International Journal of Advance Research in Science and Engineering
Vol. No.4, Special Issue No. (01), December 2015
www.ijarse.com
IJARSE
ISSN 2319 - 8354

COMPARATIVE STUDY OF VARIOUS FIXED AND VARIABLE ADAPTIVE FILTERS IN WIRELESS COMMUNICATION FOR ECHO CANCELLATION USING SIMULINK MODEL

Mr. R. M. Potdar[1], Mr. Mukesh Kumar Chandrakar[2],
Mrs. Bhupeshwari Chandrakar[3]
[1]Associate Professor, [2]Sr. Assistant Professor [3]M. Tech Scholar, BIT, Durg (India)

ABSTRACT

An adaptive filter is a filter that self-adjusts its transfer function according to an optimization algorithm obsessed by an error signal. Adaptive filter finds its essence in applications such as echo cancellation, noise cancellation, system identification and many others. In this paper we implemented fixed as well as variable algorithm for echo cancellation. This thesis briefly discusses LMS, NLMS, RLS, VSLMS and NLMS adaptive filter algorithms for echo cancellation. For the analysis, an acoustic echo canceller is built using LMS, NLMS, RLS VSLMS and VSNLMS algorithms and the echo cancelled samples are studied using Spectrogram. The study is further extended with its ERLE (Echo Return Loss Enhancement) results. Finally, this project concludes with a better adaptive filter algorithm for Echo cancellation. The implementation and analysis is done using MATLAB®, SIMULINK® and SPECTROGRAM V5.0®.

Index Terms: Acoustics, Echo, Echo Cancellation, MATLAB®, SIMULINK®, Spectrogram, ERLE.

I. INTRODUCATION

FIR and IIR digital filters are designed for applications where the desired filter co-efficient are constants but in several other digital signal processing applications such as echo cancellation, noise cancellation where the filter co-efficient are variables and cannot be specified a priori. The only approach to get the variable filter co-efficient is by an equalizer which has adjustable filter co-efficient, which can be optimized to lessen distortion, on the basis of pre-measured channel characteristics. Such a filter is called an *Adaptive Filter* [1].

An adaptive filter used in acoustic echo cancellation is given in Fig. 1. An acoustic echo is one of the simplest acoustic modeling problems. It happens when the direct signal follows multipath propagation as shown in Fig. 2.

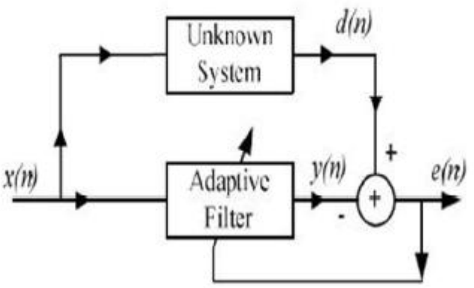


Figure 1. Adaptive filter in Acoustic Echo Cancellation

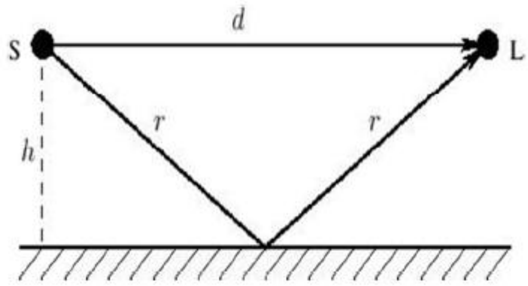


Figure 2. Multipath Propagation

As depicted in Fig. 2, direct signal *d* from the source *S* at height *h* reaches the listener *L,* which is

Followed by the reflected signals *r* having the magnitude almost same as direct signal. It is referred to as *Echo signal*. It is formed when the direct signal hits the obstacles in the room and gets reflected. Such an echo signal needs to be eliminated or suppressed for better signal perception [2].

