A Differential Algorithm for Non-Invasive Extraction of Fetal ECG and Analysis using LabVIEW

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***Abstract*—In this paper by using Differential techniques, extracting the Fetal ECG for Fetal extraction from two ECG signals recorded at thoracic & abdominal area of mother's skin. The thoracic ECG is assume to be almost completely maternal ECG while abdominal ECG is consider to be composite as it contains both mother's and Fetal ECG signals. The maternal component in abdominal ECG is non-linearly transform version of maternal ECG,so by identifying this non-linear relationship and aligned maternal ECG signals with maternal component in abdominal ECG. Thus we extract the Fetal ECG component by subtracting the aligned version of maternal ECG signals from the abdominal ECG. Extracted ECG will study along with continuous comparison with sonographic report. The User interface will be based upon LabVIEW. The output is connected to the personal computer (pc) for analysis of the result which is done using LABVIEW.**

***Keywords*-Differential Algorithm, Fetal electrocardiogram extraction, LabVIEW, Data acquisition, Signal processing.**

I. INTRODUCTION

Good health in the developing fetus is critical to the future well-being of adults. At least 8 in 1,000 infants born each year have a heart defect and congenital cardiovascular defect are present in about 1% of live birth. Fetal condition monitoring during pregnancy is an important technique which provides information about the health-state of the fetus, the fetal electrocardiogram (FECG) signal reflects the electrical activity of the fetal heart. It contains information on the health status of the fetus and, therefore, an early diagnosis of any cardiac defects before delivery increases the effectiveness of the appropriate treatment [2]. There are several technical problems associated with the noninvasive extractionof FetalECG (FECG) from ECG signals recorded at the abdominal surface,these problems are due to the power of the FECG signal which is contaminate by various source of interference.These sources include the maternal Electromyogram (EMG), 50Hz power line interference, baseline wander and random electronic noise. Assuming that we are using state of the art low noise electronic amplifiers with high common mode rejection ratio, the effect of the 50 Hz interference and electronic random noise can be eliminated. The EMG noise can also be reduced but not necessarily eliminated with the use of classical low pass filtering technique. Therefore, it is safe to say that if one is able to eliminate the maternal ECG component in the composite signal, a reasonable estimate of the FECG signal can be obtained [1]-[2].

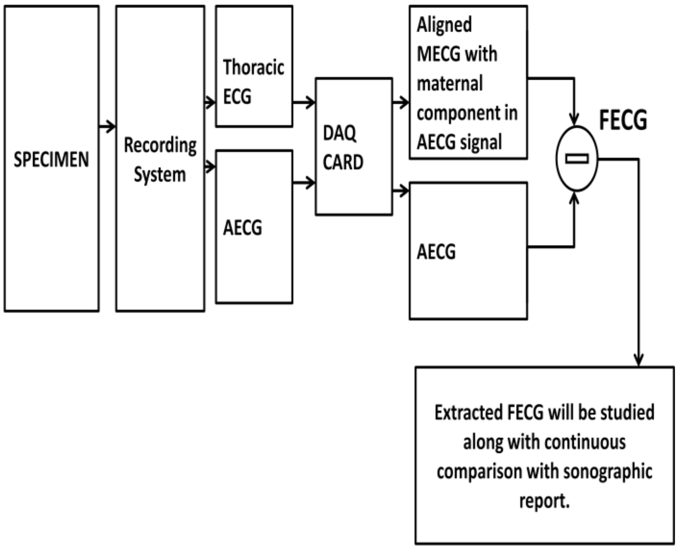

Fig. 1: Block diagram of Extraction and Analysis for FECG

Fig: 1 .shows the block diagram of extraction and analysis for FECG. Electrodes are placed into thoracic and abdominal region of pregnant women, extraction of ECG waveform of thoracic and abdominal region done by using recording system. Thoracic ECG is assume to be completely maternal ECG where as abdominal ECG is composite signal i.e. combination of maternal ECG and Fetal ECG. The maternal ECG of thoracic region is non linear transform version of maternal ECG of abdominal region. For further analysis of signal we used LabVIEW software. By using DAQ card interfacing extracted signal with LabVIEW software. In LanVIEW first identifying the nonlinearity of maternal ECG of thoracic region with maternal ECG of abdominal region and aligned these MECG signal in such a way that after subtraction of thoracic ECG and Abdominal ECG we get complete FECG waveform.

