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A Review on Hardware Implementation for Reduction of Artifacts in Bio-Medical (ECG) Signal by Using Digital FIR-IIR Filter

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Abstract— ECG signal is of nature of time varying that is most common source used for the diagnosis purpose and observation and analysis of heart diseases present in the patient. ECG is recorded by placing electrodes at specified positions of human body. During recording, ECG is sullied with noises and artifacts which always degrade its quality, and creates accurate and automatic interpretation more difficult. Mostly noticed artifacts or noises are Power line interference, baseline wanders and muscle tremors. So for accurate explanation of characteristics points of ECG, a good quality of ECG is necessary. This paper is presenting a review on various methods developed for de-noising using FIR-IIR filtering, delineation of characteristics points and classification of diseases along with their respective advantages and disadvantages.
Keywords— ECG, de-noising, delineation, classification, FIR-IIR filtering.

I. INTRODUCTION

ECG (electrocardiogram) is a recording of electrical activity of the heart present in human body.In this signal, each heartbeat is represented by an electrical impulse from special cells in right upper chamber of heart. These impulse travels to the other parts of the heart. It then causes the heart to squeeze and pump blood. Finally, it can be detected on the surface of body as ECG patterns [1]. Then, the physician can study the patterns of the recorded signals. There could be several diseases and disorders of various types that affect the ECG pattern. The normal ECG signal wave is given in figure 1.

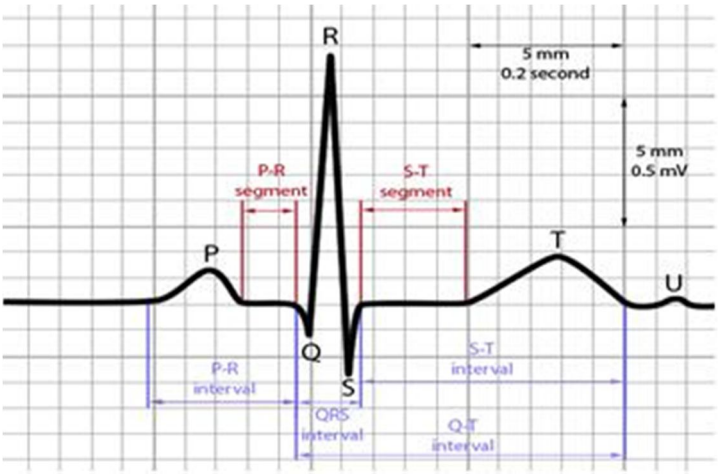

Fig. 1 – Normal ECG Signal Wave.

During recording of ECG from human body, ECG noises (anything other than muscular activity of heart) are superimposed with the recorded ECG [2]. The desired recorded ECG signal can be interrupted due to the presence of AC interference in the power supply, loose electrode connections, malfunctioning of recording machine and sometimes even due to patient movements such as respiration etc. Collectively, these can be labeled as artifacts. Baseline wander, power line interference and muscle tremors are mostly noticed artifacts/noises. So for accurate delineation of characteristics points of ECG, these artifacts must be removed so that it can be used for

proper diagnosis. In the present paper, the survey is based on some of the approaches used for analysis of de-noising ECG signal using FIR-IIR filtering [3].

II. NOISE IN ECG

In context to ECG signal, noise does not mean sound, although there is analogy between these two terms, but instead to electrical interference. In electrocardiography, rather than using the term noise, the term artifact is more suitable to point out something that is not "heart-made" [4]. The word artifact is alike to artificial in the sense that it is frequently used to indicate something that is synthetic (i.e. not natural). These are electrical disturbances created by electrical noise from elsewhere in the body i.e. any outside sources, placement or poor contact of leads, and machine malfunctions. Artifacts removal is primer requirement to prevent misinterpretation of a heart's rhythm. These are of following types-

A. Power-Line Interference (Or AC Interference)

Power line interference consists of 50/60 Hz AC (Alternating current) pickups and harmonics present in the power supply. AC more precisely describes the type of electricity that can be obtained from the power line.The electricity frequently changes its direction by 60 Hz power supplyin the United States [5]. It is 50 Hz of AC electricity in India and Europe. Major factors that cause such interferences are:

Stray effect of AC fields induced because of loops in electricity cables.

