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# A Conveyable Ecg Monitoring Application With Advanced Memory Based Technique

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**Abstract**

A portable ECG monitoring system capable of implementing filter functionality with memory based APC and OMS technique is discussed. This can be used to evaluate the computation time, power, and area occupation of the filter component. This system identifies the cardiograph disease based on signal wavelength within nanoseconds. The proposed adaptive FIR filter is designed by using the direct realization of the filter. Reduction of power consumption is achieved in the proposed design by using a fast bit clock for carry-save accumulation and a much slower clock for all other operations. The design involves the same number of multiplexors, smaller LUT, and nearly half the number of adders compared to the existing DA-based design. Best recording quality of the ECG system is achieved by using noise analysing outputs.

Keywords: *ECG, APC (Anti symmetric product code), OMS (Odd Multiple Storage), Adaptive filter, FIR filter.*

## 1. Introduction

In order to interpret the 12-lead ECG and use it to diagnose abnormalities, it is important to know the normal characteristics of the ECG, and understand the mechanisms underlying the generation of each segment of the ECG. From the survey done ,it is understood that The ECG alone is not sufficient to diagnose all abnormalities possible in the pacing or conduction system of the heart. Fig 1.1 shows the lead placement to acquire the 12-lead ECG. The SOC is implemented in 180nm CMOS process and 32μW power consumption from a 1.2V supply while heart beat detection application is running, which is integrated in a wireless ECG monitoring system with Bluetooth [1]. Both the amplitude and the frequency of the drift considered represent from the moderate to the worst drift situations. In each experiment the mean-square estimation error (MSE) is calculated to determine the performance of the BTA algorithm [2]. This method is applied to a stress test ECG from a cardiac patient. The digital notch filter can be used for suppression of 50 Hz noise in the ECG. But multiple notches occur at higher frequencies. However, this has hardly any effect on the ECG because of the limited notch bandwidth [3].The cascade adaptive filter has to follow two stages, first stage is the adaptive notch filter and the second stage is the adaptive impulse correlated filter[5]. By using an ARMAfilter better transformation can be described because this adopts poles and zeros [6].

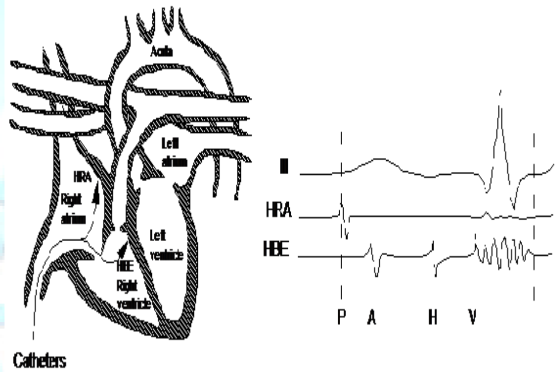


Fig1.1 Catheters within the atria and ventricles

In this unit, producing the correct output is the output from the Look Up Table. For this control and reset signals are used. The outputs from the LUT are shifted right by inserting necessary bits on LSB side according to the control signals $S_1$, $S_0$. Here the output will be reset in this block if the input ($x_4$ $x_3$ $x_2$ $x_1$ $x_0$) is 10000. The adder will

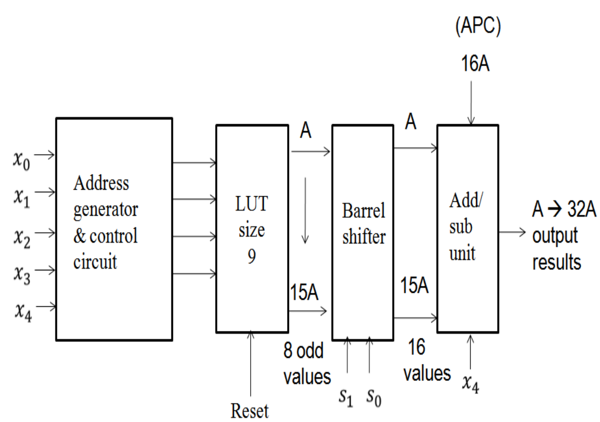


Fig 1.2 APC-OMS combined design of LUT for l=5wth fixed coefficient

add /subtract 16A(110000) depending on the inputs given. In the Second section, the APC and OMS techniques with adaptive filter is discussed. In third section, review of memory based multiplication process in adaptive filter technique. Measurement and comparison results are summarized in fourth section, and conclusion is done in the final section.

