Vol 4 Issue 11 may 2015 ISSN No :2231-5063

International Multidisciplinary Research Journal

Golden Research Thoughts

Welcome to GRT

RNI MAHMUL/2011/38595 **ISSN No.2231-5063**

Golden Research Thoughts Journal is a multidisciplinary research journal, published monthly in English, Hindi & Marathi Language. All research papers submitted to the journal will be double - blind peer reviewed referred by members of the editorial board.Readers will include investigator in universities, research institutes government and industry with research interest in the general subjects.

International Advisory Board

Editorial Board

Address:-Ashok Yakkaldevi 258/34, Raviwar Peth, Solapur - 413 005 Maharashtra, India
Cell : 9595 359 435, Ph No: 02172372010 Email: ayisrj@yahoo.in Website: www.aygrt.isrj.org

International Recognized Double-Blind Peer Reviewed Multidisciplinary Research Journal
Golden Research Thoughts
ISSN 2231-5063 Impact Factor :3.4052(UIF)
Volume - 4 | Issue - 11 | May - 2015 Available online at www.aygrt.isrj.org

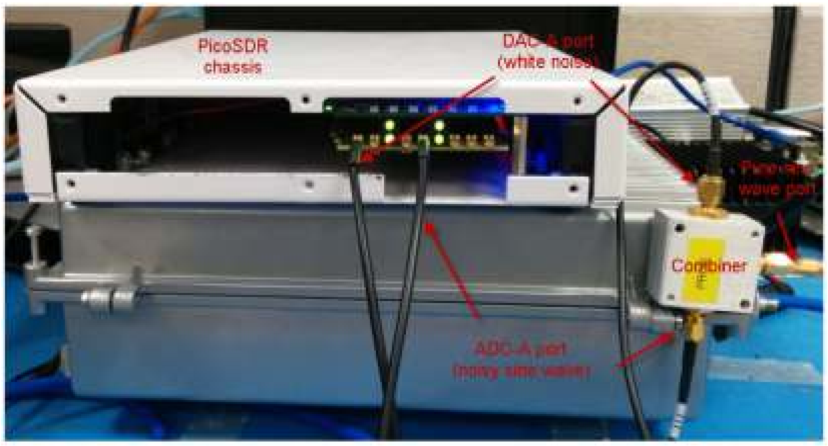
DESIGN AN ADAPTIVE FILTER USING LMS TO DENOISE ECG SIGNAL ON RECONFIGURABLE PLATFORM

Somnath K. Bagale
Department of Electronics & Telecommunication, Savitribai Phule Pune University,Pune.India (MS).

Short Profile

Somnath K. Bagale is working at Department of Electronics & Telecommunication in Savitribai Phule Pune University,Pune.India (MS). He has completed B.E., M.E. He has done one academic project on "Reconfigurable Platform to Design an Adaptive Filter using LMS for Optimum Performance to Denoise ECG."

Co- Author Details :
Venkat N. Ghodke
Department of Electronics & Telecommunication, Savitribai Phule Pune University,Pune.India(MS).



ABSTRACT:
Signal Processing has a rich history and its importance in biomedical engineering is known to all. ECG analysis and processing can be used to extract some characteristic parameters. The noise removal from Electrocardiogram (ECG) signal is very complex problem. In ECG signal baseline wander noise distorts the low frequency segments. The low frequency segment in ECG is ST segment. Heart attack related information is retrained from ST segment, so it is very necessary to have a noise free ECG signal. Baseline drift noise occurs due to respiratory signal and body movements. Respiratory signal wanders between 0.15Hz and 0.5Hz frequencies. One of the most common methods to remove baseline drift interference is Adaptive filtering. This Paper presents development and implementation of architecture for a LMS based Adaptive filter using Reconfigurable Devices such as Spartan 3s400pq208-4 board and Xilinx system Generator (XSG) software, to minimize the Baseline wander noise (0.15 to 0.5Hz) from Electrocardiogram (ECG) signal. The ECG signal is taken from the database and external noise signal is added into it. The noisy ECG signal is enhanced by minimizing the baseline drift interference. This research work is carried out by using FPGA for adaptive filter using LMS Algorithm to remove various noises to prevent low frequency component of ECG signal.