II. OBJECTIVE

In this paper, we aim to apply Differential algorithm technique for estimating the FECG component from one abdominal ECG recording and one reference thoracic MECG signal. We use algorithm to nonlinearly align the thoracic MECG with the abdominal ECG signal. This nonlinear alignment between the two signals allows for canceling the maternal component from the abdominal signal and hence offers an estimate of the FECG signal.

III. PROBLEM FORMULATION

The problem is formulated as follows. Two Leads are placed at the thoracic and abdominal region of pregnant woman such as shown in figure: 2.these signals are denoted as x (n) and y (n) to correspond to the thoracic and abdominal ECG signal respectively. Embedded in the abdominal signal w (n), are three signals: One is a non linear transform version of x as if travels from the chest to abdomen; another is the fetal ECG and third is additive noise from other sources.

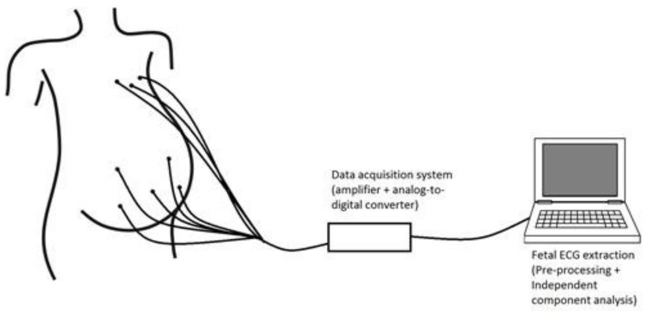

Fig: 2. Lead placement for Extraction FECG

The abdominal signal w (n), can be expressed as the sum of a non lineartransform version of the maternal ECGx (n), and a noisy version of the fetal ECG, s'(n) such that

w (n) = x'(n) + s'(n) (1)

x'(n) = T(x (n)) (2)

s'(n) = s (n) + η (n) (3)

The deformation of the maternal ECG component in w(n) is due to fact that the signal is measured far away from its source (the mother's heart), and consequently it encounters some nonlinear transformation as it travel to the abdominal area. The problem becomes trivial if the transformation T was linear (i.e. if all what x(n) encounters by traveling from heart to abdominal area was time delay and attenuation) [1].In that case, x(n) can be aligned with w(n) via correlation and the signal $s'(n)$ can be extracted by simply subtracting the aligned x(n) from w(n). The thoracic signal x (n) is predominantly maternal and hence we assume that the fetal component in it is negligible. A proper placement of thoracic and abdomen electrodes would result in a clean estimate of the FECG such that $s'(n)$≈ s(n). If the abdomen electrode is not placed low enough on the mother's abdominal area then the resulting noisy fetal ECG estimate can be cleaned by post filtering.

Our goal is to approximate the nonlinear Transformation T which will operate on the yield a signal, $x'(n)$, which is perfectly aligned with the maternal component in w(n). This alignment will allow for suppressing the maternal component in w (n) and hence the extraction of an estimate of an estimate of the FECG signals $s'(n)$.In our proposed method, we do so by Differential algorithm with multiple inputs and a single output. Input in this case would be MECG signal x (n) and a finite number of derivatives or delay along with the desired signal being the composite signal w (n).The Differential algorithm will find a nonlinear transformation that operate on x (n) and aligns with w (n).

III. HARDWARE

The hardware section incorporates the ECG amplifier circuit. The ECG amplifier circuit was designed and simulated whose output wasobserved on the oscilloscope. Noise present was removed by further optimizing the circuit so that it gave a clean representation of an ECG signal. The ECG amplifier circuit was designed using INA128UA and OPA4227UA.

