Noise Cancellation in Communication Systems using LMS and RLS Algorithms

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***Abstract* - A review of noise cancellation in communication systems based on adaptive filter algorithms is presented. The modifying of signal characteristics in noise cancellation is relatively fast which involves the utilization of adaptive algorithms for quick coverage. The LMS and RLS algorithms play a vital role in noise cancellation to increase the convergence rate. Current communication applications require reducing the computational complexity in real-time implementation. The category of adaptive filters is automatically changing the parameters of its algorithms according to the input signal. Many adaptive filters are digitally executed to update the algorithm parameters. The original applications of an adaptive filter in numerous fields including system recognition and noise cancellation can be modeled by MATLAB simulator. The input signal of an adaptive filter is with the mixed algorithms and noise signal in the specific design of MATLAB to remove the noise from the original data and produce reliable data at the output port. The filter implementation shows the strength of the suggested structure and the capabilities of the proposed algorithms have been investigated and analyzed. The performance of the filter is promising to support the current and future communication systems in terms of noise cancellation.**

Keywords - Noise Cancellation, Communication System, RLS, LMS, MATLAB Simulator

I. INTRODUCTION

The noise cancellation has high consideration and represents a fundamental technique to eliminate the noise associated with the original signal [1]. This technique could be found in many communication systems such as handphone [2]. The noise elimination has implemented in image processing, echo cancellation, biomedical signals and speech enhancements [3]. The noise phenomena could reduce the signal quality, and the elimination of these phenomena becomes more necessary to suppress and enhance receiver signal quality in many applications. The cancellation of noise from the channel become a focal point of research and has introduced first time by [4]. The computational requirements of LMS and RLS filter are of long impulse response principally when Digital Signal Processing (DSP) module is implemented [5]. The noise convergence of colored background become slow when the filter input signal mixed with high spectral density range [6]. In this field, many approaches were introduced as in [7-15]. The algorithms of LMS and RLS are most frequently used to eliminate the noise from the signal due to its simplicity and robustness in the implementation performance [16]. In the process of data transmission, the noise is automatically added to information from source to receiver part. The principle algorithms of noise cancellation have explained by [17] as illustrated in Figure 1.

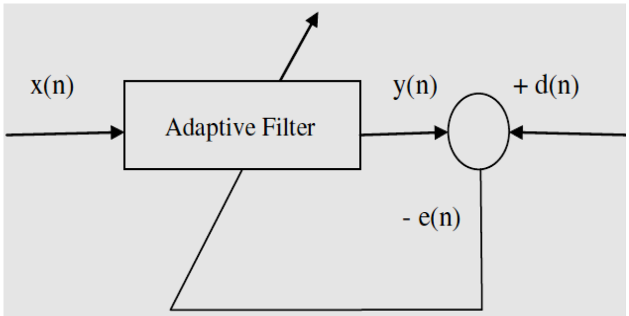

Figure 1: fundamental of Adaptive algorithms [17]

The primary goal of these algorithms is to process the input signal to get the pure signal without noise. In this manner, to remove the distortion from the original waveform, the useful signal is subtracted from the filtered signal [18]. To minimize the noise signals, the algorithms are driven by the error signal to produce the filter coefficients. By using an adaptive filter in communication systems, an excellent solution could offer when signal processing requires significant improvement against fixed filter in conventional procedure [19-20]. The objectives of this work are to review the current techniques of nose optimization and develop the performance of LMS and RLS algorithms. To select the adaptive filter, the following factors should be taken into account [21]:

a. Convergence rate
b. Structure of the filter
c. Requirements for computation
d. Robustness of the filter

The mentioned factors manipulate a great deal in filter algorithms selection for noise cancellation process. Hence, the most extensive algorithms used in the proposed work could employ LMS and RLS adaptive filters [22-23]. The category of LMS filter is used to minimize the error from an input signal and produce free output. Meaning that the difference between the useful response and noisy signal could be represented by algorithm equations [24]. Figure 2 shows the setup of adaptive noise cancellation to reference signal which estimates the noise signal and generates an error signal for cancellation task. The filter output is used to adjust the tap weight in the filter structure [25-26]. The adaptive filter is used to regulate their coefficients to reduce and optimize the error as FIR filter algorithms.

