Use of Kaiser Window For ECG processing.

MAHESH S. CHAVAN, * RA.AGARWALA, ** M.D.UPLANE
Department of Electronics engineering, PVPIT Budhagaon Sangli (MS)
* Department of Electronics, NSIT NewDelhi
** Department of Electronics, Shivaji University Kolhapur (MS)
INDIA

Abstract:
This paper deals with the design and implementation of the FIR digital filter designed using Kaiser Window for the noise reduction in the ECG signal. The simulation model is built with the help of Mathlab and implemented. Firstly three different FIR filters using Kaiser Window namely low pass high pass and notch filter are designed and then implemented in the ECG signal. The proper signal conditioning circuit has been used to access the 12 lead ECG signal. Required simulation model has been built in the mathlab. All the filters have been designed with the help of FDA toolbox the Mathlab. Digital filters plays very important role in the processing of the low frequency signals. Numbers of biomedical signals are of the low frequency. The ECG signal, generally represents the condition of the heart. It has the frequency range form .5 Hz to 100Hz. Artifacts plays vital role in the processing of the ECG signal. The work is the step in the direction for reduction of the artifacts using digital filter designed with the help of Kaiser Window. It is found that the filter introduced works satisfactorily.

Key Words: Electrocardiogram, Simulation, Kaiser Window, Real Time Filtering.

1. Introduction

Processing of the biomedical signal basically deals with filtering of the signal. This ECG signal gets distorted due to different artifacts like power line interference, muscle interference. Most of the biomedical signals appear as a weak signal in an environment that is teemed with many other signals of varies origins. The problem caused by the artifacts in biomedical signals is vast in scope and variety; there potential for depredating the performance of the most sophisticated signal processing algorithm is high. The biomedical signal in the present work is the ECG signal and the filtering technique suggested is using FIR with Kaiser Window. This ECG gets corrupted due to different kinds of the artifacts. The different types of artifacts are Power line interference, motion artifacts, base line drift and instrumental noise. The care must be taken to nullify the artifacts to avoid wrong diagnosis. Figure 1 shows the basic ECG trace.

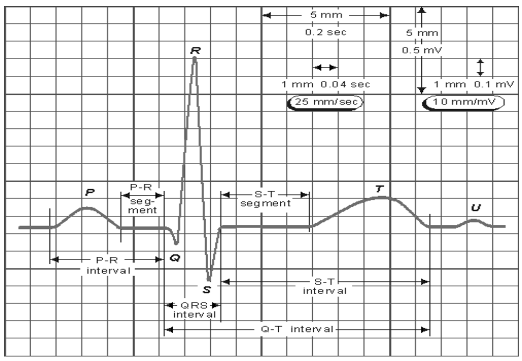

Figure 1: Basic ECG pattern.

Different researchers are working on noise reduction in the ECG signal. Seydnejad SR, Kitney RI. Provided real time heart rate variability extraction using Kaiser window by designing the band pass filters [1]. Mitov shows a method for reduction of power line interference (PLI) in electrocardiograms with sampling rate integer multiple of the nominal power line frequency is developed and tested using simulated signals and records from the databases[2]. Cramer E, McManus CD, Neubert D. Has suggested two different filters embodying a global approach .One is based on a least-squares error fit, the other uses a special summation method. Both methods are compared with a local predictive filter by applying each filter to artificial signals and to real ECGs [3]. Ferdjallah M, Barr RE. has given Frequency-domain digital filtering techniques for the removal of powerline noise with application to the electrocardiogram[4]. A method for line interference reduction to be used in signal-averaged electrocardiography (SAECG) systems is proposed and its performance is analyzed by Ider YZ, Saki MC, Gcer HA [5]. De Pinto V. has worked on removal of the base line wonder and muscle artifacts from the ECG signal [6]. Batchvarov V, Hnatkova K, Malik M. has done assessment study on the Electrocardiogram[7]. Kaiser W, Findeis M. have processed the ECG during stress [8]. Christov II, Daskalov IK have worked on filtering of the electromyogram from the electrocardiogram[9]. von Wagner G, Kunzmann U, Schochlin J, Bolz A have described Simulation methods for the online extraction of ECG parameters under Matlab/Simulink [10].