For echo cancellation, adaptive filters driven by an error signal are used. Adaptive filters have adjustable filter parameters to minimize the undesired signal by using an adaptive algorithm. There are numerous adaptive algorithms used in an adaptive filter, out of which LMS (Least Mean Square) Algorithm, NLMS (Normalized Least Mean Square) Algorithm, RLS (Recursive Least Square) Algorithm are prominent and widely used. Spectrogram is the display of the magnitude of the *Short-Time Fourier Transform*. In the spectrogram display, the x-axis represents the time-index and y-axis represents the frequency, whereas the magnitude is represented by the darkness of the plot.

ERLE (Echo Return Loss Enhancement) is defined as the ratio of the power of the desired signal over the power of the residual signal. It is a smoothed measure of the amount (in dB) that the echo has been attenuated. ERLE should stabilize in the interval [-40dB, 30dB] for a good performance. ERLE is used to measure the potential of echo cancellation.

II. LITERATURE REVIEW

Pushpalatha.G.S et al [2014] briefly discussed LMS, NLMS and RLS adaptive filter algorithms for echo cancellation. For the analysis, an acoustic echo canceller is built using LMS, NLMS and RLS algorithms and the echo cancelled samples are studied using Spectrogram. The analysis is further extended with its cross-correlation and ERLE (Echo Return Loss Enhancement) results. Finally, this paper concludes with a better adaptive filter algorithm for Echo cancellation. The implementation and analysis is done using MATLAB®, SIMULINK® and SPECTROGRAM V5.0®[1].

Radhika Chinaboina et al [2011] Proposed that Adaptive filtering constitutes one of the core technologies in digital signal processing and finds numerous application areas in science as well as in industry. Adaptive filtering techniques are used in a wide range of applications, including echo cancellation, adaptive equalization, adaptive noise cancellation, and adaptive beam forming. Acoustic echo cancellation is a common occurrence in today’s telecommunication systems. The signal interference caused by acoustic echo is distracting to users and causes a reduction in the quality of the communication. This paper focuses on the use of LMS and NLMS algorithms to reduce this unwanted echo, thus increasing communication quality [4].

Rohit Srivastava et al[2012] Described that in a phone conversation, echo is the sound of your own voice being played back to you after a delay. This paper discusses how the echo of telephonic line would be minimizing using RLS algorithm with Matlab implementation. Further it can also be implemented using TMS320C6713 DSP Starter Kit [10].

J. Velazquez Lopez et al [2005] described that In this paper, an echo canceller is presented, using an adaptive filter with a modified LMS (Least Mean Square) algorithm, where this modification is achieved coding error on conventional LMS algorithm. Simulation results, show a better convergence speed than conventional LMS algorithm, furthermore, Coded Error algorithm presents less complexity for digital adaptive filters design, due to reduction of floating point operations [12].

Zhang Jingjing [2012] suggested that through further improvements, a new variable step size LMS adaptive filter algorithm is proposed, which based on the variable step size LMS adaptive filter algorithm of Lorentz a function. This algorithm not only solves the contradiction between the convergence rate and steady-state error, but also improves the anti-interference ability and eliminates the irrelevant noise. Therefore, it provides greater flexibility for the practical application [13].

III. METHODOLOGY

This section describes the digital implementation of various echo cancellation algorithms using MATLAB SIMULINK ® V7.5. We employ SIMULINK® Signal Processing Toolbox and the common blocks used were From Multimedia File, Delay, and Signal to Workspace, Gain, Sum, To Audio Device, LMS Filter, VSLMS, VSNLMS, RLS and NLMS Filter

3.1. Echo Model

This model generates Echo signal for as given input signal. Here we use PCM 16 bit signed, 352 kbps, 22050Hz speech signal as input. The Echo – Simulink model is represented in Fig.3