Disconnected electrodes.

Unconventional grounding of ECG machine

Presence of electrical devices in input circuits of ECG machine such as X-ray machines, air conditioner that draws heavy power line current.

Electromagnetic interference generated from the power-line supply.

B. Baseline Wandering

In baseline wandering, the iso-electric line changes position that is mainly caused by respiration or the patient movements which creates problems in the detection of signal peaks. Some other possible causes are the moving cables during the reading and even by dirty lead electrodes/wires, loose electrodes, and other variety of things. Due to presence of baseline wander the location of T peaks would be detected higher than that of R peak, which might be wrongly taken as R peak instead. The variation of observed amplitude to the peak to peak ECG amplitude will be of 15% [6].

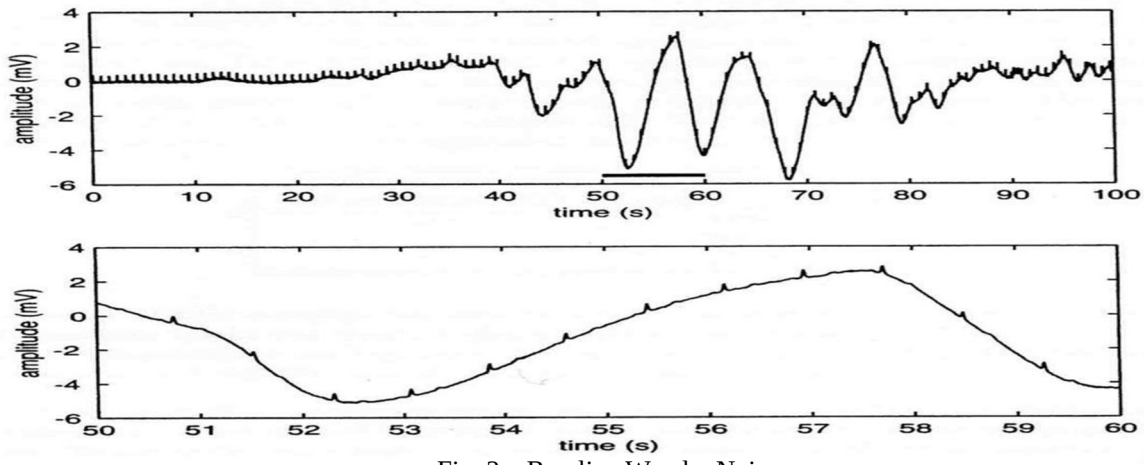

Fig. 2 – Baseline Wander Noise

C. Muscle Tremor/Noise

Muscle contractions are also called as EMG (electromyography) noise. It is induced by the patient's movement. It generates artifactual milli-volt level potentials as the heart is not the only organ in our body that produces measurable electricity. Even when skeletal muscles undergo tremors there is random activity in the ECG signal. These low amplitude muscle tremor noise can

sometimes mimic the baseline in atrial fibrillation.

D. Reversed Leads/Misplaced Electrodes

The placement of electrodes is very important task while recording ECG. The connection between patient and measuring system is interrupted for a short duration due to improper contact of the electrodes which creates electrode contact noise of 1 second duration and amplitude of which is peak recorded output of ECG signal with frequency of 60Hz. Generally, we accidentally get confused with placement of red and white lead cables. When a normal sinus rhythm with all of its waveform upside-down is observed, it is basically a view of the rhythm in a completely different lead [7]. So it's better to reconsider the placements of the electrodes to record clean signal.

E. Pacing Spikes

The pacemaker rhythm can easily be recognized on the ECG. These pacing spikes are mainly observed in patients whose implanted pacemaker is firing. These are vertical signal that represents the electrical activity of the pacemaker. The wide QRS complex represents the ventricular depolarization.

F. Absolute Heart Block

Absolute heart blockage (also known as 4th degree heart blockage) occurs seldom, only in made-up settings. Spacious and bottle-shaped QRS complexes are observed. The QRS complexes observed here has no relationship with the P wave.

