DESIGN AND IMPLEMENTATION OF RNS FIR FILTER FOR EEG ARTIFACTS AND CLASSIFICATION

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Abstract - *The EEG data are subject to various artifacts contaminations stemming from the surroundings, subject, and the experimental equipment or even from within the brain. Hence, use of filters will help in removal or limiting the influence of artifacts. Several studies suggest that optimizing the filter band could significantly improve the classification accuracy.*

This project aims to design a FIR filter using RNS (Residual Number System) to reduce power and area consumption significantly besides classifying the EEG signals for abnormalities. The approximate adders which provide reduced power, area resources consumption is used in design of the above RNS filter to accrue the benefits. This has potential for use in portable EEG and many limited resource environments.

***Key Words*: EEG, RNS, FIR Filter design, Artifacts, Classification, Adaptive filters, approximate adders**

1. INTRODUCTION

EEG's artifacts have many sources biological and non biological sources .During the measurement EEG signals, other kinds of signals, such as ECG, EMG, 50Hz electric interference, are also captured by electrodes.

There are many types of artifacts. Some of them will not influence the frequency band of alpha waves. For instance, we see a sharp peak around 50 Hz. This is not a feature of EEG signals; however, it is caused by the artifacts of 50Hz electric interference. They include eye-blink, muscle, swallowing, facial, and cardio artifacts. Eye-blink introduces large variation both in amplitude and frequency of EEG data, which generally falls in the alpha rhythm. Since alpha is the most important rhythm in EEG, eye-blink artifacts reduce the data classification accuracy substantially, besides biological artifacts, other important artifacts, such as AC power line noise, DC noise, etc., may contaminate the EEG signal. Electroencephalogram (EEG) reflects the electrical activity occurring at the surface of a functioning brain.

Ocular artifacts are caused by eye movements, such as blinking eyes and rolling eyeballs. Here we show a segment of EEG [20] signals contaminated by eyeballs rolling. In the frequency domain, ocular artifacts increase the power of EEG signals from 2Hz to 20 Hz. Hence, the presence of ocular artifacts in EEG signals will cause unreliable detection of alpha power

2. RELATED WORK

The [1][10][12] talks about a modified Multiply-Accumulate (MAC) units called truncated MAC units and using residue number system (RNS) with moduli of a special form. The proposed approach based on RNS claims increase of 4 times of speed and reduced 3 times, in comparison with the use of the traditional positional number system increase the frequency by about 2-6 times, and reduce the hardware costs by 1.5-5 times, with increasing power consumption by 23%. [2] talks present digit-reconfigurable finite impulse response (FIR) filter architecture with a very fine granularity an 8-digit reconfigurable FIR filter chip is implemented in a single-poly quadruple-metal 0.35- m CMOS technology.

However the methods has limitations as FIR filter accuracy is achieved by compromising speed and various responses is not possible. [4] Talks about Multiplier less FIR filter optimization by means of the sparse filter technique is makes the search space at bit-level significantly decreased.

However, for higher order filter complexity will be very high, composed architecture is not used. The paper [19] talks about the application of the unprocessed ECG signal and finds the best window technique used to design FIR filter by comparing the spectral densities and average power before filtration and after filtration and found parameters well suited for various applications.

3. OBJECTIVES:

i. To address the fore-mentioned problems in hardware implementation of FIR filter design.

ii. To propose solutions to overcome hardware complexity and high speed limitation problems.

iii. The proposed project aim is to reduce artifacts and aberrations in EEG by training the feeding dataset.

iv. To implement the FIR filter using approximate adder and check its performance.

v. To design digital filter for low frequency removal.

4. ADAPTIVE ALGORITHM

The adaptation algorithmic program used to update the parameter values of the system will be as variety of improvement procedure that minimizes a slip criterion that's helpful for the task at hand. we have a tendency to provides a easy derivation of the least-mean-square (LMS) algorithmic program as utilized by [16], that is probably the foremost standard technique for adjusting the coefficients of AN adaptive filter, and have extraction may be a special variety of spatiality reduction, and this can be done by extracting a selected feature from the electrocardiogram, these options carry the characteristics of the electrocardiogram that area unit totally different from one speaker to a different, therefore these options can play the key role.

