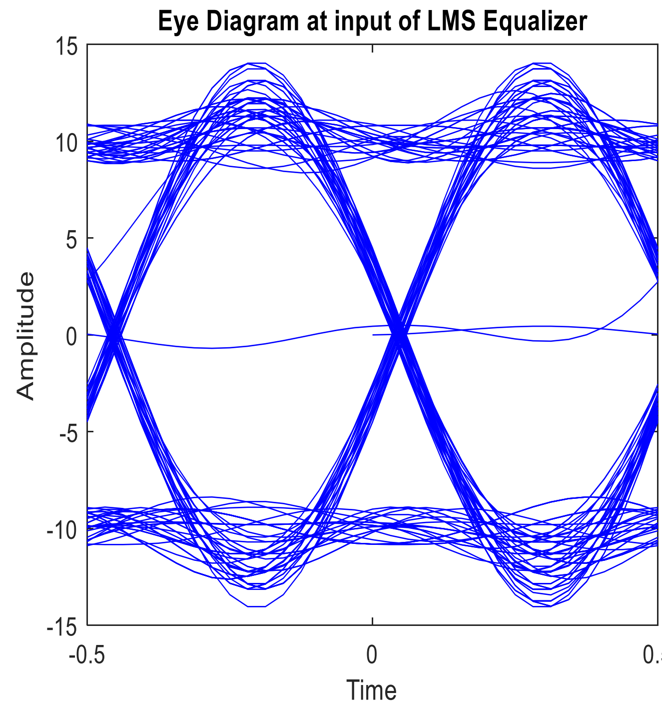

Figure 11: *Eye Diagram at input of the Equalizer*

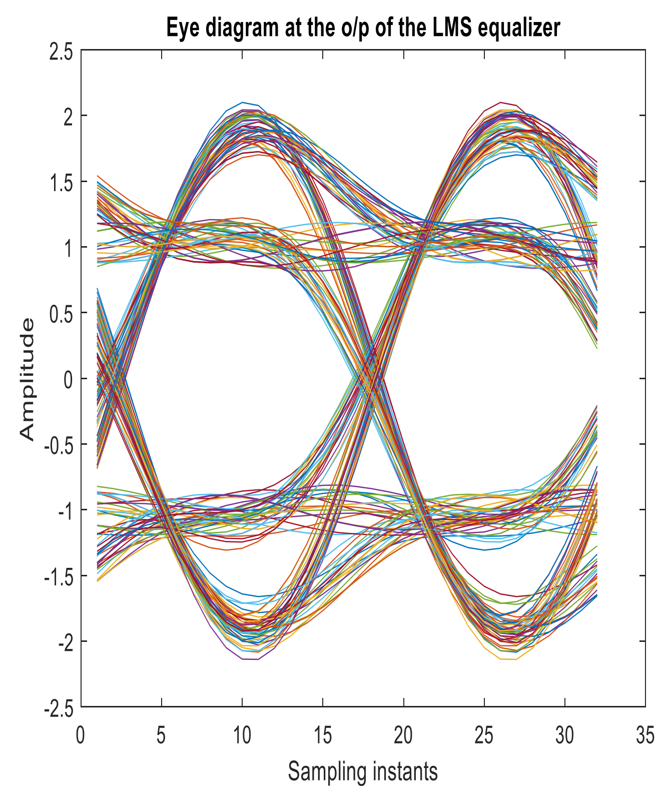

Figure 12: *Eye Diagram at the output of the Equalizer*

RESULT

[1] LMS equalizer with Rectangular pulse Low Pass channel

Table I: *Mean Square error for different E_b/N_o with Rectangular Pulse*

E_b/N_o	Mean Square Error
1	0.4014
2	0.2342
10	0.0652
50	0.0121
75	0.0091
Noiseless	0.0030

[2] LMS equalizer with Sinc pulse Low Pass channel

Table I: *Mean Square error for different E_b/N_o with Sinc Pulse*

E_b/N_o	Mean Square Error
1	0.1816
2	0.1007
10	0.0216
50	0.0089
75	0.0062
Noiseless	0.0038

It is noticed that the MSE is increases as noise increases and E_b/N_o decreasing. LMS equalizer with Rectangular Pulse as E_b/N_o = 10, MSE = 0.0652 and E_b/N_o = 75, MSE = 0.0091. Same way, LMS equalizer with Sinc Pulse MSE is improve. Convergence of error plot shows how error converges with sampling instant. Result is given in Table I & II.

CONCLUSION

This paper shows the performance analysis of LMS equalizer technique with Rectangular Pulse & Sinc Pulse Low pass channel for various value of MSE according to E_b/N_o variation. Result shown the eye diagram is improved and MSE is also decreases as E_b/N_o is increases.

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