Optimization of Rls Adaptive Filter Architecture Using Gate Level Modification for Clamor Cancellation

P. KaviyaPriya, V. Kaviyasree, S. Mahalakshmi, M. Mohanapriya,

Abstract--An adaptive filter constitutes a major part in the noise cancellation application. In this paper, we introduce associativity technique instead of conventional technique using MatLab Simulink. Recursive least square is an adaptive algorithm that periodically finds the coefficients that modify a weighted linear squares cost function according to the input signals. The proposed method shows better enhancement in LUT respectively. From the results, it is clear that Associativity technique shows LUT reduced by 77.14% than that of Conventional technique for 8 tap FIR Filter and it is reduced by 12.8% than that of Conventional technique respectively.

Keywords—Adaptive filter, Associativity, LUT, RLS, SNR.

1. INTRODUCTION

An adaptive filter is a computational device that aims to mould the relationship between two signals in real time in a repetitive manner. It constitutes an important part of statistical signal processing.

The adaptive filters are most commonly used in different areas such as acoustics, communications, signal processing, control systems, and others to deal with random signals with stationary or quasi stationary statistics. Some applications of adaptive filter are adaptive inverse, adaptive prediction, adaptive identification, and active noise cancellation.

Error signal is used as feedback to the Adaptive filter to refine the transfer function. The common cost function is the signal to noise ratio. There are parameters that decide the performance of the adaptive filtering algorithms.

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2. ADAPTIVE NOISE CANCELLATION

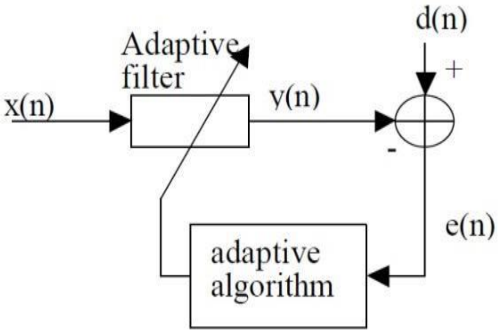

Figure 1: Block diagram of Adaptive Noise Canceller

Figure 1 shows the block diagram of Adaptive Noise Canceller. In this figure, the Adaptive Noise Canceller has two inputs which are main input and auxiliary input. The main input delivers a signal from the signal source which is manipulated by the presence of noise $\hat{n}$ unrelated with the signal.

The auxiliary input is the noise n_0 unrelated to the signal but related in some way with the noise n. The noise n_0 is stated as an input to a filter which produces an output $\hat{n}$ which is a close estimate of main input noise. The filter output obtained is deducted from the manipulated signal which produces the signal ŝ, which is the ANC system output.

2.1 RLS ALGORITHM

Recursive Least Square (RLS) algorithm is a widely used adaptive technique due to its fast convergence rate than other algorithms like LMS, NLMS. At every iteration,the solution of new samples of the incoming signals is computed in recursive form .RLS filter outperforms LMS filter by the factors such as fast convergence , utility of past available information in computation and no approximations in the algorithm.

Step 1: Weight Initialization

w(0) = 0

Step 2: Inverse Correlation Matrix Initialization

P(0) = δ-1IM

Step 3:Compute Gain Vector

π(m+1) = P(m)u(m+1)

k(m+1) = π(m+1)/λ+ut(m+1)π(m+1)

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Step 4:Compute Error Estimate
$e(m+1) = d(m+1)-wt(m)u(m+1)$
Step 5:Compute Inverse CorrelationMatrix
$P(m+1)=\lambda-1p(m)-\lambda-1k(m+1)ut(m+1)P(m)$
Step 6:CoefficientsUpdation
$w(m+1)=w(m)+k(m+1)e(m+1)$
where λ is forgetting factor

3. CONVENTIONAL FILTER DESIGN

3.1 CONVENTIONAL FIR FILTER DESIGN

In Conventional design, FIR filter follows Systolic Architecture, Pipelining, Parallel processing and folding techniques .

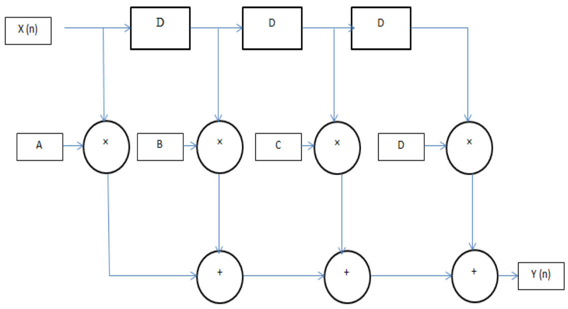

Figure 2. Conventional 4-tap FIR filter

Figure 2 shows the Conventional 4-tap FIR filter diagram.

