ECG RECTIFICATION THROUGH MULTI-STAGE ADAPTIVE FILTERING

Rajesh Dey[1], Peeusa Mitra [2] Rajkumar Mandal[1,]Syed Samser Ali[3], Achintya Das[2]

[1,]Department of Electronics and Communication Engineering SDET-Brainware Group of Institutions, Barasat, Kolkata, India

[2] Department of Electronics and Communication Engineering Kalyani Government College of Engineering, Kolkata, India

[3] Department of Electronics and Communication ngineering , Gargi Memorial Institute of chnology,Baruipur,Kolkata,india

Correspondance: de.rajesh@gmail.com

ABSTRACT: *–Death due to Cardiac Disease across the world is increasing day by day . Electrocardiogram (ECG) is one of the effective ways of detecting heart disease. The ECG (electrocardiogram) is a framework that gives patient's basic heart movement. The Adaptive Electro gram Filter will be intended to diminishing noise brought about by outer frameworks and body antiques. This paper intends to decrease the commotion obstruction in the ECG signals and better distinguishes results. Probably the most widely recognized instances of noise that the ECG filter would need to remove so as to give valuable outcomes incorporates Power line interference, motion artifacts, muscle compression, electrode contact noise and obstruction caused due other electronic equipment's.. In this report exhibited study and usage of Least Mean Squares (LMS) in noise remedy of ECG signal is being described. As it is known the rudimentary bandwidth used for the ECG monitoring is from 0 .5 Hz to 100 Hz. So being a very low frequency signal it is affected by artificial artifacts named as power line interference, Base line wander, Electrostatic potentials and noise of electronic devices. This paper presents methods for removal of different noises related with ECG signal acquirement and processing using the method of adaptive filtering. LMS algorithm based adaptive filtering is being used to remove power line interfaces. For other two major noises like base line wander and Electronic devices noises resampling and band pass filtering is used*

.**Keywords:** Least Mean Square (LMS), Electrocardiogram (ECG),Power line interference(PLI),Baseline Wander (B.W.) Adaptive Filter.

I. INTRODUCTION

The electrical signal generated due to the rhythmic contraction and expansion of the heart muscle is known as ELECTROCARDIOGRAM. Since ECG is the reflection of heart's real time activity, any irregularity is mirrored as change in rhythm of the ECG signal. This is one of the main cause behind the huge usage of ECG analysis in detection of cardiac abnormalities. ECG is often used as cardiovascular signal in clinical diagnosis because of its cost efficiency

and non-invasive technique which gives us a lot of Diagnostic information. In the last five decades the study of the ECG signal developed from the simple visual assessment to completely automated diagnosis system. ECG detects abnormalities in cardiac muscles; e.g: arrhythmia, myocardial infarction, conduction defects. Conversely recording of ECG get affected from different kinds of noise and interferences like power-line interference, baseline wander, electrode motion artifacts etc.

Heart's electrical activity starts with a movement delivered by the extraordinary tissues situated in the mass of right chamber known pacemaker of heart. The conduction of this signal to Atrioventricular node and after that to His-Purkinje fibre is responsible for synchronized constrictions and development of Atrium and ventricle.

An ordinary human heart beats at the rate of 60 to 100 times per minute in resting condition. The ECG waveforms comprise of for the most part 4 areas. P wave, QRS complex, T wave and U wave. Every one of these sections comprises of their typical amplitude and time span (PR interim, R to R length, QRS, ST interim, QT interim). ECG is performed with a gathering of 12 to 15 numbers of electrodes which contain sensors. There are distinctive designs of joining these terminals in arms chest and legs of the patient. The waveforms of ECG recorded through every one of the sensor will be disparate yet the morphology continues as before.

Alongside the planned ECG signal these sensors likewise get the motion artifacts, muscle compressions, and contact noise. These noise influence ECG standard to meander among a few voltage levels and this twisting is known as Baseline wander which is a prevalent noise present in ECG. De-noising incorporates removal of the noise from ECG signal. As ECG is a non-stationary signal evacuation of noise isn't a simple errand. Filtration of noise may prompt loss of data as both the noise and data signal lies in a similar band. So every de-noising procedure goes for least loss of data and agreeable dimension of noise reduction. [1]

Figure1: IDEAL ECG SIGNAL

II. RELATED RESEARCHS AND FINDINGS

A lot of research work has been done in the zone of ECG noise reduction and their examination. Various techniques are utilized for this reason, for example, :