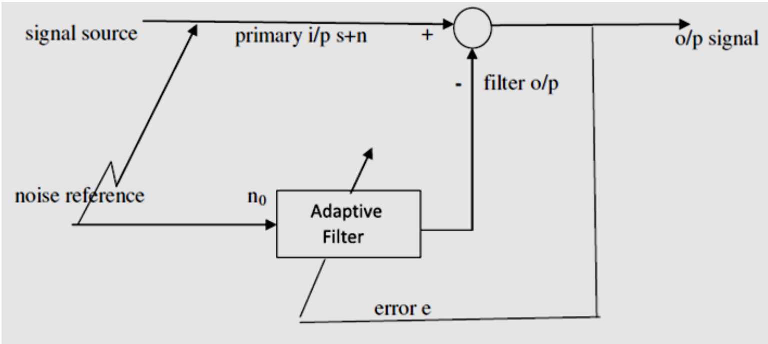

Figure 2: the setup of adaptive noise cancellation [22]

This paper proposes the algorithms shown in Figure 3 to optimize the noise in the channel which supports the task of an adaptive filter in noise cancellation. The rapid growth in most communication systems requires efficient algorithms to control the noise and attenuation in the order that produced by different sources.

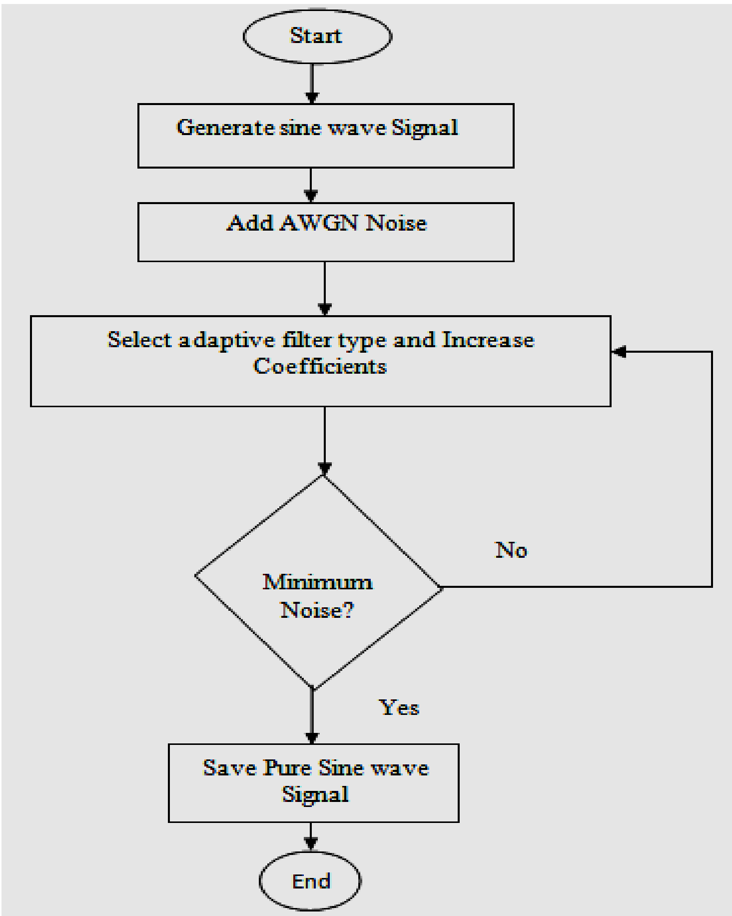

Figure 3: Proposed algorithms for noise cancellation optimization

II. NOISE CONTROL USING FIR-LMS ADAPTIVE FILTER

The reduction of the unwanted amount of noise in the channel can be achieved by the active noise control system using FIR-LMS adaptive filter algorithms. Typically, the noise signal is introduced by a device chain in the system or from channel medium. As a result, the noise close to the data source should be determined and then suppressed by generating an anti-noise signal equal to an error signal using adaptive filter algorithms. The band-limited range from 80 KHz to 300 KHz which represents the baseband signal of many communication systems with specific filter length could be simulated by MATLAB command window to get filter response as shown in Figure 4.