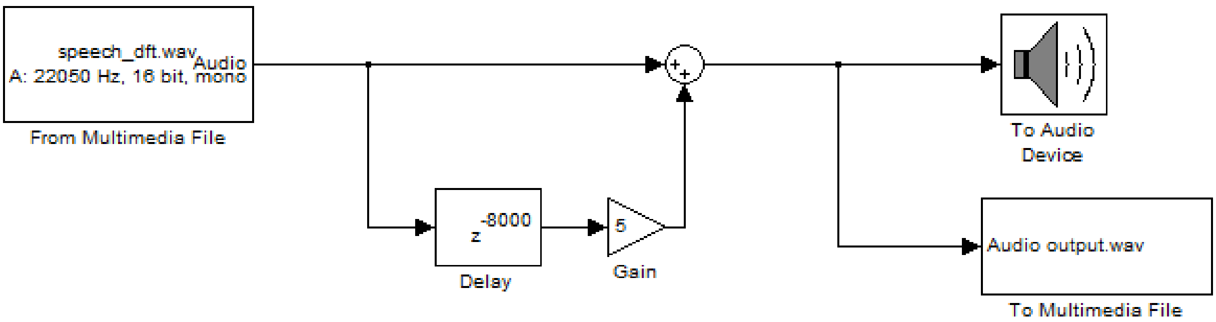


Fig.3Echo-Simulink Model

3.2 Echo Cancellation Model

We implement Echo Cancellation model using LMS, VSLMS, VSNLMS, RLS, NLMS algorithms which are shown in Fig. 5, Fig.6, Fig.7, Fig.8 and fig.9 respectively. Fig. 5 represents LMS filter Simulink block.

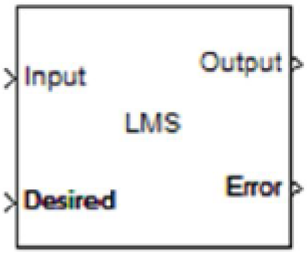


Fig.4 LMS filter simulink block

The above block has the below input and output ports.

Input Port: Signal + its Echo

Desired Port: Desired Audio signal

Output Port: Echo cancelled/suppressed signal

Error Port: Difference between desired signal and adaptive filter output.