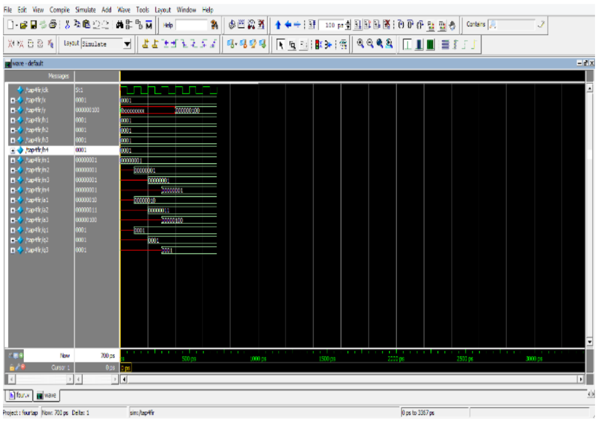

Figure 3. Output of Conventional 4-tap FIR filter using ModelSim

Figure 3 shows the output of conventional 4-tap FIR filter using ModelSim

3.2 CONVENTIONAL RLS FILTER DESIGN IN SIMULINK

3.2.1 ECG signal denoising

The design is tested for noise cancellation of ECG signal. ECG signal with the Power Line Interference (PLI) noise is taken as the desired signal.

The power line interference (PLI) noise is sinusoidal wave of 50 Hz is given as reference input to the filter. Then the denoised ECG signal is obtained by subtracting the filter output from the desired input.

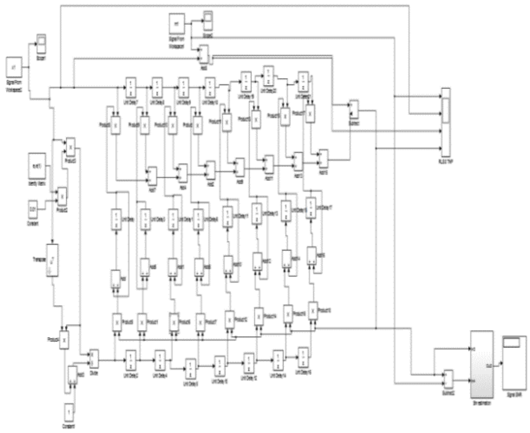

Figure 4. MatLab Simulink model for Conventional 8-tap RLS filter

Figure 4 shows the simulation of the Conventional 8-tap RLS filter for denoising ECG signal is carried out with the following specifications: Filter order N=8, iterations= 4000, Small positive constant δ= 0.01 andforgetting factor λ=1.

The input ECG signal is taken from MIT-BIH database (105.dat). The first 4000 samples are taken to the process and simulated in MatLab.

Then this signal is used in MatLab Simulink by using signal from workspace block. The power line interference (PLI) noise is sinusoidal wave of 50 Hz, generated in MatLab and it is given as reference input to the filter using signal from workspace block.

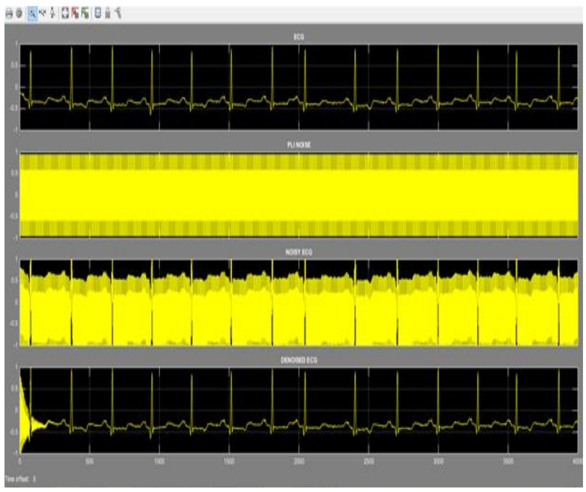

Figure 5. Output of Conventional 8-tap RLS filter using MatLab Simulink

Figure 5 shows the output of Conventional 8-tap RLS filter using MatLab Simulink for denoising ECG signal is carried out with the following specifications: Filter order N=8, step size μ= 0.2 and iterations= 4000.

4. PROPOSED FILTER DESIGN

4.1 ASSOCIATIVITY FIR FILTER DESIGN

Adaptive filter architecture is designed by using Associativity technique which is a High level transformation

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method.Associativity technique is used to reduce the critical path of the design. This High level transformation technique results in area reduction.