KEYWORDS
Adaptive filter, Xilinx system generator (XSG), LMS Algorithm, MIT BIH database, Simulink etc.

Article Indexed in :
DOAJ Google Scholar DRJI
BASE EBSCO Open J-Gate

1.INTRODUCTION :

The function of the human body is based on signals of electrical, chemical or acoustic origin. Such signals provide information which may not be immediately perceived but which is hidden in the structure of the signal. This hidden information has to be decoded in some way before the signals can be given useful interpretations. The baseline wander is an extraneous, low-frequency activity in the ECG which may interfere with the signal analysis, making the clinical interpretation inaccurate. Since the spectrum of baseline drift and low frequency component of ECG signal usually overlaps, removing of baseline drift may cause distortion of important clinical information. Baseline drift is often exercise-induced and may have its origin in a variety of sources, including perspiration, respiration, body movements and poor electrode contact. The spectral content of the baseline drift is usually in the range between 0.05-1Hz but, during strenuous exercise, it may contain higher frequencies. Baseline drift noise occurs due to respiratory signal and body movements. Respiratory signal wanders between 0.15Hz and 0.5Hz frequencies [5]. This Paper is based on Adaptive filtering of ECG signal to remove this baseline wander while preserving the low frequency ECG clinical information. ADAPTIVE DIGITAL FILTERS (ADFs) are widely used in various signal-processing applications, such as echo cancellation, system identification, noise cancellation and channel equalization etc. [1]. Amongst the existing ADFs, least mean square (LMS)-based finite impulse response (FIR) adaptive filter is the most popular one due to its inherent simplicity and satisfactory convergence performance. However, the delay in availability of the feedback-error for updating the weights according to the LMS algorithm does not favor its pipeline implementation when sampling rate is high. The delayed LMS is similar to the LMS algorithm except that the correction terms for updating the filter weights of the current iteration are calculated from the error corresponding to a past iteration.

In this Paper, the ECG signal is taken from the database and external noise signal is added into it. The noisy ECG signal is enhanced by minimizing the baseline drift interference. This interference reduction is takes place by designing the digital filter on FPGA platform. Various filters are designed and simulated with cut-off frequency of 0.5Hz. The best suited filter technique is chosen for FPGA implementation which gives a lesser order of filter, lesser power consumption and improved SNR.

2. PROPOSED SYSTEM

2.1 Noises in ECG

A] Power line interferences

Power line interferences contains 60 Hz pickup (in U.S.) or 50 Hz pickup (in India) because of improper grounding [10]. It is indicated as an impulse or spike at 60 Hz/50 Hz harmonics, and will appear as additional spikes at integral multiples of the fundamental frequency. Its frequency content is 60 Hz/50 Hz and its harmonics, amplitude is up to 50 percent of peak-to-peak ECG signal amplitude [8]. A 60 Hz notch filter can be used remove the power line interferences [7].

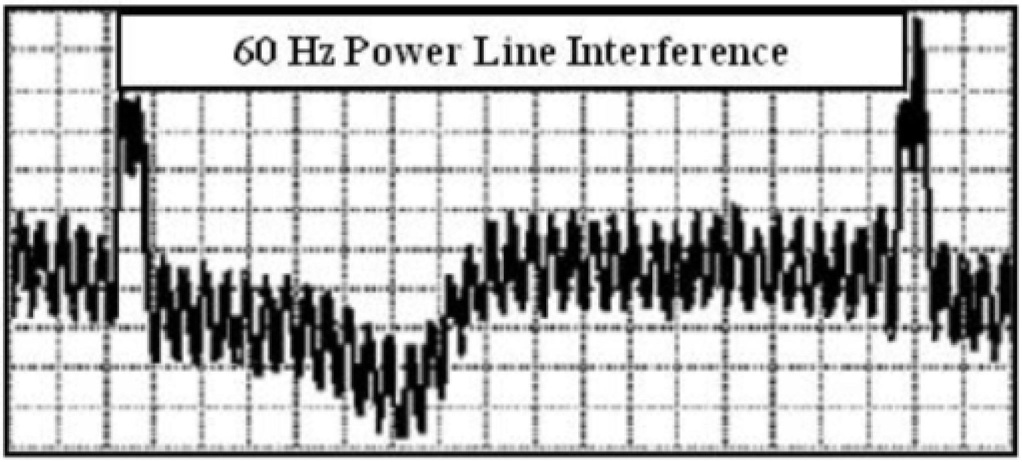


Figure 1: 60 Hz Power line interference.