III. SIMULATION AND RESULT

The hardware implementation of fast FIR low pass filter for Electromyogram (EMG) removal from Electrocardiogram (ECG) signal. The architecture having less critical delay then convention FIR design and fast enough to remove EMG from ECG signal. They Proposed branched tree architecture for adder connection to reduce the critical delay. The Proposed architecture has been implemented on FPGA using Verilog Hardware Description Language (HDL).Since coefficient quantization technique is used, so this implementation consumes lesser area that reduces the Hardware consumption.

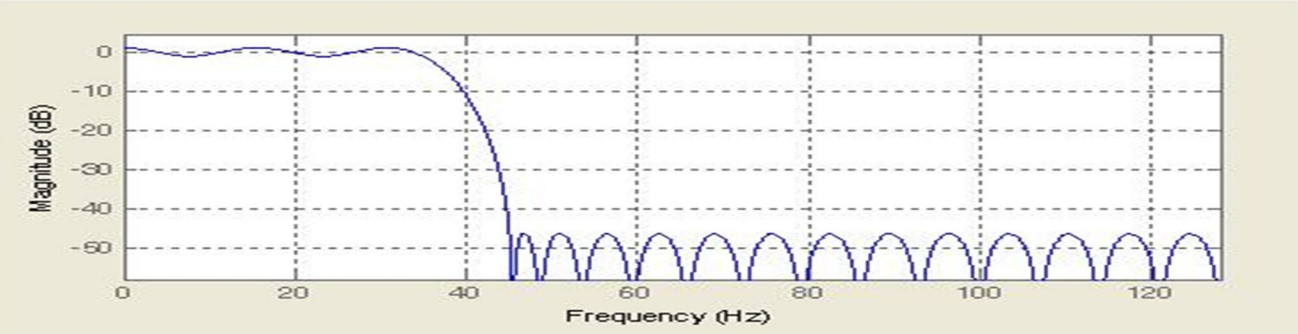

Fig. 3. - Fast low pass FIR filter response.

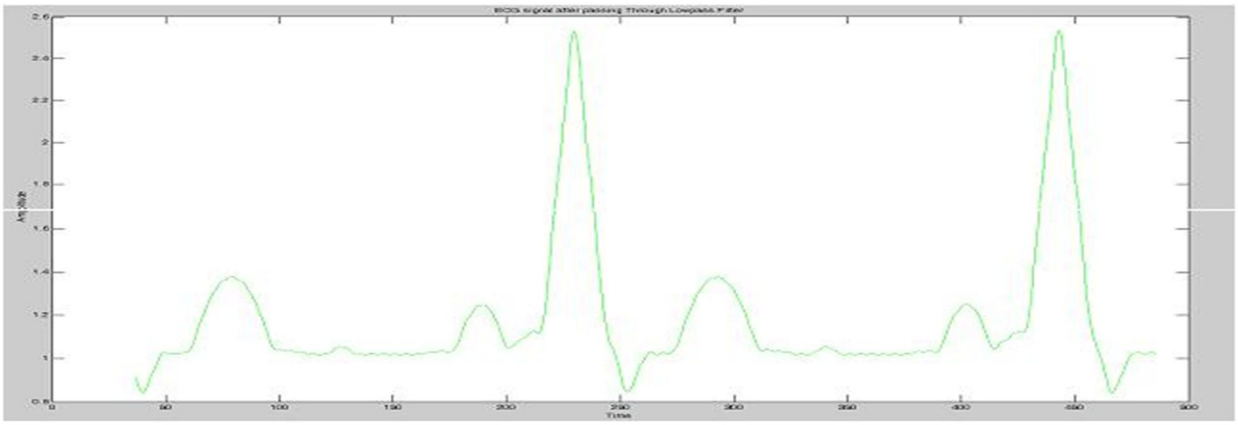

Fig. 4.- ECG signal after Fast FIR lowpass filtering.