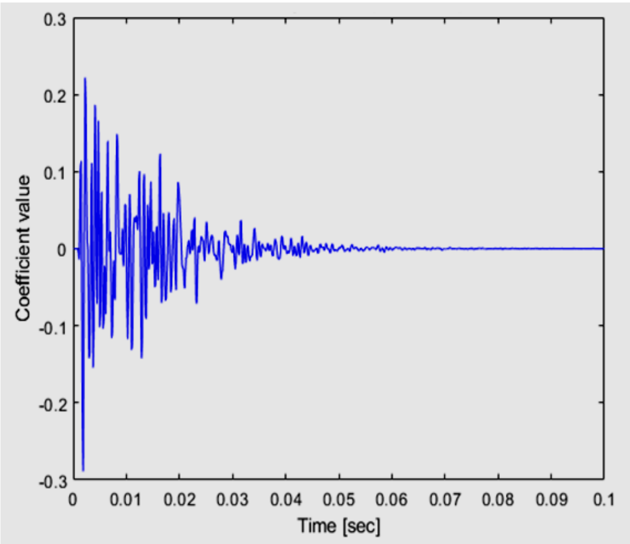

Figure 4: FIR filter response for noise control

To estimate the secondary path of propagation, the noise controller response showing in Figure 5 is written in MATLAB code. Classically, the filter length in most cases could not be for sufficient control. This figure illustrates the coefficients of actual and estimated propagation path to demonstrate the accuracy of secondary path response. Through the operation of the filter, the performance of a noise control system does not harm the residual error. The applications of the noise control system involve the coming noise by channel. To emphasize the difference between the original and noise signals, the adaptive filter has been enabled. The estimated time delay model shown in Figure 6 is designed and simulated in SIMULINK block set, and the waveforms of mixed signal are illustrated in Figure 7 and Figure 8.