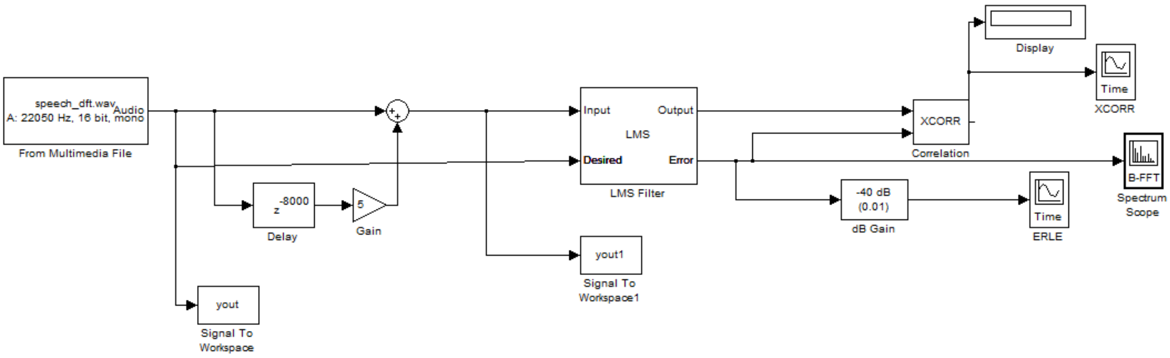


Fig.5LMS Echo Cancellation – Simulink model

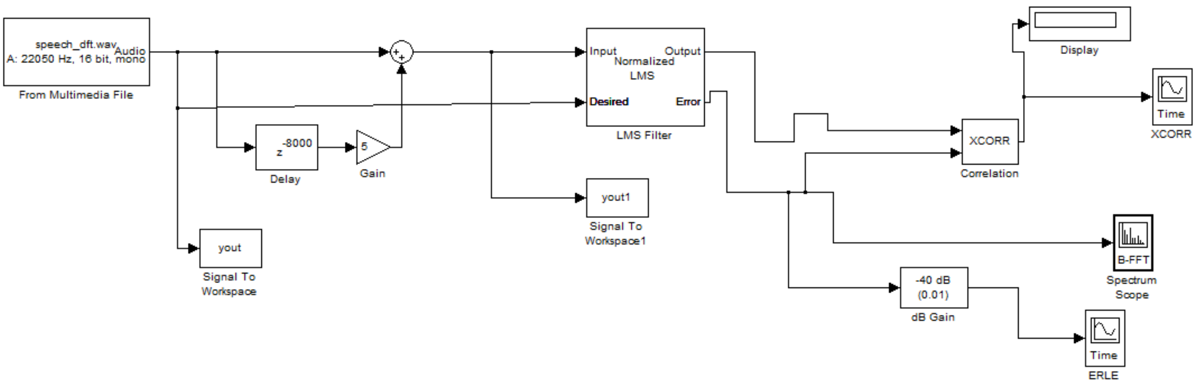


Fig.6LMS Echo Cancellation – Simulink model

IJARSE
ISSN 2319 - 8354

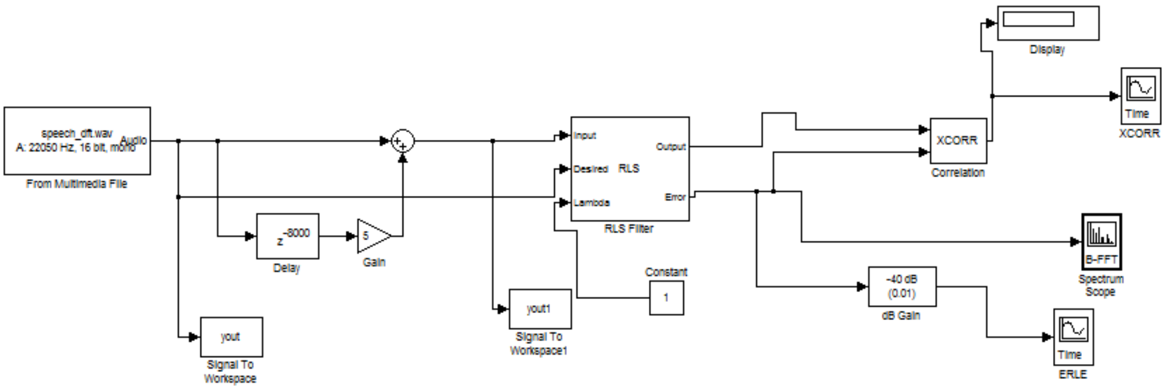


Fig.7RLS Echo Cancellation – Simulink model

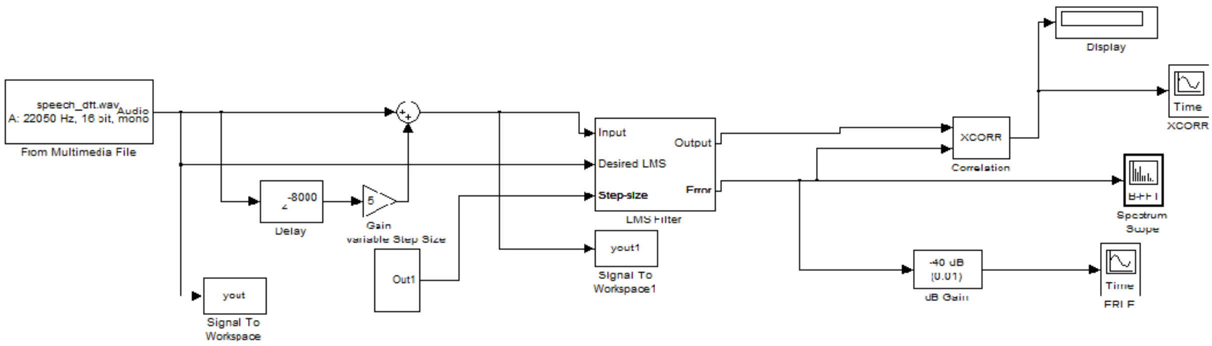


Fig.8VSLMS Echo Cancellation – Simulink model

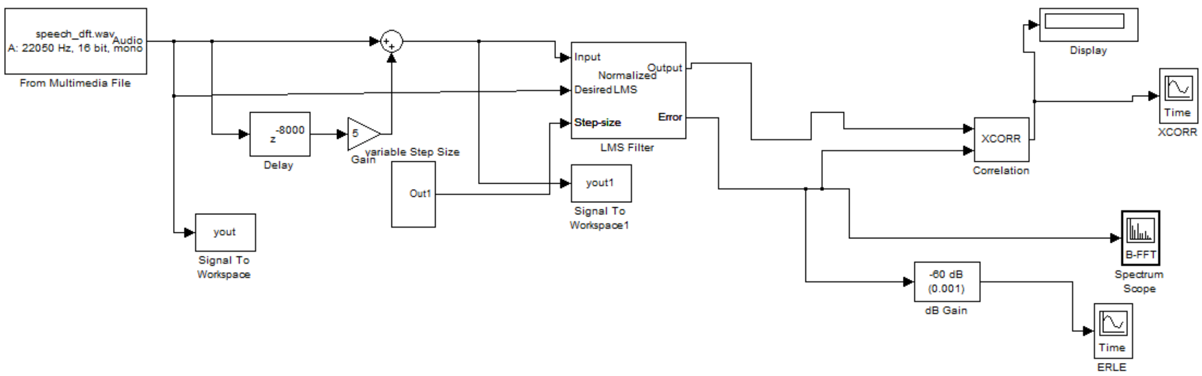


Fig.9VSNLMS Echo Cancellation – Simulink model

3.3 Experimental/Implementation Procedure:

STAGE 1:

1) Initially, a speech signal without any echo components is used as desired/ideal signal. It is a PCM (Pulse Code Modulation) signed 16-bit, 352kbps, 22050Hz, 1 channel speech signal.

2) Echo Model is implemented using Simulink and the value of is kept constant at 0.5 and the value of R (delay) is kept constant at 8000 samples throughout the experiment. Generated signal is an echo signal.

3) The desired signal and signal+ Echo will be used as inputs to LMS Echo Canceller.

4) Simulation is run for 8 seconds and the Output port of LMS block gives the echo cancelled signal.

IJARSE
ISSN 2319 - 8354

Error Port of LMS block gives the difference between desired and LMS output.

5) Desired signal, Signal+ Echo, Output signal and Error signal are saved in the workspace for further analysis.

6) Spectrogram Plots are obtained for desired and output signals using *SPECTROGRAM V.5.0* Tool [8]

7) The same procedure is repeated for VSNLMS, VSLMS, RLS and NLMS Echo Canceller Algorithms

STAGE 2:

1) We use the concept of ERLE (Echo Return Loss Estimation) to measure the potential of Echo cancellation. It is defined as the ratio of the power of the desired signal over the power of the residual signal. The expression to determine ERLE is given in Equation.