## 2. APC and OMS technique with adaptive filter

2.1. Operation of APC-OMS based adaptive FIR filter structure

The proposed adaptive FIR filter is done by using the direct realization of the filter. In this proposed adaptive filter, at each cycle, the inner product computation block gives product corresponding to the different coefficients with the help of APC and modified OMS block. After L bit cycles, the carry-save accumulator shift accumulates all the partial inner products and generates a sum word and a carry word of size (L + 2) bit each. The carry and sum words are shifted added with an input carry "1" to generate filter output which is subsequently subtracted from the desired output d(n) to obtain the error e(n).in the modified APC and OMS techniques for each cycle coefficient update takes place with the help of the devices present in the four blacks as shown in figure. The memory unit stores (2L/2) words of (W+L) bit width and all possible odd multiples of the filter coefficient. The L-bit input word is mapped to (L-1) bit LUT address. The barrel shifter derives all possible even multiples of the filter coefficient. The coefficients are controlled by the control unit to process the shift operation of LUT output. RESET signal is generated by the same control signal when X=0. Therefore the corresponding product values which are stored in the LUT of the particular input is given to the LUT based product computation circuit in the adaptive filter .These product values are accumulated and given as an adaptive filter output and it is based on number of taps given in filter.

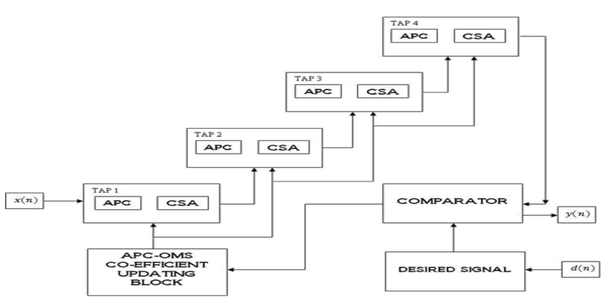


Fig 2.1 The adaptive filter design using the APC with modified OMS based LUT

2.2. Modified OMS for LUT in adaptive Filter

A barrel shifter for producing a maximum of (L-1) left shifts is used to derive all the even multiples of A. Table 2.1 shows the OMS based design LUT of APC word length L=5.Where the number of input is denoted as variable X'.

## 3.Proposed memorybased multiplication in adaptive filter

The APC- modified OMS combination reduces the data size to half and stores the data as first half data then the second half data is computed by taking 2's complement In Table 2.1 for L=5, the product value for different values of X are given. The first column of each row is 2's complement of their successive rows. the product value on the 2nd and 4th column shows mirror symmetryIt can be written be represented in the following equation. equation (1) and (2) modified(3)(4).From the equation,it can be understood , without storing value LUT usage can be reduced .In the fifth and sixth column, 4-bit LUT addresses and coded words are listed below. From the above equation, $X_L = (x_3, x_2, x_1, x_0)$ is four less significant bit of X and $X_L'$ is the2's complement of $X_L$.The desired product value can be calculated by adding or subtracting the stored value of from or to the fixed value 16A.For $X_4 = 1$, the sign value is equal to 1 and -1 for $X_4 = 0$. The product value X= (10000) corresponds to 'zero' which is made to reset the LUT output rather than storing the value in LUT. Therefore the product representation is derived from the anti symmetric product coding. The 4-bit address $X' = (x_{3'}, x_{2'}, x_{1'}, x_{0'})$ of the APC word is determined as,

$X' = X_L$ if $X_4=1$ (1)

$X_L$ if $X_4=0$ (2)

Product word= 16A+(sign value)*(APC word) (3)

Reset =$(X_0+X_1+X_2+X_3)*X_4$ (4)

Table 2.2 OMS-based design of the LUT of APC words for *L= 5*

| Input X' $x_3'x_2'x_1'x_0'$ | Product value | # of shifts | Shifted input, X'' | Stored APC word | Address $d_3d_2d_1d_0$ |
|---|---|---|---|---|---|
| 0001 | A | 0 | 0001 | P0=A | 0000 |
| 0010 | 2×A | 1 | | | |
| 0100 | 4×A | 2 | | | |
| 1000 | 8×A | 3 | | | |
| 0011 | 3A | 0 | 0011 | P1=3A | 0001 |
| 0110 | 2x3A | 1 | | | |
| 1100 | 4x3A | 2 | | | |
| 0101 | 5A | 0 | 0101 | P2=5A | 0010 |
| 1010 | 2x5A | 1 | | | |
| 0111 | 7A | 0 | 0111 | P3=7A | 0011 |
| 1110 | 2x7A | 1 | | | |
| 1001 | 9A | 0 | 1001 | P4=9A | 0100 |
| 1011 | 11A | 0 | 1011 | P5=11A | 0101 |
| 1101 | 13A | 0 | 1101 | P6=13A | 0110 |
| 1111 | 15A | 0 | 1111 | P7=15A | 0111 |