B] Baseline drift

Base-line drift may be caused in chest-lead ECG signals by coughing or breathing with large movement of the chest, or when an arm or leg is moved in the case of limb-lead ECG acquisition [6]. Base-line drift can sometimes caused by variations in temperature and bias in the instrumentation and amplifiers. Its frequency range generally bellows 0.5 Hz.

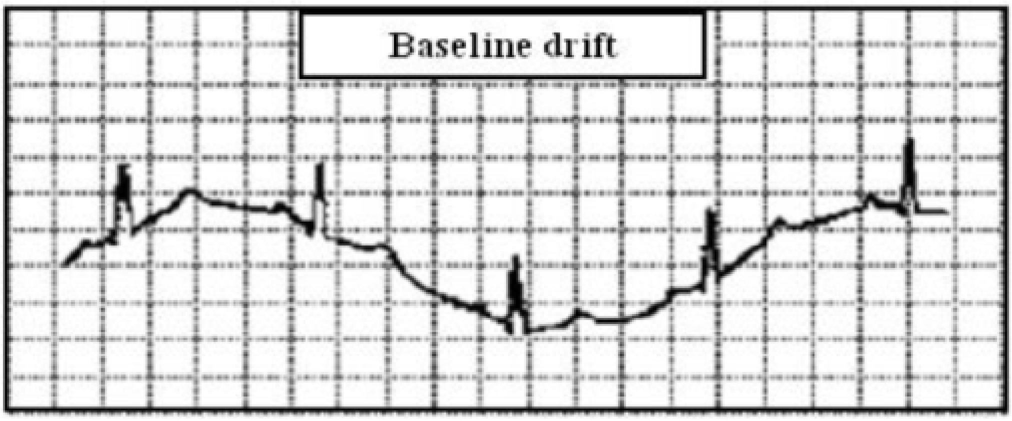


Figure 2 : Baseline drifts in ECG signal.

2.2 ECG Dataset:-

Massachusetts Institute of Technology / Beth Israel Hospital (MIT/BIH) database is a rich database of several hundred ECG recordings, extending over 200 hours [Moody, 1992]. Each recording contains one to three signals and ranges from 20 seconds to 24 hours in duration. Most of the signals have been annotated on beat-to-beat basis. The MIT-BIH Arrhythmia database contains 48 ECG signals that were recorded between 1975 and 1979 at the Beth Israel Hospital Arrhythmia Laboratory. The recordings were digitized at 360 samples per second per channel with 11-bit resolution over a 10 mV range. Each record was independently annotated by two or more cardiologists; disagreements were resolved to obtain the computer-readable reference annotations for each beat (approximately 110,000 annotations in all) included with the database. This directory contains the entire MIT-BIH Arrhythmia Database. About half (25 of 48 complete records, and reference annotation files for all 48 records) of this database has been freely available here since PhysioNet's inception in September 1999 [9].

2.3 Xilinx System Generator Tool:-

System Generator is a DSP design tool from Xilinx that enables the use of the Math Works model based design environment Simulink for FPGA design. Designs are captured in the DSP friendly Simulink modeling environment using a Xilinx specific blockset. Xilinx Simulink blockset is a highly parameterized library that includes DSP functions and algorithms. Over 90 DSP building blocks are provided in the Xilinx DSP blockset for Simulink. These blocks include the common DSP building blocks such as adders, multipliers, and registers. Also included are a set of complex DSP building blocks such as FFTs, filters, and memories.

Figure 3 shows a snapshot of a Simulink DSP design that instantiates DSP blocks. The software automatically converts the high level system DSP block diagram to RTL. The result can be synthesized to Xilinx FPGA technology using ISE tools. All of the downstream FPGA implementation steps including synthesis and place and route are automatically performed to generate an FPGA programming file.

System Generator provides a system integration platform for the design of DSP on FPGAs that allows the RTL, Simulink, MATLAB, and C/C++ components of a DSP system to come together in a single simulation and implementation environment. System Generator supports a black box block that allows RTL to be imported into Simulink.