$$ERLE = 10\log_{10}\frac{E(d^2(n))}{E(e^2(n))}dB$$

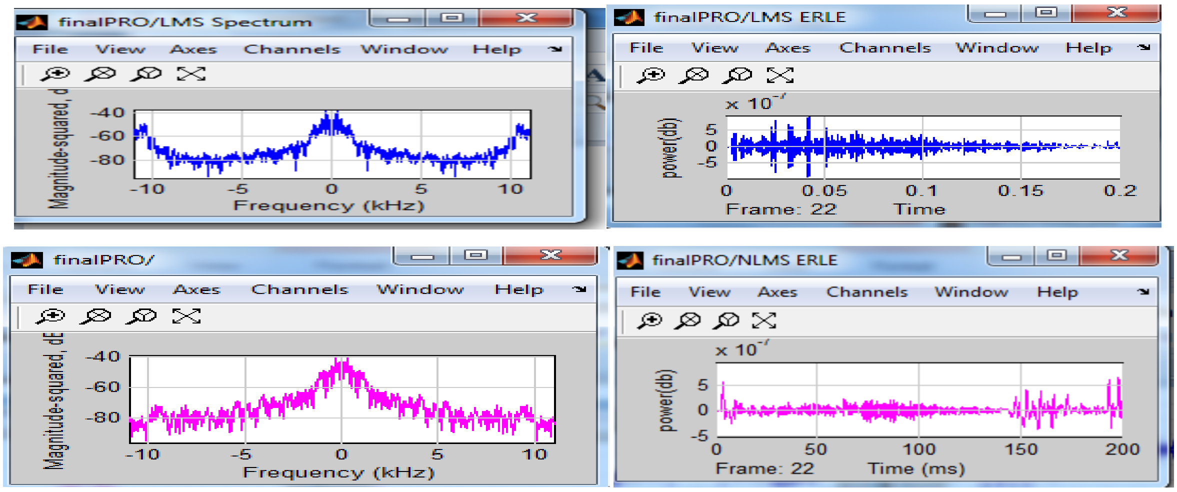
2) It is a smoothed measure of the amount (in dB) that the echo has been attenuated. ERLE should stabilize in the interval [-40dB, 30dB] for a good performance

IV. IMPLEMENTATION ANALYSIS

This section discusses the analysis of Echo cancellation algorithm implemented using Spectrogram, ERLE, and Cross-Correlation.

Spectrogram Analysis – For LMS, NLMS and RLS echo canceller output samples, spectrograms were determined and the plots are represented in figure. From the spectrogram plots we observe that the NLMS cancels the echo signals to a maximum extent and RLS cancels the echo signals to a minimum extent whereas in LMS algorithm, echo signals are cancelled out moderately.

ERLE Analysis – As discussed earlier, ERLE measures the potential of echo cancellation. It is calculated as per the Equation. The ERLE plots for LMS, NLMS, and RLS algorithms are represented in figure. For LMS algorithm, ERLE value lies in the range [-65dB, 50dB]. For NLMS algorithm, ERLE value lies in the range [-60dB, 40dB] and for RLS algorithm, ERLE value lies in the range [-80dB, 60dB]. But, ERLE value has to stabilize in the range [- 40dB, 30dB] for better performance. Hence, NLMS algorithm offers better performance when compared to LMS and RLS.