5. APPROXIMATE ADDERS

Two basic adders area the ripple-carry adder (RCA) and also the carry look ahead adder (CLA). In associate n-bit RCA, the carry of every full adder (FA) is propagated to consecutive carry, so the delay AND gate complexness increase proportionately with n (or O(n)).

However, a CLA needs a bigger circuit space (in O(nlog(n))), [13]. [21] are planned by decreasing the critical path associated hardware complexness of an normal adder. Another methodology for reducing the important path delay and power dissipation is by approximating a full adder.

5.1 Using 2-Bit, 3-Bit and 5 Bit Sub-Adder Based Designs

The design implementation in FPGAs is through LUTs. Considering addition of 2 operands of 3 bits each, the addition needs computations over six input bits to yield 3 output bits (ignoring the carry in/out), which might be handled by 3 six-input LUTs. every of those 3 LUTs shall have a six-input mapping onto one bit output.

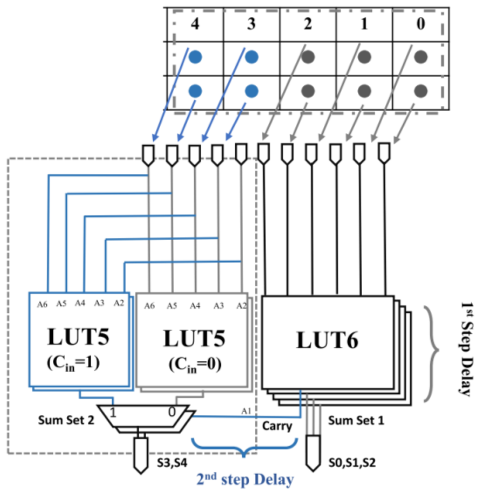

Figure 1 : LUT6 to perform sub-module addition

Table 1 Performance analysis of various components of sub-adders

ADDER	AREA(LUT)	TIME (ns)	POWER (mW)
Sa2ov0	17	0.788	0.177
Sa2ov1	31	0.799	0.177
Sa3ov1	31	0.882	0.177
Sa3ov2	32	0.887	0.177
Sa5ov1	32	1.213	0.177
Sa5ov4	32	1.289	0.177

Modern FPGAs (such as Virtex-7) provide 5-LUT combinatory blocks, which might operate as 6-input LUTs with common input, as displayed in Fig. 2. Thus, the logic enforced at intervals the 2 - 5-input LUTs may be tuned in such some way that one LUT5 is designed for carry-in as '1', whereas the opposite calculates result if the carry is '0'. This LUT-specific sub-adder style seeks

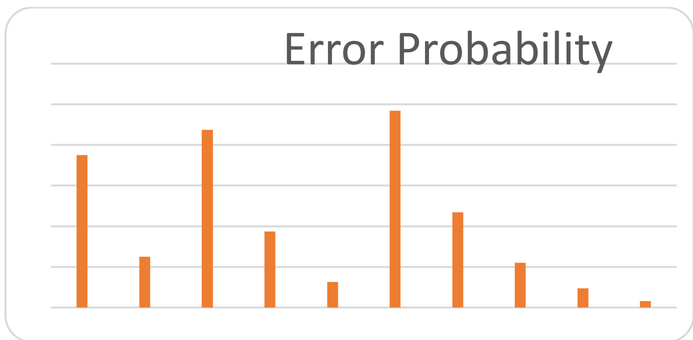

Figure 2: Error Probability of approximate adders of various sizes

motivation from the correct Carry Save Adder. Using this configuration, the scale of this sub-adder exaggerated to five bits with a latency overhead of one built in FPGA electronic device.