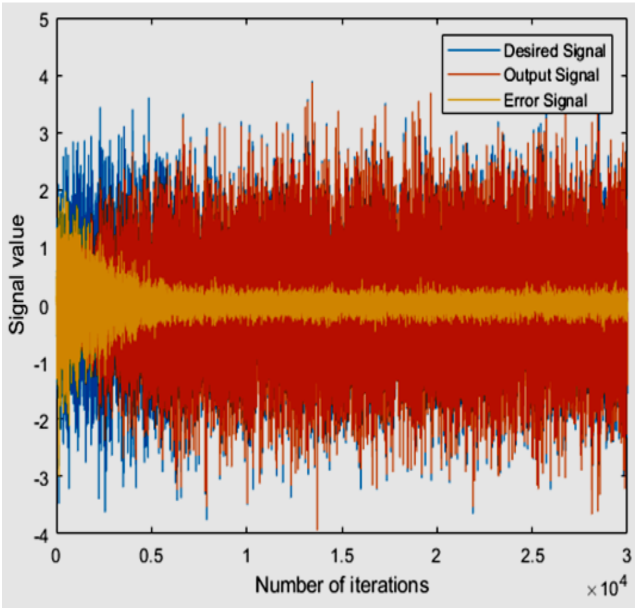

Figure 5: secondary identification of the adaptive filter

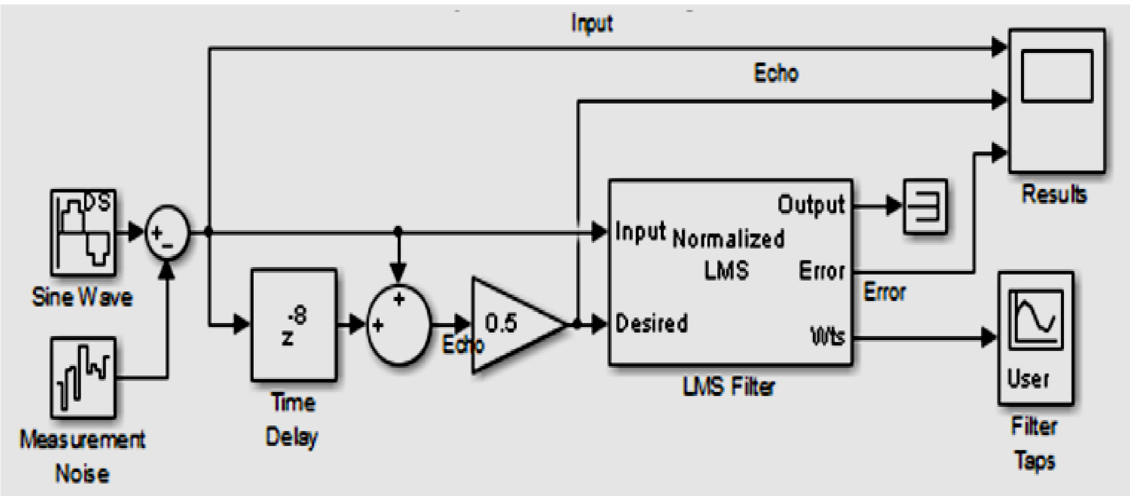

Figure 6. Delay Time Estimation Model

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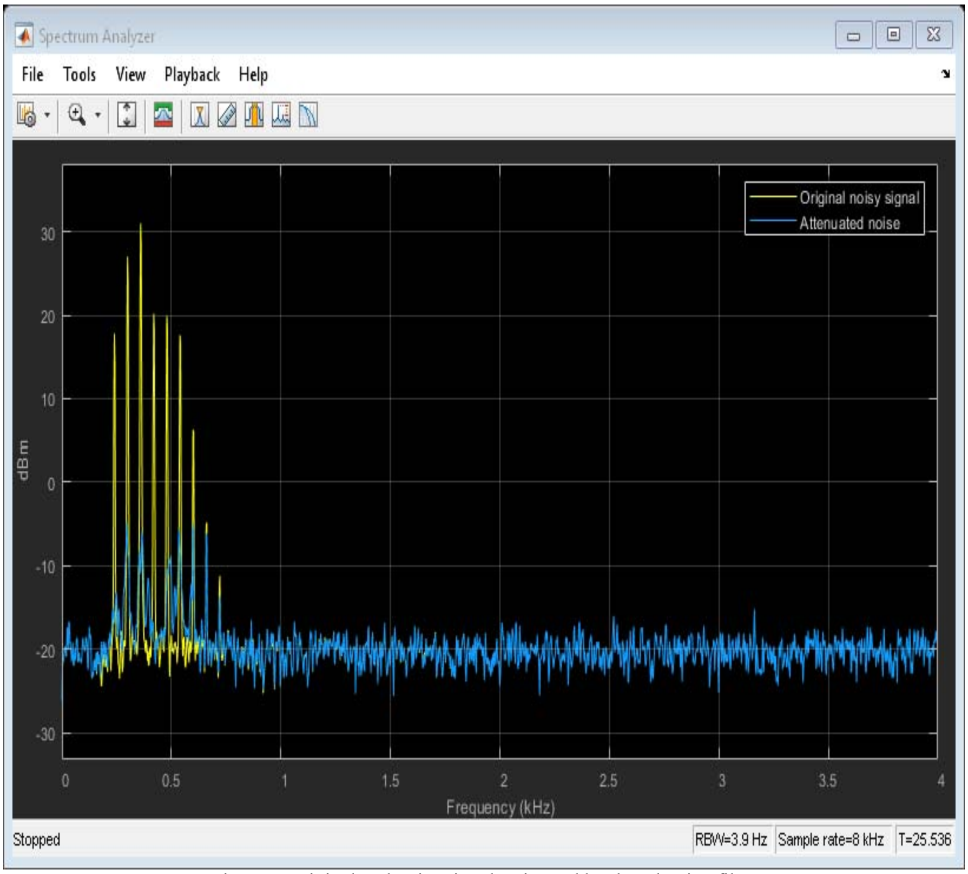