IJARSE
ISSN 2319 - 8354

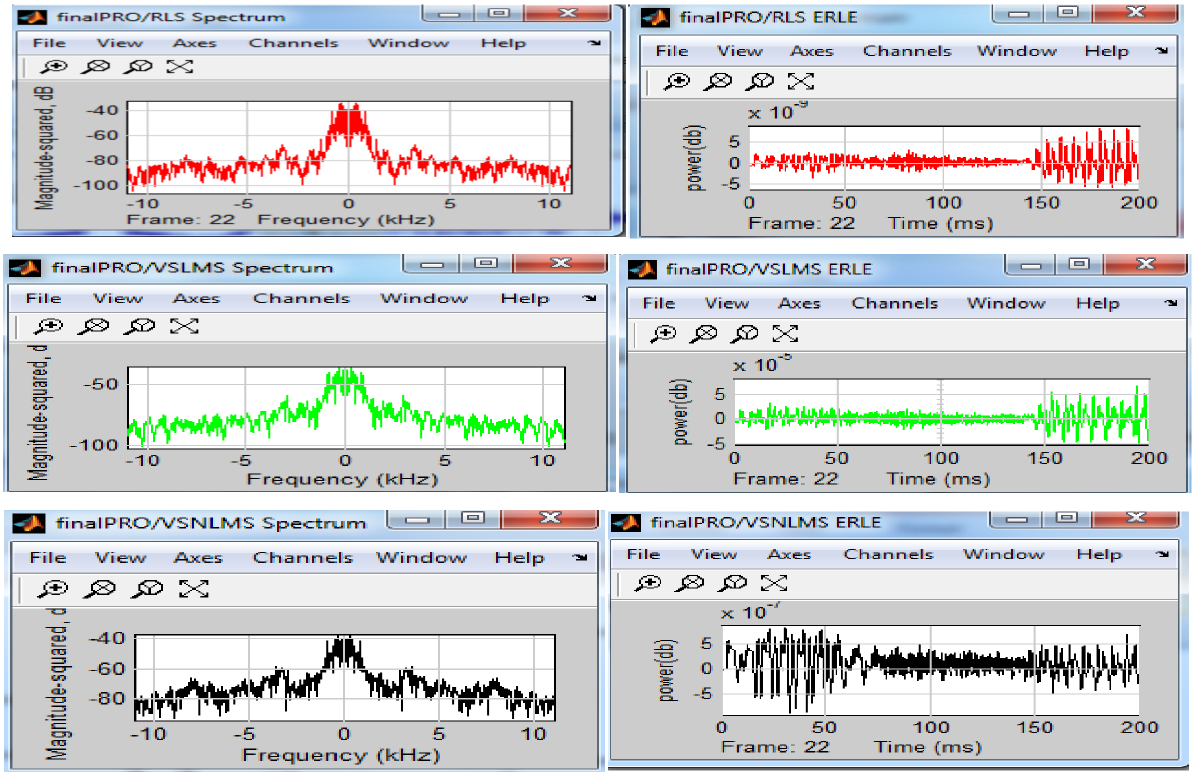


Fig.10 Results of All Filters.

V. CONCLUSION

Considering the Spectrogram analysis, cross correlation and ERLE results of three adaptive filter algorithms, this paper concludes that the NLMS algorithm is best suited for echo cancellation. NLMS algorithm provides better ERLE stability in the range [-40dB, 30dB]. Also the amplitude of time shifted in Cross Correlation plot is minimum for NLMS algorithm.

Listening tests indicate that the perceived temporal quality or texture is better for NLMS, followed by LMS and RLS. This is also evident from Spectrogram, ERLE and Cross-Correlation plots. This paper also discusses the implementation of LMS, NLMS, VSNLMS, VSLMS and RLS adaptive filter algorithms for echo cancellation in a concert hall and it brings out the difference between LMS, NLMS, RLS, VSLMS and VSNLMS algorithms, finally it performs a better analysis of echo cancellation algorithms considering Spectrogram, ERLE and cross-correlation. This paper concludes with the NLMS adaptive filter algorithm to be a better algorithm among all echo cancellation.

REFERENCES

[1]. Pushpalatha.G.S, Mohan Kumar. 2014. Echo Cancellation Algorithms using Adaptive Filters: A Comparative Study. Int. J. on Recent Trends in Engineering and Technology, Vol. 10, No.2.

[2]. Rafid Ahmed Khalil 2008. Adaptive Filter Application in Echo Cancellation Systemand Implementation using FPGA. AI Refidain Engineering Vol.16 No.5.

[3]. Hung Ngoc Nguyen Majid Dowlatnia Azhar Sarfraz. 2009. Implementation of the LMS and NLMS algorithms for Acoustic Echo Cancellation in teleconference system using MATLAB. Report 09087 ISSN 1650-2647 ISRN VXU/MSI/ED/E/--09087/--SE.

[4]. Radhika Chinaboina, D.S.Ramkiran, Habibulla Khan, M.Usha, B.T.P.Madhav, K.PhaniSrinivas & G.V.Ganesh. 2011. ADAPTIVE ALGORITHMS FOR ACOUSTIC ECHO CANCELLATION IN SPEECH PROCESSING. Vol7Issue1/IJRRAS_7_1_05.

[5]. Raghava Yathiraju 2013. Acoustic Echo Cancellation Using Conventional Adaptive Algorithms. International Journal of Inventive Engineering and Sciences (IJIES) ISSN: 2319–9598, Volume-1, Issue-12.