6. DATASET

The Bonn EEG database [20] has been dataset for this study, that's a famous benchmark dataset for this problem. The database consists of recordings for each healthy and epileptic subjects, divided in 5 subsets (denoted as A-E and named as Z, O, N, F and S, respectively) every of them containing one hundred single-channel EEG recordings. Sets A and B (Z and O files) are recordings from 5 wholesome volunteers with eyes open and eyes closed, respectively. The recordings are made greater cranially, the usage of the usual 10–20-electrode positioning system. Sets C and D (N and F files) are seizure-loose recordings from 5 epileptic patients, from the epileptogenic zone (set D) and the hippocampal formation of the alternative mind hemisphere (set C), whilst set E (S files) includes seizure activity, decided on from numerous recording webweb sites showing ictal activity. Sets C, D and E are recorded intra-cranially, the usage of intensity electrodes implanted symmetrically into the hippocampal formation and strip electrodes are implanted onto the lateral and basal regions (center and bottom) of the neocortex. The sampling charge of the EEG statistics is 173.sixty one Hz, and every of them has length of 23.6 s (4096 samples), recorded the usage of 12-bit resolution, whilst the spectral bandwidth is 0.five to eighty five Hz. Datasets Five sets ~denoted A–E each containing 100 single channel EEG segments of 23.6-sec duration, were composed for the study. These segments were selected and cut out from continuous multichannel EEG recordings after visual inspection for artifacts, e.g., due to muscle activity or eye movements. Sets C, D, and E originated from our EEG archive of presurgical diagnosis. For the present study EEGs from five patients were selected, all of whom had achieved complete seizure control after resection of one of the hippocampal formations, which was therefore correctly diagnosed to be the epileptogenic zone. Segments in set D were recorded from within the epileptogenic zone, and those in set C from the hippocampal formation of the opposite hemisphere of the brain. While sets C and D contained only activity measured during seizure After 12 bit analog-to-digital conversion, the data were written continuously onto the disk of a data acquisition computer system at a sampling rate of 173.61 Hz. Band-pass filter settings were 0.53–40 Hz ~12 dB/OCT.

7. DESIGN METHODOLOGY

The paper consist executed in following stages

1 Reverse Conversion From RNS To Binary Representation

2 EEG signal reprocessing and segmentation

3 Wavelet analysis and signal feature extraction

3.1 EEG Classification System Refinement

3.2 Optimal Number of Mixtures

3.3 Signal Segmentation

4 Using Adaptive algorithm to develop a memory bank using adaptive algorithm to be used in detection of epilepsy.

8. REVERSE CONVERSION FROM RNS TO BINARY REPRESENTATION

Reverse conversion is the process, commonly used after a few residue-mathematical operations, of translating from residue representations lower back to standard notations. The fundamental strategies for opposite conversion are primarily based on the Chinese Remainder Theorem (CRT) and the Mixed-Radix Conversion (MRC) technique.

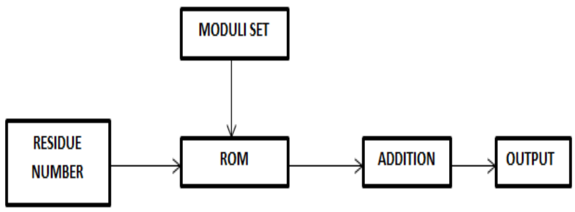

Figure 3: Block diagram of a reverse conversion

The first step in designing a reverse converter is the moduli set selection. Moduli set selection can play a significant role in dynamic range, speed, and the hardware realization of RNS.

The second step for designing a reverse converter is, the values of the moduli of the moduli set must be substituted in new CRT conversion algorithm formulas.

Third step, then the resulting equations is simplified by using arithmetic properties and propositions.

Finally, final equations are realized by adder components like CSA-EAC, CPA-EAC and CPA.

9. WAVLET ANALYSIS AND SIGNAL FEATURE EXTRACTION

Wavelet transform is used for time-scale signal analysis, signal decomposition and signal compression.

9.1 EEG Classification System Refinement

We have optimized a system for EEG signal classification based on models. The aim of this work was to to determine the number of mixtures and to test the stability of training algorithm and the possibility of automatic segmentation.