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Table I: HDL Synthesis Report Macro Statics

Component Name	Number of Components
#Multipliers	38
16x16-bit multiplier	38
#Adders/Subtractors	154
16-bit adder	76
32-bit adder	78
64-bit adder	5
# Registers	1808
Flip-Flops	1808
# Xors	38
1-bit xor2	38

High Frequency Noise removed from ECG Signal Using Digital IIR Butterworth Filter. The ECG should be free from noise and of good quality for the correct diagnosis. In real time situations ECG are corrupted by many types of artifacts. The high frequency noise is one of them. The present paper deals with removing of noise from ECG of high frequency contents with help of Low pass digital filter of the cutoff frequency 100Hz. The sampling period used is .001sec. The filter is designed with Butterworth Approximations. The results of before filtration and after filtration are depicted in the paper. Paper contains detail design of the digital Butterworth filter and its realization. The experimentation is performed on the database generated in Laboratory. The simulation results show the filter works satisfactorily with some modifications in PQRST waveform.

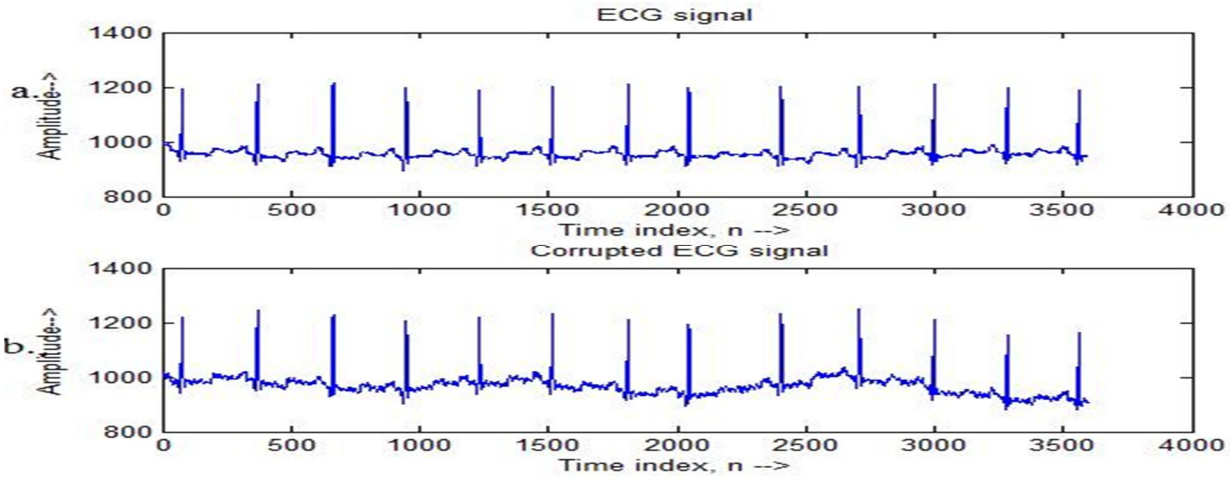

Fig.5. - a) ECG signal b) Noisy ECG signal

ECG data sample and original sample are taken as reference signal. The suggested method considers the magnitude response for choosing the cutoff frequency and the FFT spectrum estimate response to find the lowest filter order. The structure and the coefficients of the digital IIR filter are designed using FDA tool in MATLAB. The filter output's average power before and after filtration are calculated using FFT and for simulation of this filter, the hardware is designed using microcontroller At mega 16A. For hardware designing the samples taken are record no. 108 and record no.119 (taken from MIT-BIH database, ML II signal). Here samples are taken from MIT-BIH arrhythmia database (mitdb) ML II are used.

Table II
Comparison of average power of various filters for Removal of Baseline noise.

Filter	Filter Order	Average Power before filteration (dB/Hz)	Average Power after filteration (dB/Hz)
FIR Equiripple	320	60.30	30.62
FIR Kaiser	450	60.30	29.74
FIR Rectangular	450	60.30	29.33
FIR Hanning	1200	60.30	30.83
FIR Blackman	1500	60.30	30.98

IV. CONCLUSIONS

Powerful computer based software tools are commonly used to perform the ECG signal filter. But when we talk about the implementing filter on hardware, the biggest challenge is to achieve specified speed of data processing at minimum hardware cost. The newer paper will present a new design approach to design the digital FIR-IIR low pass filter and comparision of their results for filtering artifacts from ECG signal. Then the Filter will be designed, coded using VHDL and finally implemented on Virtex-5 FPGA (xc5vlx110t-3-ff1136) device as a prototype to ASIC (Application Specific Integrated circuit).