Figure 7. original and noise signal estimated by the adaptive filter

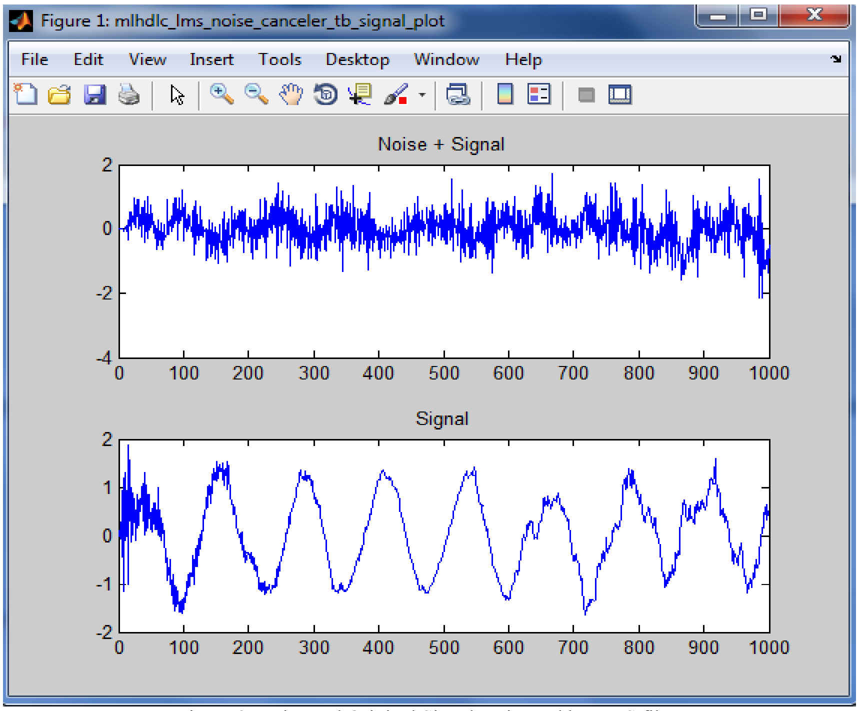

Figure 8. Noisy and Original Signal Estimated by LMS filter

III. NOISE CONTROL USING RLS ADAPTIVE FILTER

To extract the useful data from the noisy signal, the RLS algorithms can be used. The data represented by the sine-wave that is mixed with AWGN noise to eliminate the error caused by the noise signal using suggested algorithms. The adaptive noise cancellation block diagram is shown in Figure 9, and Figure 10 has been designed using SIMULINK block set in MATLAB.