Table 2.1APC words for different input values for *L= 5*

| INPUT VALUE X | ( A ) | INPUT VALUE X | ( A ) | ADDRESS X' | APCWORD |
|---|---|---|---|---|---|
| 00001 | A | 11111 | 31 A | 1111 | 15 A |
| 00010 | 2 A | 11110 | 30 A | 1110 | 14 A |
| 00011 | 3 A | 11101 | 29 A | 1101 | 13 A |
| 00100 | 4 A | 11100 | 28 A | 1100 | 12 A |
| 00101 | 5 A | 11011 | 27 A | 1011 | 11 A |
| 00110 | 6 A | 11010 | 26 A | 1010 | 10 A |
| 00111 | 7 A | 11001 | 25 A | 1001 | 9 A |
| 01000 | 8 A | 11000 | 24 A | 1000 | 8 A |
| 01001 | 9 A | 10111 | 23 A | 0111 | 7 A |
| 01010 | 10 A | 10110 | 22 A | 0110 | 6 A |
| 01011 | 11 A | 10101 | 21 A | 0101 | 5 A |
| 01100 | 12 A | 10100 | 20 A | 0100 | 4 A |
| 01101 | 13 A | 10011 | 19 A | 0011 | 3 A |
| 01110 | 14 A | 10010 | 18 A | 0010 | 2 A |
| 01111 | 15 A | 10001 | 17 A | 0001 | 1 A |
| 10000 | 16 A | 10000 | 16 A | 0000 | 0 |

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## 4. Measurement and Comparison results

4.1 Measured output

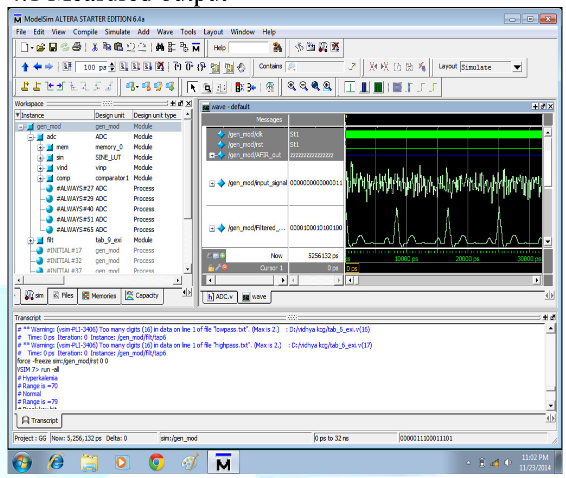

Fig 4.1 Simulation result of disease

Fig 4.1 shows the simulation result of disease. It identifies the disease called Hyperkelamia based on the signal wavelength within nanoseconds.

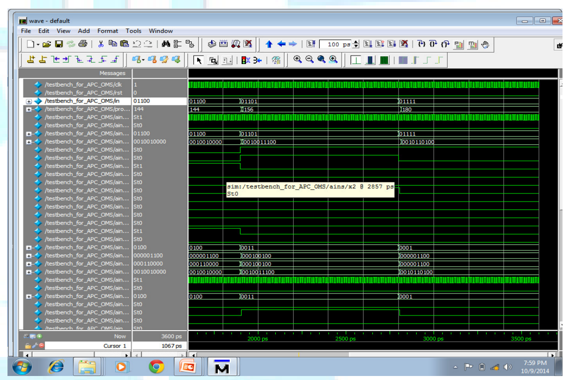

Fig 4.2 Simulated output of APC and OMC.

Fig 4.2 shows the simulated output of APC and OMC in which the barrel shifter control values $S_0$, $S_1$, address generation ($d_0$, $d_1$, $d_2$, $d_3$), APC word output and process of OMS values and final output are described.

4.3 Comparison table

Table 4.1 shows the comparison between of Area and Power FIR and Adaptive Filter .The proposed adaptive filter based on APC and modified OMS multiplier are compared with FIR filter in terms of total area used by the logic elements, static power and dynamic power shows from simulated output.

Table 4.1 Comparison of area and power for FIR and Adaptive filter

| FILTER DESIGN | AREA | TOTAL POWER | DYNAMIC POWER | STATIC POWER | I/O POWER DISSIPATION |
|---|---|---|---|---|---|
| FIR FILTER | 1332 LEs | 146.72m W | 35.10.mW | 52.72mW | 58.61Mw |
| ADAPTIVE FILTER | 736 LEs | 107.95 m W | 40.48mW | 46.24mW | 21.22mW |

## 5. Conclusion

The combination of the APC(Anti symmetric product code),and OMS(Odd Multiple Storage), provides reduction in LUT to one fourth of its size in adaptive FIR filter when compared with the conventional Look up Table (LUT) of adaptive FIR filter. The obtained results from the proposed architecture shows much reduction in computation time and area used.

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