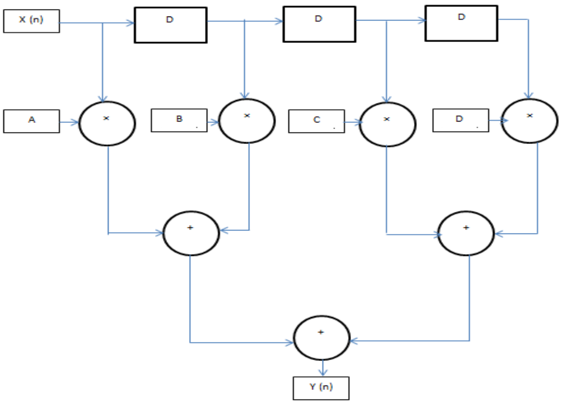

Figure 6. Associativity 4-tap FIR Filter

Figure 6 shows the Associativity 4-tap FIR filter diagram

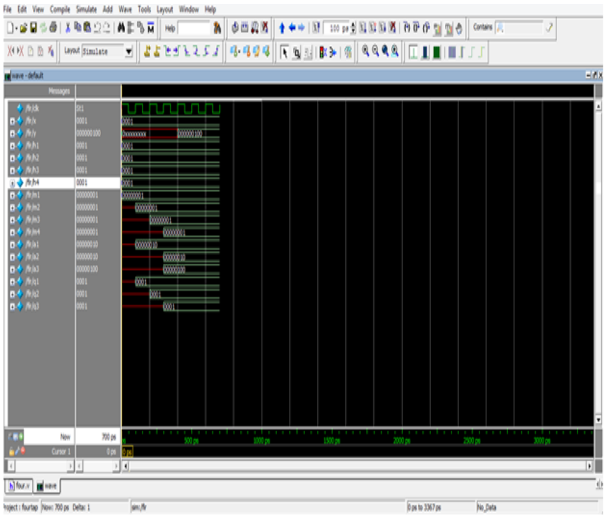

Figure 7. Output of Associativity 4-tap FIR filter using ModelSim

Figure 7 shows the output of Associativity 4-tap FIR filter using ModelSim

4.2 ASSOCIATIVITY OF RLS ADAPTIVE FILTER DESIGN

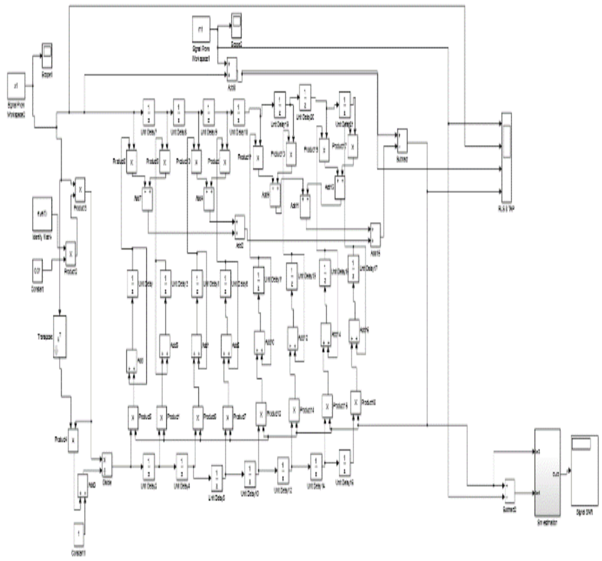

Figure 8.MatLab Simulink model for Associativity 8-tap RLS Filter

Figure 8 shows the simulation of the Associativity 8-tap RLS filter for denoising ECG signal is carried out with the following specifications: Filter order N=8,iterations= 4000, Small positive constant δ= 0.01 andforgetting factor λ=1.

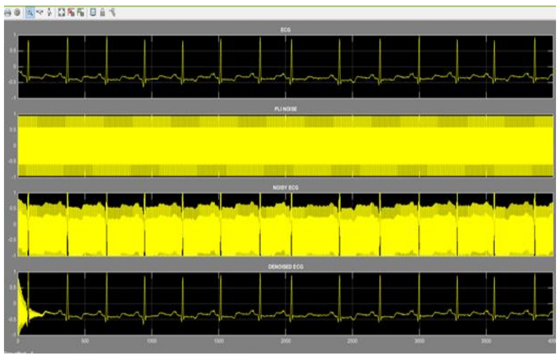

Figure 9. Output of Associativity 8-tap RLS filter using MatLab Simulink

Figure 9 shows the output of Associativity 8-tap RLS filter using MatLab Simulink for denoising ECG signal is carried out with the following specifications: Filter order N=8, step size μ= 0.2 and iterations= 4000.

