Available online at www.elixirpublishers.com (Elixir International Journal)

Advanced Engineering Informatics

Elixir Adv. Engg. Info. 39 (2011) 4631-4633

ISSN: 2229-712X

# VLSI implementation of canceling maternal ECG from fetal ECG

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**ARTICLE INFO**

**Article history:**

Received: 19 July 2011;

Received in revised form:

20 September 2011;

Accepted: 26 September 2011;

**Keywords**

Adaptive Filters,

ECG Extraction,

VLSI synthesis,

FPGA implementation report.

**ABSTRACT**

Abdominal elcetrocardiograms make it possible to dertermne the fetal heart rate and to detect multuiple fetuses and are often used during labor and delivery.the background noise due to muscular activity and feotus motion, however, often had an amplitude equal to or grater than that of fetal heartbeat.A still more serious problem is the mother's heart beat,which has an amplitude 2 to 10 times grater thatn that of the fetal heartbeat, and often interferes in recording[1]. The Maternal ECG (MECG) is the main source of interference in Fetal ECG (FECG) monitoring. The MECG is detected at all electrodes placed on the mother's skin (thoracic and abdominal). In the case of multi-fetal pregnancies the traditional adaptive filtering technique provides a "maternal clean" signal consisting of the two fetal ECG signals. The noise was found to be too strong for the algorithm (and the naked eye) to notice any fetal heart signal[1]. This paper briefs the implementation of Adaptive noise cancellation algorithms such as LMS algorithm and RLS algorithm using MATLAB 6 (R12) suitable for real time implementation, which can be used during measurements, is being developed using VLSI. The best solution in case of multiple fetuses is the BSS filtering which has successfully been implemented in MATLAB.



## Introduction

The monitoring of FECG has clinical importance. If the physician could obtain a reliable reading of the FECG, he could detect problems in the fetal heart activity even before he is born[6]. The procedure for obtaining the FECG should be non-invasive. The fetal heart is a small heart so that the electrical current it generates is very low. In order to record the FECG, electrodes are placed on the maternal abdomen as close as possible to the fetal heart. The FECG may be acquired by placing a number of electrodes around the general area of the fetus and hoping that at least one of the electrodes will have the FECG with high enough SNR. Beside the problem of electrode placement, noise from electromyographic activity effects the signal due to the fetus low voltage signal. Another interfering signal is the maternal ECG (MECG) which can be 5-10 times higher in its intensity and ability to induce surface potentials [1]. The MECG effects all the electrodes, those that are placed on the chest (thoracic electrodes), and those placed on the abdomen (abdominal electrodes) of the mother. Because the FECG is a very weak signal, an electrode placed on the thorax of the pregnant woman will hardly record any of it, if at all.

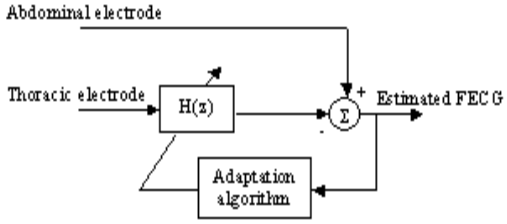


**Figure 1: Adaptive scheme for MECG cancellation**

## Single fetus extaction

This fact implies that an adaptive cancellation algorithm may be employed. An illustration of this conventional approach is given in figure 1.

Alternatively, four ordinary chest leads can also beused to record the mother's heartbeat and provides multiple reference inputs to the canceller. A single abdominal lead was used to record the combined maternal and fetal ECG that served as the primary input.Multichannel adaptive noise canceller is used in this case.

## Adaptive Filters

An adaptive filter is very generally defined as a filter whose characteristics can be modified to achieve some end or objective, and is usually assumed to accomplish this modification (or "adaptation") automatically, without the need for substantial intervention by the user. Implicit in this assumption is that the system designer could (over any particular substantial time window) in fact use a time-invariant, maladaptive filter if only the designer knew enough about the input signals to design the filter before its use. This lack of knowledge may spring from true uncertainty about the characteristics of the signal when the filter is turned on, or because the characteristics of the input signal can slowly change during the filter's operation. Lacking this knowledge, the designer them turns to an "adaptive" filter, which can "learn" the signal characteristics when first turned on and thereafter can "track" slow changes in these characteristics [5].

When,

- There is a spectral overlap between the signal and noise,
- Band occupied by noise is unknown or varies with time,

adaptive filters are sought for.

## Adaptive algorithms used for noise cancelation

Adaptive algorithms are used to adjust the co-efficient of digital filter such that the noise is minimized. The algorithms widely used is RLS (Recursive Least Square Algorithm)[5]

## Simulation using matlab

The MATLAB program responded for both original ECG as well as manually generated ECG. However the response of the

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program for the original ECG was more apt. Although the Maternal ECG is uncorrelated with the Fetal ECG, the adaptive technique proved worthy. The Maternal ECG Signal (i.e.)., interference is cancelled from the Heart ECG Signal. ECG Signal was given as an input and was simulated using MATLAB 6. The result of the program is shown in the figure below.