Neural systems analysis[2], computerized filter(IIR or FIR)[3,4] undecimated wavelet transform[5, 6], discrete wavelet transform[7], Fast Fourier Transform, wavelet transform[8, 9]and so forth. Adaptive filtering concept is advantageous however it enhanced the S-peaks at times [10]. Moving averaging filter are utilized for smoothing out the signal and evacuating power line noise [11,12] and these techniques can be effectively actualized in the MATLAB or LABVIEW environment[13]

.But the techniques used are not superior also. So let us compare between the various techniques used in de-noising E.C.G signal. In some cases IIR Filter is used for noise removal but the main constrains here are nonlinear phase response and also system is very unstable so hard to control. Another process used is Fast Fourier transform. In case of fast Fourier transform the main problems are Filters which are used in fast Fourier transform approach. It is slow for long data sequence. There is another problem also, i.e. we get only frequency resolution in this process and no time resolution can be achieved. Different procedures which are widely utilized are Wavelet transform and discrete wavelet transform and undecimated wavelet transform. Be that as it may, wavelet transform isn't reasonable for high unwavering quality. Additionally it Does not separate among noise and signal coefficient of the of the wavelet disintegration at low SNRs. If there should arise an occurrence of discrete wavelet transform the framework is Shift delicate, experiences poor directivity and does not have the stage data that precisely depicts nonstationary signal behavior. Undecimated wavelet transform computationally less productive.

PROBLEMS OF ARTIFACTS

The sources of the ECG noises are of two types environmental and biological. Power line interface is example of predominant environmental noise which lies in the 60 Hz frequency band and Baseline wander and motion artifacts are the examples of biological noise. Here we are going to discuss about few main noises present in ECG signal.

Power Line Interference

Alternating current changes its direction of flow 60 times in a second, hence we take its frequency as 60Hz. The source of this environmental noise in the ECG signal is poorly grounded ECG recording machines. The range of this noise is 60Hz and its harmonics just because of the AC frequency. So if the sampling rate is 360Hz, this noise reappears at 60Hz, 120Hz, 180Hz i.e. n*60.

Instrumentation Noise

It is one of the environmental noise present in ECG. The source of this noise is hardware which is used in recording the ECG signal. Since this noise can be filtered using Low Noise Amplifiers (LNAs).

Baseline Wander

Baseline drift is basically a unwanted biological signal that appears as a noise signal in ECG signal. It changes the position of the isoelectric line so the ECG looks like it is “wandering” in several levels. Source of this noise is patient movement, moving cables during recording, loosely placed electrodes, etc.

Motion Artifact

The most challenging part of noise removal from ECG is discarding Motion artifact . It is also a biological noise, which appears in the ECG signal. The frequency band of Motion Artifact is wide-ranging and it totally overlaps the ECG’s spectrum. Most of the linear filtering methods are unable to eliminate this noise and that’s why adaptive filtering technique is used.

IV. **DIFFERENT SOLVING APPROACH**

At first the raw data is being collected from the MIT BIH database available at www.physionet.org

PhysioBank is a huge and growing archive of well-categorized digital recordings of signals generated by human organs like ECG EEG etc. Related data is used by the biomedical research community.

Resampling:

Collected signal is resampled at the rate of 128 hz. Resampling makes it relatively noise free, especially Baseline wander is removed.

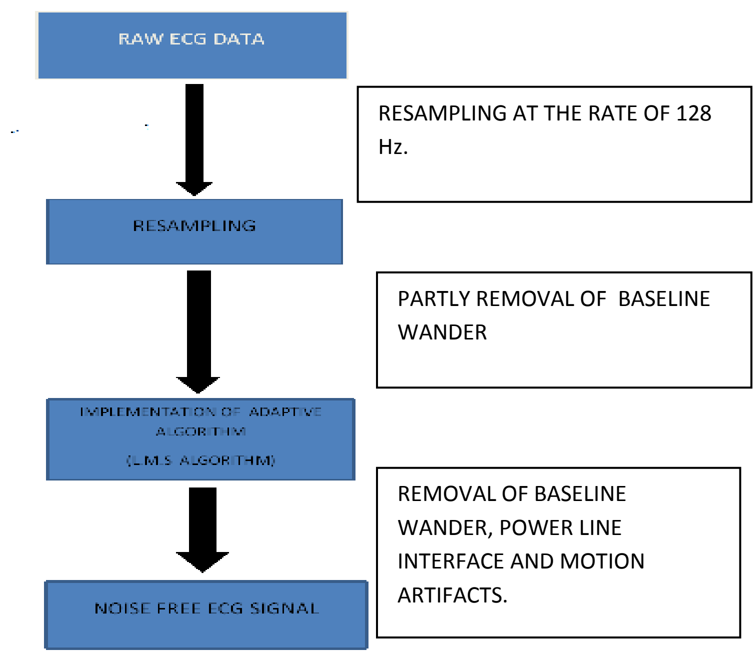
Adaptive approach:

To minimize power line interference an adaptive filtering technique is used. In this case it is seen that type 1 adaptive filter is the better option to achieve the goal of continuous subtraction of 60 Hz sinusoidal signals from ECG signal which is function of time or random dynamic ECG signal.

Rectification of baseline wander can also be done using time varying adaptive filtering technique. To nullify the previously mentioned noise is done using notch filtering technique which follows a particular adaptive algorithm. In this case Least Means Square algorithm with variable step size is used. The main moto is to nullify or removal of 0 to 0.5 Hz frequencies. It is observed that the smaller parameter i.e. step size is very useful for Baseline wander rectification

Adaptive filtering technique is the better option when noise is time dependent and random in nature. In the beginning of P wave a particular reference input is applied to a suitable adaptive filter. In this case an weighted impulse value is taken as reference input. The residue from adaptive subtraction technique or filtering technique applied to the particular reference signal and time varying noisy ECG signal is motion artifact. By this way we can remove motion artifact from noisy ECG signal.

GENERAL STEPS OF NOISE FILTERING IN ECG:



V. SIMULATION & RESULTS

Here the multistage adaptive filtering technique is used to rectify noisy ECG signal. The entire experiment is performed in MATLAB simulation environment.

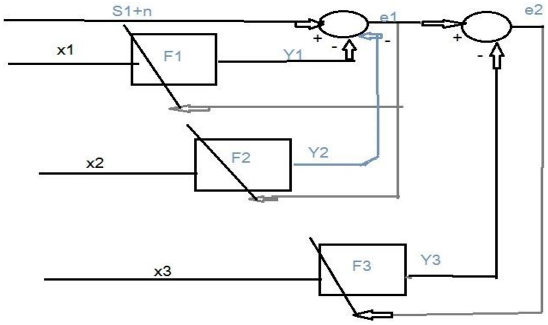


Figure1: BLOCK DIAGRAM OF MULTISTAGE ADAPTIVE FILTER

S1+n = NOISYECG SIGNAL
X1= INPUT SIGNAL IN FIRST STAGE
X2 = INPUT SIGNAL IN SECOND STAGE
X3= INPUT SIGNAL IN THIRD STAGE.
F1= 1ST STAGE FILTER
F2= 2ND STAGE FILTER
F3= 3RD STAGE FILTER
e 1 = error generated by 1ST comparator
e2= error generated by 2ND comparator.
Y1= OUTPUT IN 1ST STAGE
Y2= OUTPUT IN 2ND STAGE
Y3= OUTPUT IN 3RD STAGE