5. PERFORMANCE ANALYSIS & RESULTS

5.1 FIR FILTER

Xilinx configuration used for Synthesize:

Family	:	Spartan3E
Device	:	XC3S250E
Speed	:	-4

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Table 1. Performance analysis based on LUT using Xilinx

PARAMETER	8 TAP		16 TAP	
	CONVENTIONAL	PROPOSED (ASSOCIATIVITY)	CONVENTIONAL	PROPOSED (ASSOCIATIVITY)
Area (LUT)	35	8	132	115

From the table 1, it is clear that the LUT of proposed structure is decreased by 77.14% than that of conventional structure for 8-tap FIR filter.and the LUT of proposed structure is decreased by 12.8% than that of conventional structure for 16-tap FIR filter. The LUT is calculated by using Xilinx

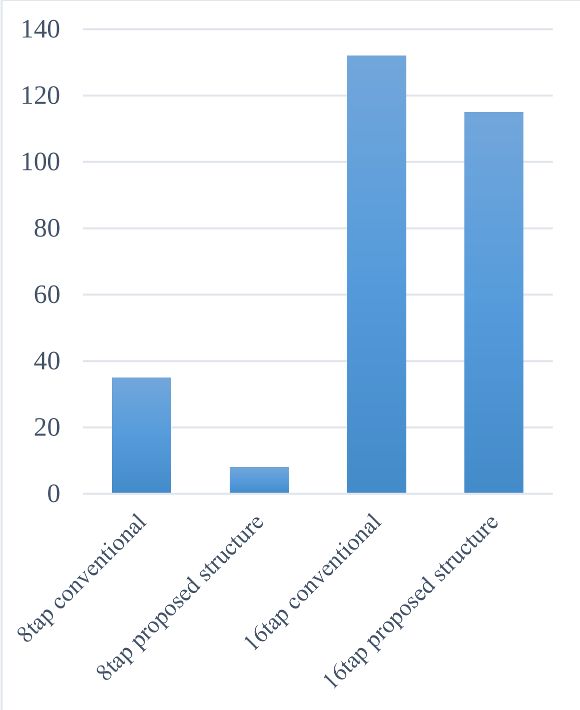

Figure 10. Graphical representation of LUT Comparison

Figure 10 shows the graphical representation of LUT Comparison for Conventional and Associativity techniques.

5.2 RLS PERFORMANCE ANALYSIS

for SNR calculation, here 25 ECG signal was used. There is a constant SNR for both conventional and associativity.

Table 2. Performance analysis based on SNR using MatLab Simulink

ECG SIGNAL	4-TAP		8-TAP		16-TAP	
	CONVENTIONAL SNR	ASSOCIATIVITY SNR	CONVENTIONAL SNR	ASSOCIATIVITY SNR	CONVENTIONAL SNR	ASSOCIATIVITY SNR
ECG100	36.6	36.6	31.81	31.81	58.63	58.63
ECG101	36.82	36.82	32.25	32.25	59.12	59.12
ECG105	37	37	32.68	32.68	59.57	59.57
ECG108	36.43	36.43	31.28	31.28	58.63	58.63
ECG111	37	37	32.68	32.68	59.57	59.57
ECG114	36.6	36.6	31.81	31.81	58.63	58.63
ECG116	37.87	37.87	35.57	35.57	62.49	62.49
ECG118	37.87	37.87	35.57	35.57	62.49	62.49
ECG121	36.6	36.6	31.81	31.81	58.63	58.63
ECG123	36.6	36.6	31.81	31.81	58.63	58.63
ECG200	37.87	37.87	35.57	35.57	62.49	62.49
ECG203	38.35	38.35	37.42	37.42	64.42	64.42
ECG205	36.6	36.6	31.81	31.81	58.63	58.63
ECG208	38.67	38.67	38.4	38.4	65.38	65.38
ECG210	36.6	36.6	31.81	31.81	58.63	58.63
ECG213	36.6	36.6	31.81	31.81	58.63	58.63
ECG215	36.6	36.6	31.81	31.81	58.63	58.63
ECG219	36.6	36.6	31.81	31.81	58.63	58.63
ECG222	36.6	36.6	31.81	31.81	58.63	58.63
ECG223	37.87	37.87	35.57	35.57	62.49	62.49

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ECG228	35.64	35.64	29.51	29.51	56.28	56.28
ECG230	36.6	36.6	31.81	31.81	58.63	58.63
ECG232	36.6	36.6	31.81	31.81	58.63	58.63
ECG234	36.6	36.6	31.81	31.81	58.63	58.63

From the table 2, it is clear that the SNR of Conventional and Associativity for 4-tap, 8-tap, and 16-tap RLS filters are compared. In the proposed method, SNR have not been increased or decreased.

6. CONCLUSION

In this paper, the proposed Associativity technique is applied to FIR filter. LUT is calculated by using Xilinx ISE. Here it shows better improvement by decreasing LUT in proposed technique when compared to conventional technique. The LUT of proposed structure is decreased by 77.14% than that of conventional structure for 8-tap FIR filter and the LUT of proposed structure is decreased by 12.8% than that of conventional structure for 16-tap FIR filter. Then it is implemented in the RLS Adaptive filter for optimization of noise cancellation of ECG signal. The results are obtained from the MATLAB Simulink. The SNR of proposed technique has to either increase or maintain constant when compared to conventional technique. For this paper, SNR has maintained constant. Further, it can be implemented in FPGA kit.

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