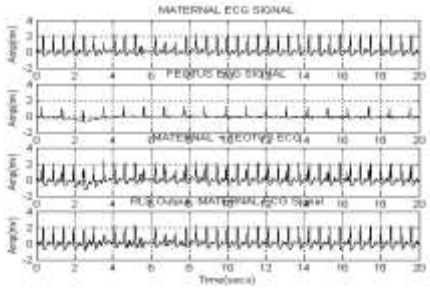

**Figure 2. RLS algorithm output**

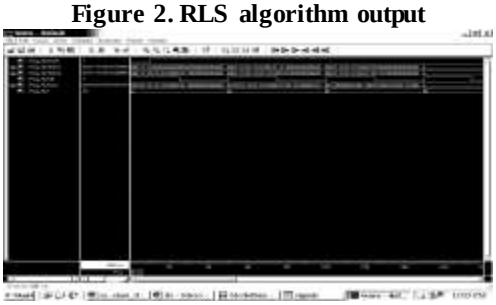

**Figure 3. VLSI simulation**

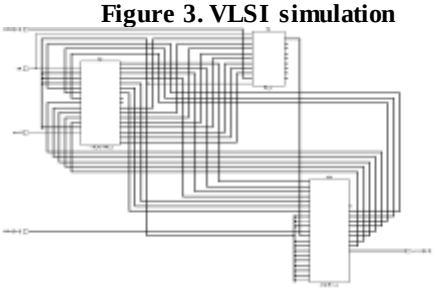

**Figure 4. Synthesis**

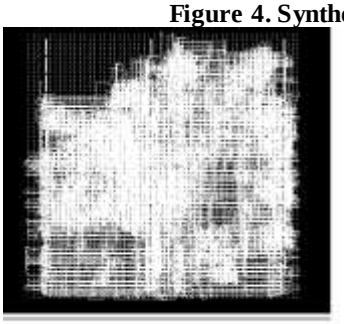

**Figure 5.Implementation repor in FPGA**

In case of multiple fetus the above method would just give a maternal ECG clean multiple fetus ECG. But not the separate ECGs.The solution to blind source seperation depends on the following five issues[7].

- Whether the mixer is linear or non linear.
- Whether the mixer is fixed or time varying.
- Whether the mixing operation is non convolute or convolutive.
- Whether the sensors are noisy or noise less.
- How many number of sensors and number of sources

**The Extended Infomax Algorithm**

The extension of the INFOMAX algorithm is the Extended INFOMAX algorithm for the Gaussian and Non Gaussian Signals.the steps involved are

- Extension to Gaussian and Non Gaussian signals

$$k_i = \operatorname{sign}\left(E\{\operatorname{sech}^2(u_i)\}E\{u_i^2\} - E\{\tanh(u_i)u_i\}\right).$$

- Learning rule

$$\Delta W \propto \begin{cases} [I - \tanh(u)u^T - uu^T]W & : \text{supergaussian} \\ [I + \tanh(u)u^T - uu^T]W & : \text{subgaussian} \end{cases}$$

- The next step is the calculation of the Kullback distance

$$I(x) = \int p(x) \log \frac{p(x)}{\prod_{i=1}^{N} p_i(x_i)} dx.$$

- Following the kullback distance calculation we have the weight updation

$$\Delta W(n+1) = (1-\alpha)\Delta W(n) + \alpha W(n),$$

- Finally the independent components are obtan\ined from this as

$$\mathbf{u}(t) = \mathbf{W}\mathbf{x}(t) = \mathbf{W}\mathbf{A}\mathbf{s}(t),$$

- The goal of ICA is to find a linear mapping W such that the unmixed signals u,

$$\mathbf{u}(t) = \mathbf{W}\mathbf{x}(t) = \mathbf{W}\mathbf{A}\mathbf{s}(t),$$

**Matlab Implementation**

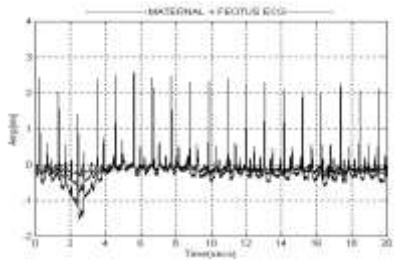

**Figure 6.Abdomianal Electrode Signal**

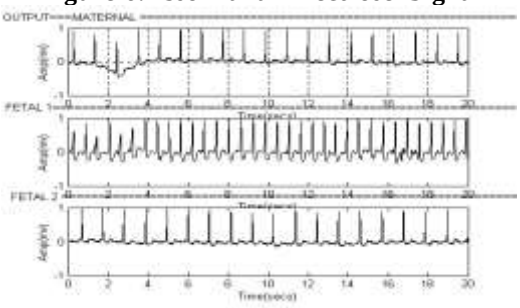

**Figure 7.Obtained output signals**

**Conclusion**

The cancellation of Maternal ECG from the Fetal ECG is more important in case of ascertaining the proper growth of fetal because the distorted Fetal ECG will lead to abnormal conclusions. This implementation gives us the way for extracting the Fetal ECG in order for the checking of the working of the fetal heart. This implementation in VLSI carves a new path in technology for averting the usage of the harmful Echocardiogram that can be put into real time evaluation. Further enhancement of BSS using VLSI implementation is under work.

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**Authors Biography**

N.J.R.Muniraj is presently working as a Principal of Tejaa Shakthi Institute of Technology, Coimbatore. He has more than 22 years of teaching and five years of industrial experience. He has presented more than 40 National and International papers and published fifteen international journal papers. His research area includes VLSI Signal Processing, Neural Networks, Image Processing and MEMS. He is also heading the Tejaa Shakthi Innovation centre. He expresses his sincere thanks to his chairman Mr.T.N.P.Muthu Natarajan and the secretary Ms.A.Tharalakshmi for their support and encouragement.