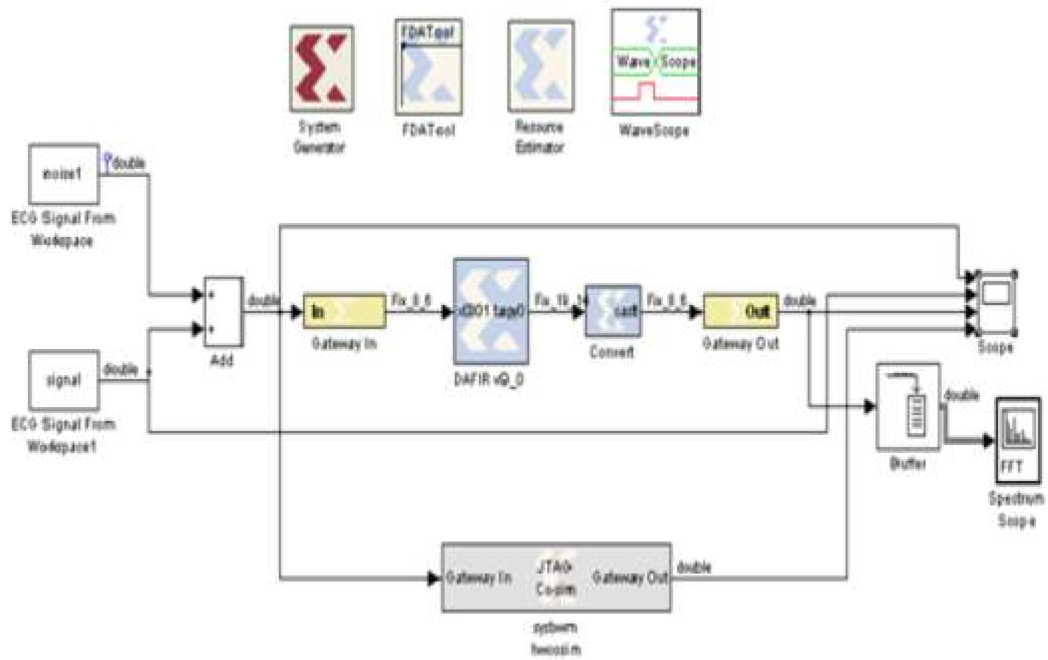


Figure 3. Snapshot of a Simulink DSP design.

DSP building blocks are provided in the Xilinx DSP blockset for Simulink. These blocks include the common DSP building blocks such as adders, multipliers, and registers. Also included are a set of complex DSP building blocks such as forward error correction blocks, FFTs, filters and memories.

3. IMPLEMENTATION

A major element of the foundation stage is the extraction of ECG signals from the standard database i.e. (MIT/BIH) database. After extraction, the signals are subject to processing using several tools available by the MATLAB software for simulation purpose. For ECG de-noising the digital FIR filter is designed with various available filter design techniques. Output of this various designs are simulated and analyzed with the help of performance parameters like SNR. After comparing the different techniques of filter design, select the best technique for implementation of filter on FPGA platform and verify the results. These steps are illustrated in design flow shown in figure 4.below:

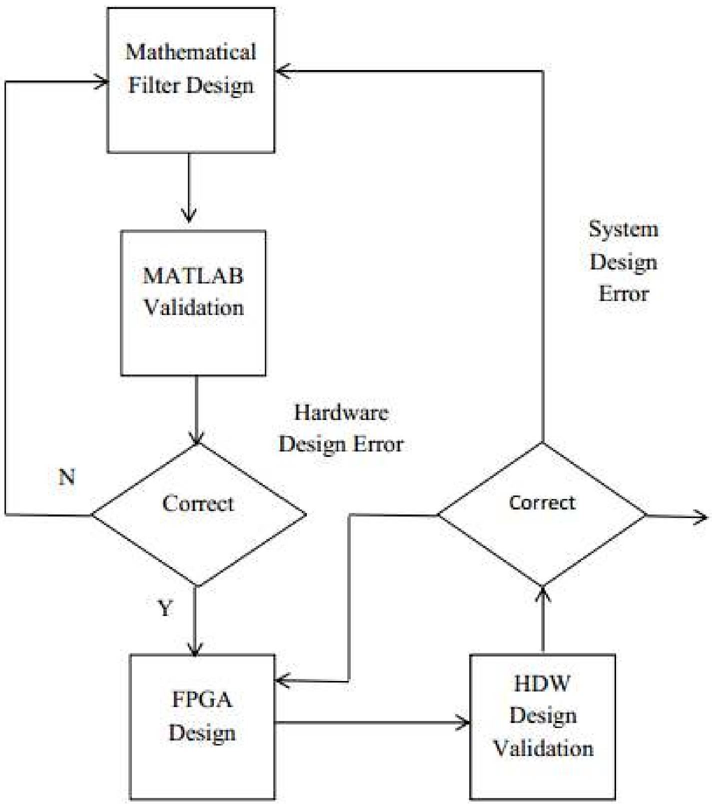


Figure 4.: Experimental Design Flow

Xilinx System Generator is a MATLAB-Simulink based design tool for Xilinx's line of FPGAs. The synthesis of these modules creates netlist files which serve as the input to the implementation module. After generating these files, the logic design is converted into a physical file that can be downloaded on the target device. The performance of the design adaptive filters will be checked by Designing Simulink model [1] or writing code for adaptive filter using appropriate software. The analysis of these signals will give the optimum solution for the noise removal from the ECG.

Fig.5 shows the Adaptive Filter implementation using Xilinx system generator tool. IN and OUT block decides the boundary of hardware. Clean ECG is taken from MIT_BIH which is added with Baseline wander noise. Simulation was done on SIMULINK available with MATLAB (2013b). Fig.5 shows Adaptive filtering using Xilinx system generator tool.

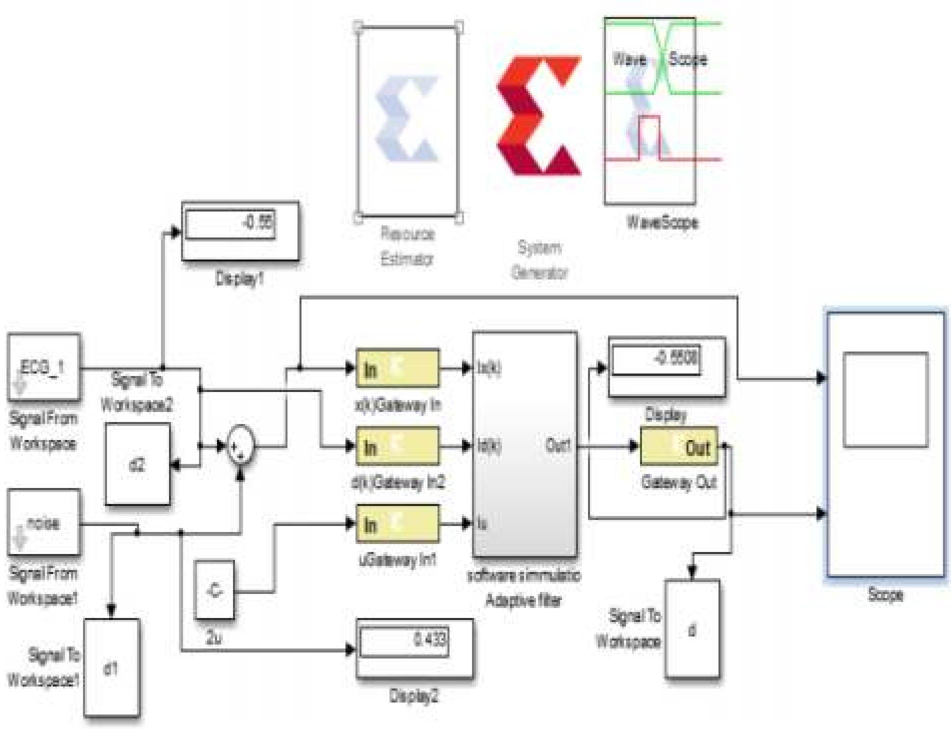


Fig.5.: Adaptive Filter implementation using Xilinx system generator tool.

Adaptive Filter implementation using Spartan-3s400pq208-4 board and Xilinx system generator tool is shown in fig.6.