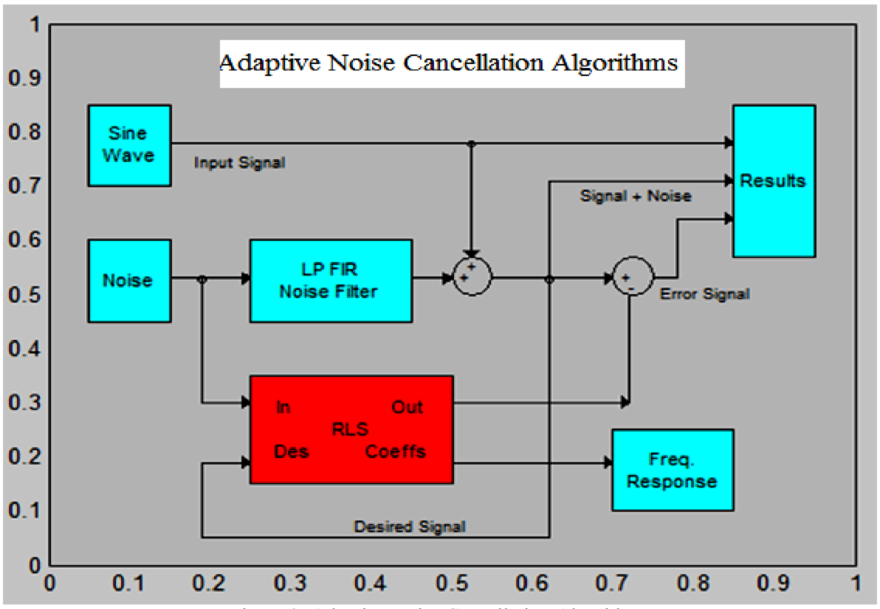

Figure 9: Adaptive Noise Cancellation Algorithms

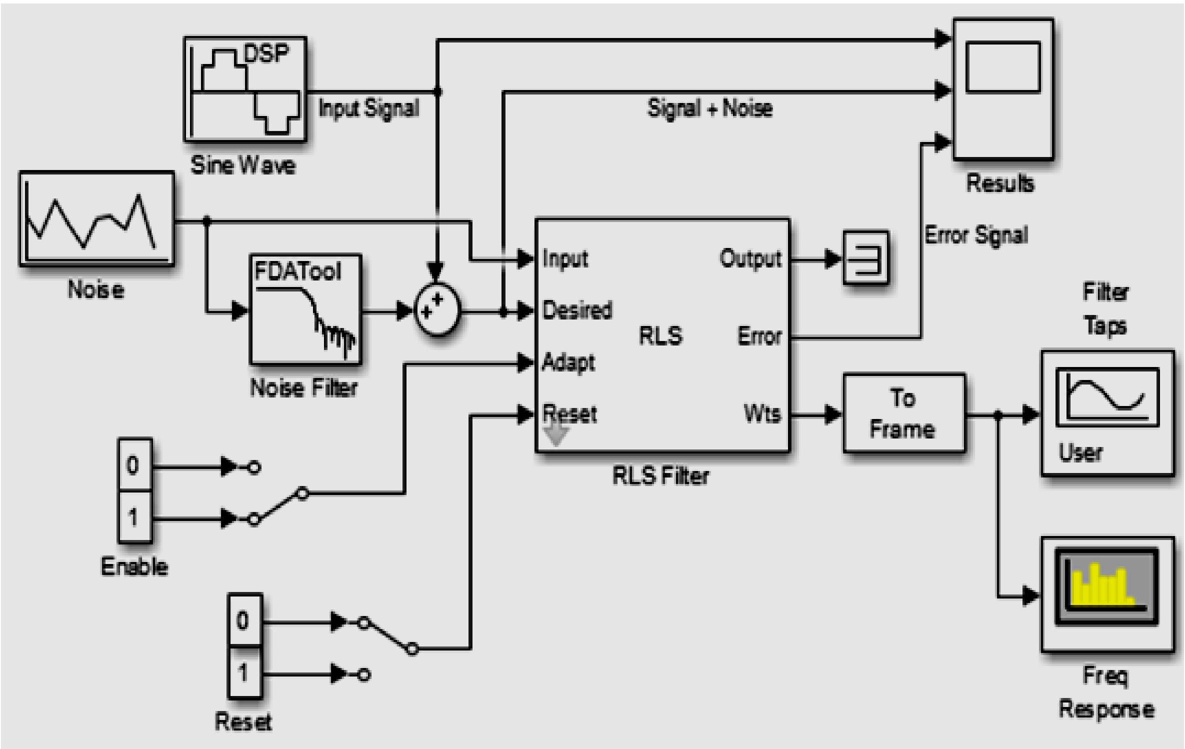

Figure 10: Adaptive noise cancellation model

Figure 11 shows the input and output waveform of adaptive noise cancellation model. The capability of suggested algorithms is apparent in the error estimation and removes from the original signal after mixed with the noise signal.

Figure 11: Input and output waveforms of the RLS model

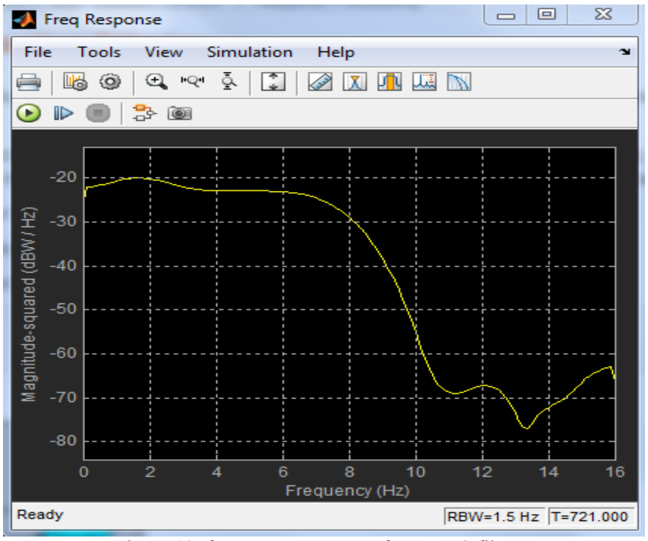

Figure 12: frequency response of FIR-RLS filter.