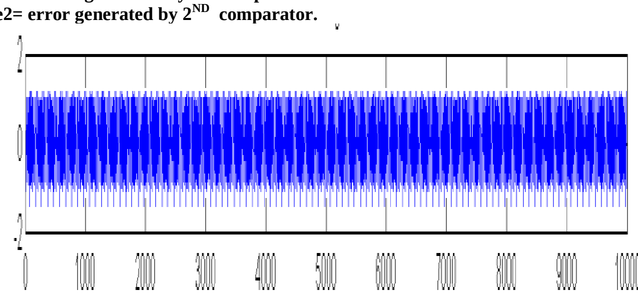


Figure 2: NOISY ECG SIGNAL

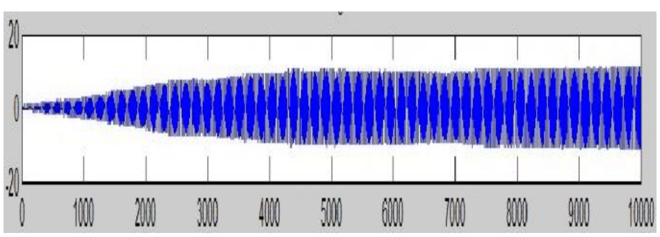


Figure 3: ECG SIGNAL AFTER FIRST STAGE OF ADAPTIVE FILTERING USING STEP SIZE 0.003

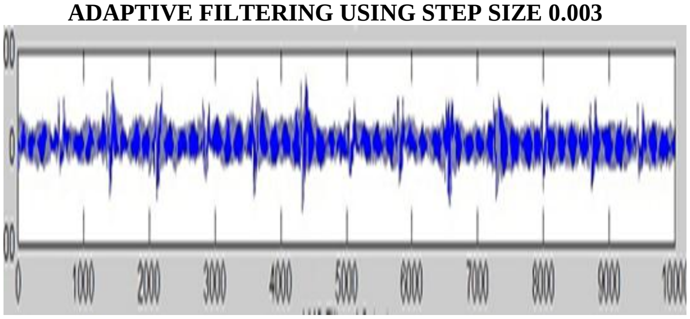


Figure4: ECG SIGNAL AFTER FIRST STAGE OF ADAPTIVE FILTERING USING STEP SIZE 0.004

The multistage filtering technique is divided into two stages. First one removes powerline interference and baseline wander and the second one eliminates motion artifacts.

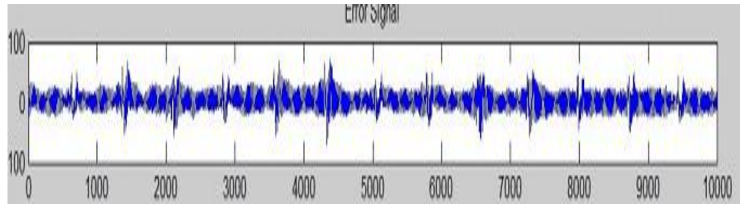


Figure 5: ECG SIGNAL AFTER FIRST STAGE OF ADAPTIVE FILTERING USING STEP SIZE 0.005

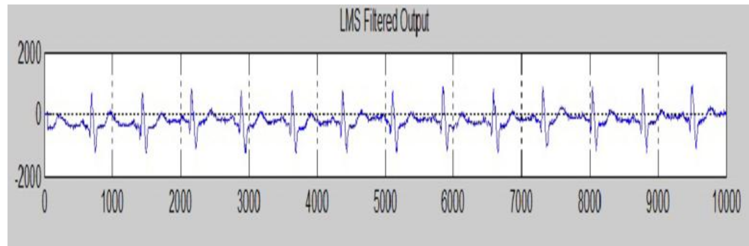


Figure6: ECG SIGNAL AFTER FINAL ROUND OF FILTERING USING STEPSIZE 0.003

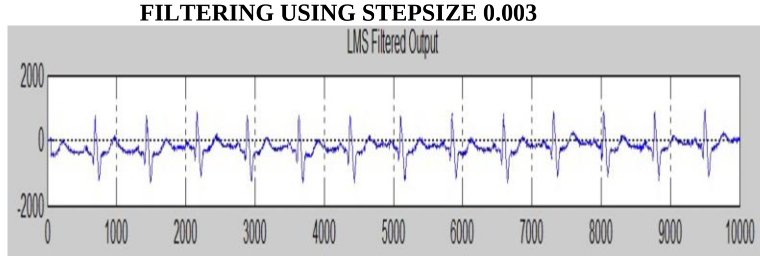


Figure7: ECG SIGNAL AFTER FINAL ROUND OF FILTERING USING STEPSIZE 0.004

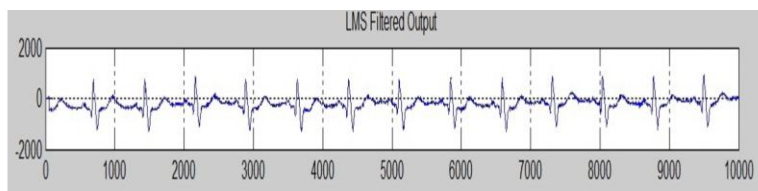


Figure8: ECG SIGNAL AFTER FINAL ROUND OF FILTERING USING STEPSIZE 0.005

VI. CONCLUSION:

Here it has been studied and analyzed conventional adaptive Based on results from simulations it can be seen that various adaptive stages are giving better performance in nullifying noise from ECG signal. For improving the result, variable step size can be implemented which gives faster convergence of algorithm. A faster adaptation technique removes the noise in smaller segment which reduces noise from each part of ECG segment.

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