PARAMETERS	OPA4227UA
BANDWIDTH	WIDE BANDWITH = 8MHz
OPEN LOOP GAIN	160Db
INPUT BIAS CURRENT	10nA
PRECISION	HIGH

IV. LABVIEW

LabVIEW is a program development environment, much like modern C or BASIC development environments, and National Instruments LabWindows/CVI. Other programming systems use text–base language to crate line of code, while LabVIEW uses a graphical programming language, G, to create programs in block diagram from. LabVIEW programs are called virtual instrument (VIs) because their appearance and operation can imitate actual instruments. Virtual instrument software architecture (VISA) is a standerdapplication programming interface (API) for instrument I/O communication. VISA is not LabVIEW specific, but is a standard available to many languages. When a LabVIEW instrument driver uses VISA Write, the appropriate driver for the type of communication being used is called. This allows the type of communication being used is called. This allows same API to control a number of instruments of different type. A VI written to perform a write to an instrument will not need to be changed if the user swiches from a GPIB to a serial device. Only the resource name must be modified where Instrument Open is used. Another benefit of using VISA is platform independence. Different platforms have different definitions for items like the size of integer variable. The programmer will not have to worry about this type of issue; VISA will perform the necessary conventions.

The biomedical signals acquired from the human body are frequently very small, often in the mV range, and each has its own processing needs. For instance, electroencephalography signals are in the microvolt range and have many frequency components. Obviously these biomedical signals require processing before they can be analyzed. LabVIEW contains the tools, from fast Fourier transforms (FFTs) to digital filters, to do the job. In order to do frequency analysis a complex signal must first be broken down into its frequency components. One of the most common ways to do this is with an FFT. In order to facilitate this type of analysis, LabVIEW comes with built in FFTs that make the process of component separation quick and easy. In addition, biomedical signals, being extremely small in amplitude, are prone to being overwhelmed by noise. To combat this, it is necessary to run the acquired signal through a set of filters. This can be done Signal Processing and Analysis Software Data Acquisition Card Personal Computer Signal and Analysis Display Data Acquisition Card external to the computer using standard hardware filtering devices. However, after the signal reaches the computer, it can still contain noise. Another way to solve the noise problem is to use the digital filters provided with LabVIEW. LabVIEW offers the choice of Butterworth, Bessel, Chebyshev, and Chebyshev II digital filters. With a few adjustments, these filters can be configured for almost any design that is needed.

The G file I/O functions are a powerful and flexible set of tools for working with files. In addition to reading and writing data, the LabVIEW file I/O functions move and rename files and directories, create spreadsheet-type files of readable ASCII text, and write data in binary form for speed and compactness.

We can store or retrieve data from files in there different formats.

ASCII Byte Stream: You should store data in ASCII format when you want to access if from another software package, such as a word processing or spreadsheet program. To store data in this manner, you must convert all data to ASCII string.

Data log files:These files are in binary format that only G can access. Data log files are similar to database files because you can store several different data types in to one (log) record of file.

Binary Byte Stream: These files are most compact and fastest method of storing data. You must convert the data to binary string format and you must know exactly what data type you are using to save and retrieve the data to and from files

V. SOFTWARE

The analysis part of FECG will be done by using the LabVIEWsoftware. For Fetal extraction of two ECG signals are recorded at thoracic & abdominal area of mother's skin and given to LabVIEW by using data acquisition card and then using differential algorithm for identifying non-linear relationship between maternalcomponent in abdominal ECG & maternal ECG and alignthese two ECG. Thus we extract the Fetal ECG component by subtracting the aligned version of the maternal ECG signals from the abdominal ECG. In Fig: 3. given below shows block digram of signal alignment and subtraction. By taking two different frequencies simulated ECG waveform i.e 1st ECG signal has 60Hz and 2nd signal has 80Hz frequency. These ECG signal given to input of 'aliened and resample' block which gives the aligned signal at output.