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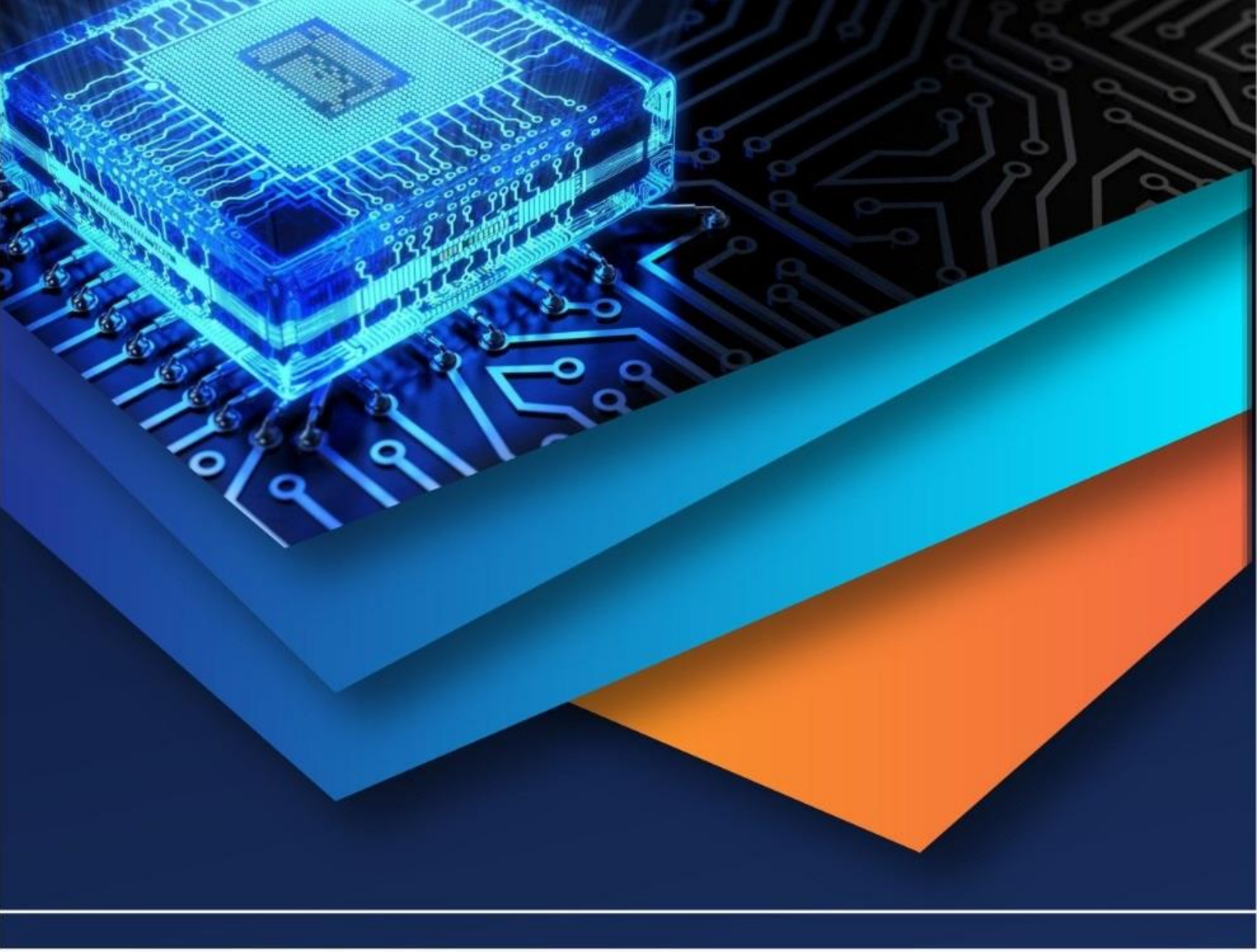

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