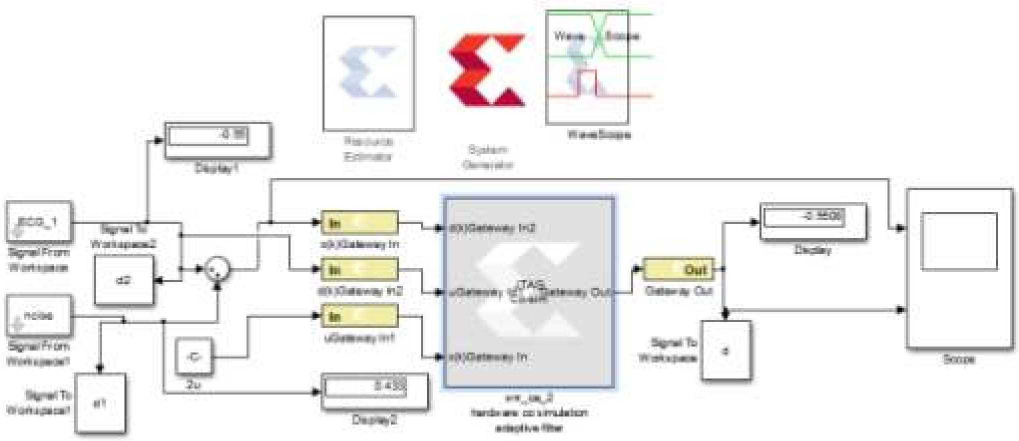


Fig 6: Adaptive Filter implementation using Spartan-3s400pq208-4 board and Xilinx system generator tool

4. CONCLUSION AND FUTURE SCOPE

The simulation and implementation results are presented for Adaptive filter design to denoise the baseline drift interference from ECG signal. There are various artifacts that contaminate electrocardiogram (ECG) recording; the most common are power line interference and baseline drift. The baseline drift in ECG signal is caused due to body movement, respiration or poor electrode contacts etc. The Adaptive filter has been designed to denoise the noisy ECG signal. The proper order of Adaptive filter is chosen on the basis of output SNR. As DSP have some disadvantages like flexibility, cost and performance over FPGA. FPGA is chosen for implementation of final design and also adaptive filter design gets less complexity and because of Xilinx system generator it is easy to implement.

Therefore, first order Adaptive filter is producing same SNR as it producing to higher order. In order to measure the performance of de-noising, SNR of processed ECG is calculated and MSE was determined to find the degree of mismatch between noisy ECG and filtered.

The designed Adaptive filter works excellent in removing noise from ECG signal. Fig. 7 shows results of Adaptive filter implemented on Xilinx system generator. Within fig.7 above graph show input signal which is mixed with Baseline wander noise and below graph shows filtered ECG signal.

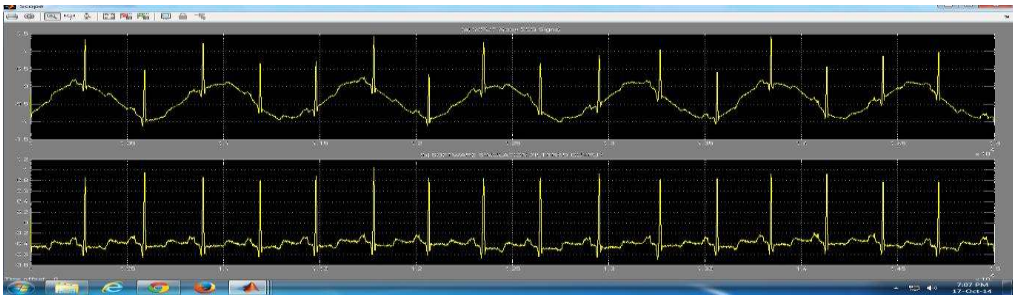


Fig.7.: Adaptive filter result implemented on software simulation

Similar results obtained on hardware using Spartan-3s400pq208-4 board, which are shown infig.8.