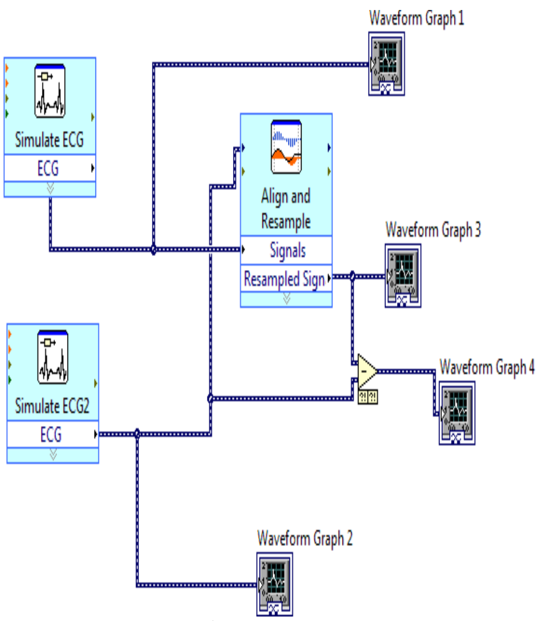

Fig: 3 Block diagram of signal alignment and subtraction

The output will be displayed on the Front Panel (graphical display) of LabVIEW.Fig: 3 show result of signal alignment and subtraction. First two graphs shows simulated ECG waveform having 60Hz and 80Hz frequencies respectively. Both these ECG are given to inputs of 'Align and Resample' block which then gives the aligned ECG waveform atoutput. This aligned ECG signal is then,subtracted from 80Hz simulated ECG signal ECG signal of which givesthe differential output waveform of 1st and 2nd EGC signal such as shown in graph 4.

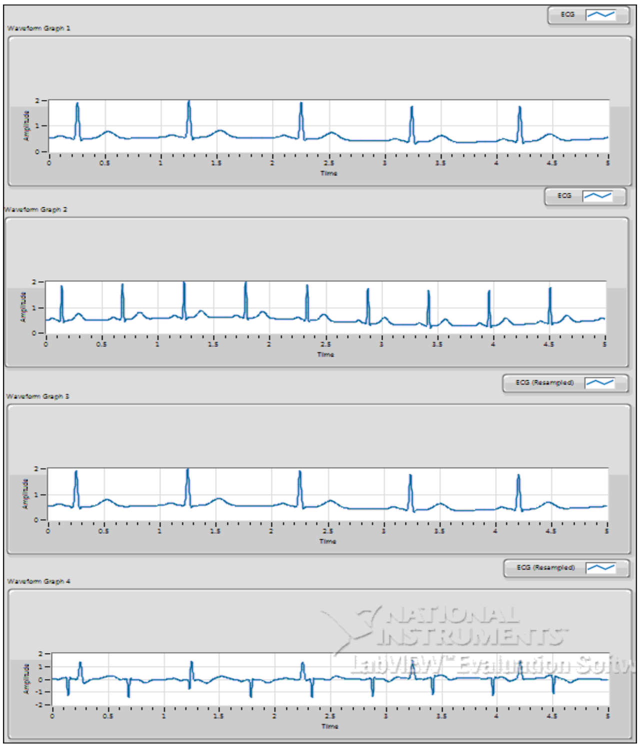

Fig: 3The result of signal alignment and subtraction

VI. CONCLUSION

In this paper, we have applied Differential algorithm to extract FECG signal from two ECG signals recorded at thoracic and abdominal area of mother’s skin. This is done by employing Differential algorithm to identify the nonlinear relationship between the maternal component in the abdominal ECG and thoracic MECG which is assumed to include no fetal component in it. Once the MECG is nonlinearly transformed to be aligned with the maternal component in the abdominal ECG, the FECG can be extracted by subtracting the aligned version of the MECG signal from the abdominal ECG signal.

The focus of this paper has been on suppressing the maternal component from the abdominal ECG signal, the extracted FECG signal may include other additive noise signals. We believe that such noise can be suppressed by post processing method. We believe that attempting to remove noise before FECG extraction may result in losing the fetal component from the composite signal especially when the SNR is very low and the QRS regions of the fetal and maternal components are overlapping.

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