9.2 Optimal Number Of Mixtures

Several experiments with number of mixtures varying from 1 to 4 were performed. The results showed that the optimal number of mixtures is one. This corresponds with the results of X2 tests made before the distribution of spectral line magnitudes is close to normal one.

9.3 Signal Segmentation

After training the models we treated them as a source for the automatic segmentation of EEG. The realizations were divided to four intervals: "silence" before the movement, de synchronization, synchronization, "Silence" after the movement. The movement takes place on the boundary between the second and the third interval. The correlation between computed and real interval boundaries was very good.

Most of the EEG recordings may be taken into consideration as random signal, being nearly 90% of the signal to be interpreted as none (specifically noise). This totally spontaneous background EEG artifact is of the order of I -V and represents an index of integrity of the shape and mind function, in the course of unique brain states of sleep/wake or, rather diseases [20].

10. RESULT AND DISCUSSION

The results for the above filter designed is looked in terms of speed, area, and FPGA resources used this is done by comparing our approximate RNS FIR adders with conventional FIR filters and ordinary approximate adders, The results are tabulated in Table 2.

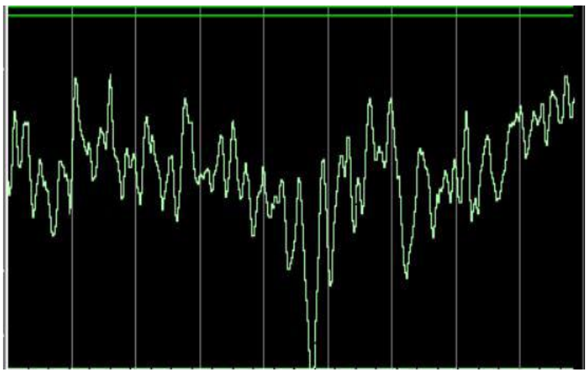

Figure 4: MODELSIM EEG simulation output

Figure 5: EEG coefficients stored in each channel

Based on the results shown it's clear that RNS FIR using approximate filters has the best speed performance though it adds hardware, it's power usage will be low compared to other formats, especially it's non usage of multiplier circuits,

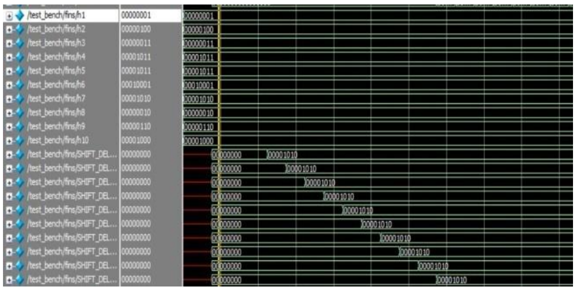

Figure 6: FIR filter implementation

***TABLE* 2 Comparative analyzes of various FIR MAC unit designs with QUARTUS II hardware synthesis using CYCLONE III family (EP3C16F484C6)**

Model	9 bit embedded multiplier	Area (Les)	FMAX(MHz)
Conventional FIR filter	8	205	104.11 MHz
FIR filter using approximation adder	8	196	133.87 MHz
RNS FIR filter using approximation adder	NIL	3508	5617.98 MHz

11. CONCLUSION

In this paper we show the performance of approximated adder primarily based RNS multiplier unit for FIR filter over traditional multiplier FIR filters. First, we examine the low value proposed RNS primarily based totally set of rules with most adder intensity accompanied via way of means of the bring approximation primarily based totally accumulation of FIR coefficients. The proposed RNS primarily based version that used strategies to executed FIR filtering in EEG signal classification applications. The effectiveness of our improved RNS coded MAC is demonstrates the usage of FIR implementation unit. And sooner or later the whole change of metrics of RNS encoded multiplier unit with adder topology primarily based totally accumulation unit is confirmed the usage of hardware synthesis. The results are formulated and compared with other fir filter formats the results show a significant improvement in speed and power saved also this hold promise for filters and efficacy of approximate adders in the domain of epilepsy detection and can be further developed into portable diagnostics tool for the epilepsy detection, Further study is required for accuracy estimation and then it's usage for other bio medical signals.

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