2. Design of the Elliptic filter

In the filters design using windows like Rectangular, Bartlett, Hanning, Hamming and Blakman it has been found that a trade off exists between the main lobe width and the side lobe amplitude. The main lobe width is inversely proportional to the N order of the filter. An increase in the window length decreases the transition band of the filter. However, The minimum stop band attenuation and pass band ripple, the designer must find a window with an appropriate side lobe level and then choose order to achieve the prescribed transition width. In this process, the designer may often have to settle for a window with undesirable design specifications. To over come this problem Kaiser has chosen a class of windows based the portable Speriodal functions. These functions have the property that they are limited as much as possible. In both time and frequency domains. The Kaiser window is given by

$$w_k(n) = \frac{I_0\left[\alpha\sqrt{1-\left[\frac{2n}{N-1}\right]^2}\right]}{I_0(\alpha)} \text{ for } |n| \leq \frac{N-1}{2}$$

$$=0 \qquad \text{othewise.}$$

Where α is the adjustable parameter and $I_o(x)$ is the modified zeroth-order Bessel functions of the first Kind. In some literature the factor β is also defined and used in the above equations. The β can be defined as $\beta = \left[1-\left[\frac{2n}{N-1}\right]^2\right]$. In the present work, the required ECG signal containing important information lies only in the frequency range of .5Hz to 100Hz. Therefore to study the application filter using Kaiser window on ECG three filters are designed viz low pass, High pass, Band stop of 50 Hz for removal of power line interference. All designs are performed using filter design toolbox in the MATLAB.

The sampling frequency for the design is 1000 Hz. The low pass filter is design for the 100Hz cutoff frequency and order 100. Figure 2.3shows the Magnitude response, Phase response, and impulse response of the filter respectively. The high pass filter is designed for the frequency of .5Hz. Figure 4.5 Shows the Magnitude response, Phase response, impulse response of the high pass filter respectively. Similarly Notch filter of 50 Hz has been designed for removal power line interference for the order of 100. Figure 6, 7 Show the Magnitude response, Phase response, impulse response of the notch filter respectively. All filters provide the linear phase. In the high pass and the notch filters some ripples are indicated in the magnitude responses.

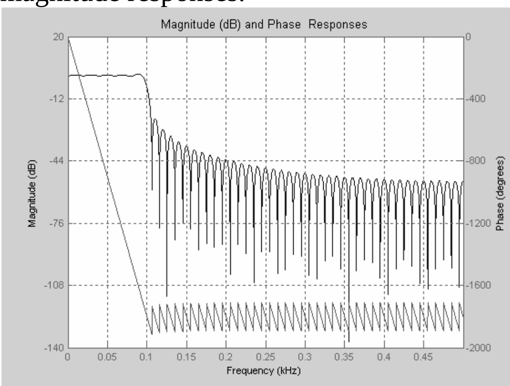

Figure 2: Magnitude and Phase response of the Low pass filter.

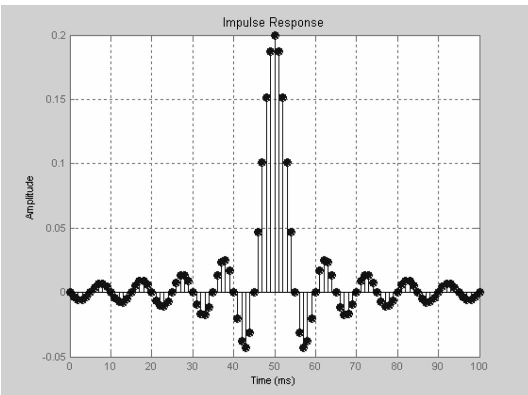

Figure 3: Impulse response of the low filter.

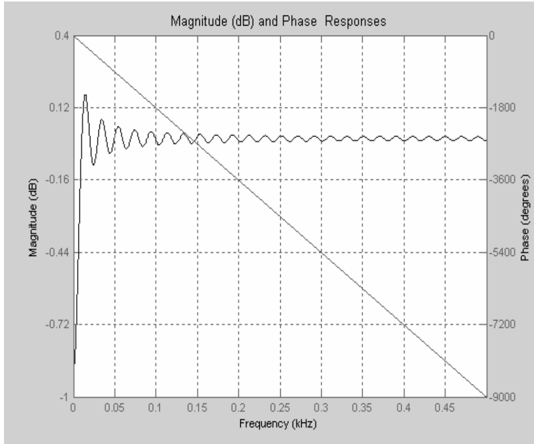

Figure 4: Magnitude and Phase response of the High pass filter.