The first waveform represents pure input sine wave and the second waveform shows the attenuated signal by error effect. Hence, the error signal has isolated from the original signal properly. Figure 12 illustrates the frequency response of FIR-RLS filter and low pass filtering. Figure 13 shows the FIR filter taps.

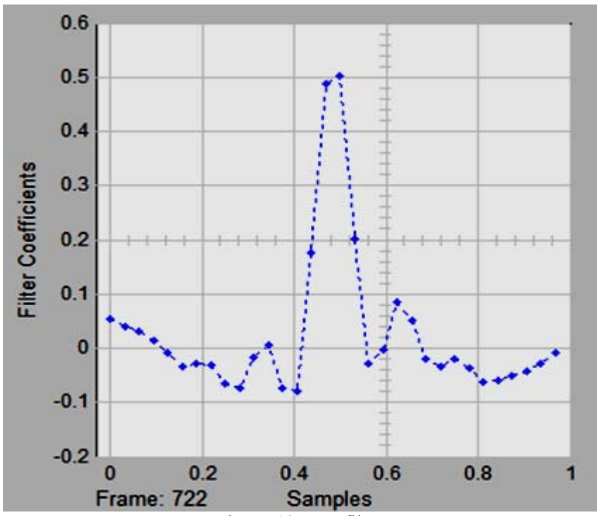

Figure 13: FIR filter

IV. RESULTS AND DISCUSSION

The results of proposed LMS and RLS algorithms by SIMULINK for problem consideration are focused on noise cancellation and MATLAB script to show the algorithm performance. The sine wave mixed with AWGN noise is considered as an input signal for the filter algorithms. The adaptive filter shows a significant reducing of noise in the channel. The difference between the desired and adaptive filter output waveforms represent the error which should remove the signal under the processing system. The adaptive filter provides approximately zero error which considered as promising design to support different communication systems. The normalized LMS and RLS algorithms error calculation for a different amplitude of noise signal are illustrated in Table I. These results show that the RLS algorithms provide better performance than the LMS algorithm. While during transmission phase, the LMS algorithms are looking better. Meaning that, each algorithm has a weak point is some applications and highly effective in other applications.

TABLE I. ERROR CALCULATION IN LMS AND RLS ALGORITHMS

An amplitude of Noise Signal	LMS algorithm Error	RLS algorithm Error
200 mv - 50% of the original signal	4.607×10-4	2.1264×10-5
100mv-40% of the original signal	4.664×10-4	2.2464×10-5
50 mv – 30% of the original signal	4.702×10-4	2.4764×10-5
20 mv – 10% of original signal	4.851×10-4	2.6964×10-5

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V. CONCLUSION

This paper introduced an extensive review and improvements in adaptive filtering including LMS and RSL algorithms. Noise reduction in the LMS filter is better than the RLS filter in many noise cancellation applications due to its high computational complexity. Additionally, the stability and reliability of the LMS algorithms were shown to be better than the RLS algorithms. The implementation of the LMS filter was better and easier to estimate the error in the system. Furthermore, the LMS technique provides a useful frame of reference for further evaluation which could be achieved via more complicated adaptive filtering design. The performance of adaptive noise cancellation is associated with many parameter in the system design including the effect of step size, number of samples and coefficients number of the FIR filter. Each parameter had an optimization effect on noise cancellation which gave high quality and more efficient computation algorithms. Many experiments of simulation were performed by designing a practical communication system with AWGN noise, and random attenuation were prepared to show the efficiency of the two adaptive filters. The impact of many steps and particle size was examined. This work needs more tuning by calculating the BER of both algorithms by designing a model to monitor the noise with variable frequencies in software defined radio, which is rapidly growing currently to meet the user demands in many applications.

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