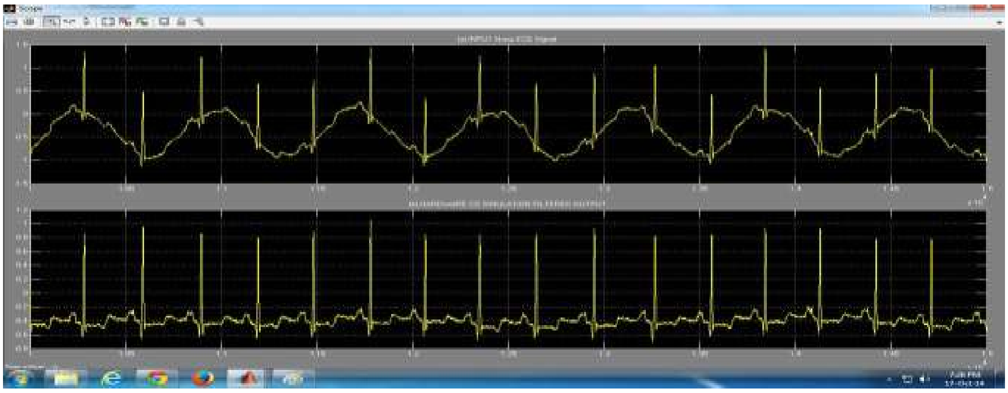


Fig.8: Adaptive filter result implemented on hardware co-simulation using Spartan-3s400pq208-4 board.

5.REFERENCES

[1]Sande Seema Bhogeshwar, M.K.Soni, Dipali Bansal, "Design of Simulink Model to denoise ECG signal using various IIR & FIR filters", IEEE International Conference on Reliability, Optimization and Information Technology - ICROIT 2014, India, Feb 6-8 2014, pp. 477-483.
[2]M.zivanovic and M.Gonzalez-Izal, "Simultaneous power line interference and baseline wander removal from ECG and EMG signals by sinusoidal modelling." In Medical Engineering & Physics, xxx, pp. I-II, 2013.
[3]S.B.S.Bagha, "Removal Of 50hz Powerline Interference For Quality Diagnosis Of Ecg Signal", In International Journal of Engineering Science and Technology, vol.5, pp.1149- 1155, May 2013.
[4]B.Chandrakar,O.P.Yadav and V.K.Chandra, "A Survey Of Noise Removal Techniques For Ecg Signals", In International Journal of Advance research in computer and Communication Engineering vol. 2 , Issue 3 , pp.1354- 1357, March 2013.
[5]M.Leelakrishna. and ISelvakumar, "FPGA Implementation of High Speed FIR Low Pass Filter for EMG Removal from ECG", In International Journal of Engineering Research & Technology vol. 2 Issue 5, pp.855-863, May 2013.
[6]P. J. Joshi, Y. P. Patkar, A.B. Pawar, P. B. Patil, U.R.Bagal. And B. D. Mokal , "ECG Denoising Using MATLAB", In International Journal of Scientific & Engineering Research, vol 4, Issue 5,pp.140 1-1405, May-2013.
[7]A.Sanyal, A.Baral and A.Lahiri, "Application of Framelet Transform in Filtering Baseline Drift from ECG Signals", In Sciverse Science Direct Procedia Technology vol.4 pp. 862 - 866, 2012.
[8]G. Kadam and P.C.Bhaskar, "Reduction of Power Line Interference In ECG Signal Using Fir Filter", In International Journal Of Computational Engineering Research, Vol. 2, Issue No.2, pp.314-319, 2012.
[9]N.kumar, I.Ahmad and P.Rai, "Signal Processing of ECG Using Matlab", In International Journal of Scientific and Research Publications, ISSN 2250-3153, vol2, Issue 10, pp.I- 6, October 2012.
[10]D.V.L.N Sastry,K.S.Gupta ,V M.Krushna and D.S.y'S N. Reddy, "Improved Snr Of Ecg Signal with New Window- Fir Digital Filters", In International Journal of Advanced Research in Electronics and Communication Engineering, vol I, Issue 3, pp.88-85, September 2012.
[11]M.Z. U.Rahman, R.A. Shaik and D. V .R.K.Reddy, "Efficient sign based normalized adaptive filtering techniques for cancelation of artifacts in ECG signals: Application to wireless biotelemetry", In Elsevier, Signal Processing, vol-91 pp. 225-239, 2011.
[12]M.Kaur,B.Singh and Seema, "Comparisons of Different Approaches for Removal of Baseline Wander from ECG Signal", In 2nd International Conference and workshop on Emerging Trends in Technology, pp.30-36, 2011.
[13]M.Chan, "Filtering and Signal-Averaging Algorithms for Raw ECG Signals." In ESE 482 Digital Signal Processing - Washington University in Saint Louis Final Project – December 14, pp.1-16, 2010.