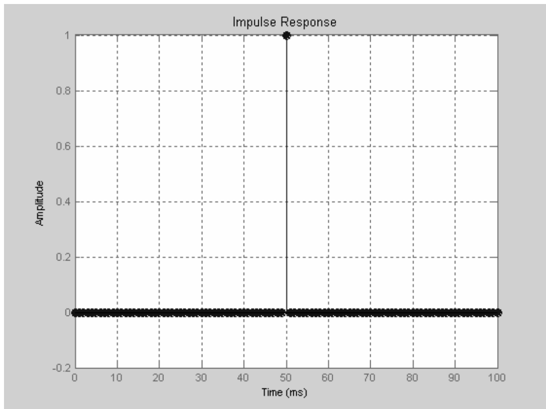

Figure 5: Impulse response of the high filter.

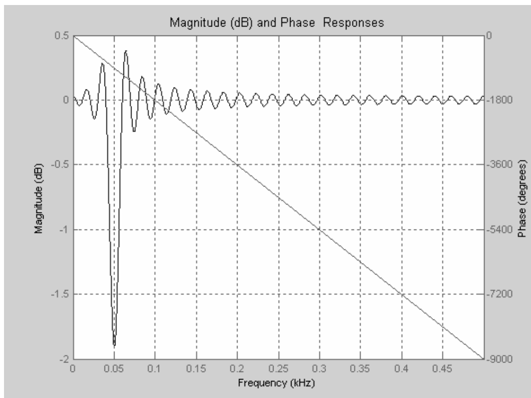

Figure 6: Magnitude and Phase response of the notch filter.

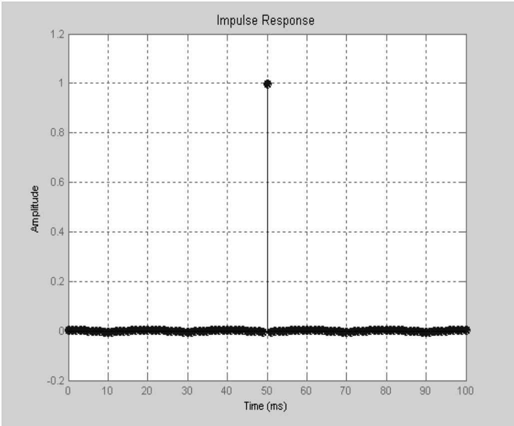

Figure 7: Impulse response of the notch filter.

3. Application of Filter to ECG

The model using three digital filters is built in the Matlab. All the three filters are cascaded. The output of the Filter cascade combination is given to the time scope. The model is built in the simulink of the MATLAB. In the model, digital inputs indicate the ECG, out of the ADC. For accessing ECG signal 711B adds on card has been used. This application also requires the real time window of the MATLAB. Figure – shows the model used in the system.

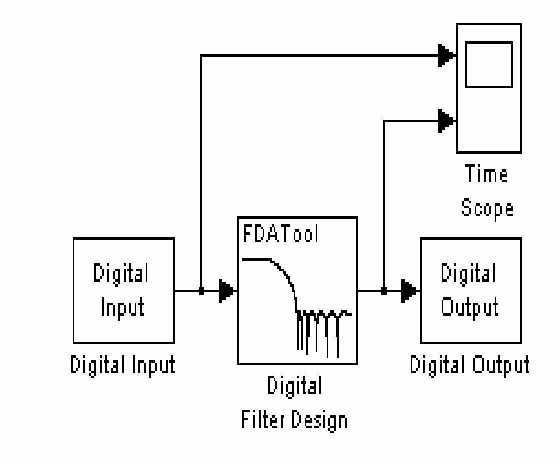

Figure 8: Simulation model used for the ECG processing.

4. Results and Conclusions:

Application of the window function is difficult task. Figure 9,10,11 shows the typical ECG traces for the different lead combinations. Each trace shows the reduction in the noise present in the Original signals. Difficulties in theoretical design of the filter become easier in the design using mathlab. Simulation model works well for the real time application.

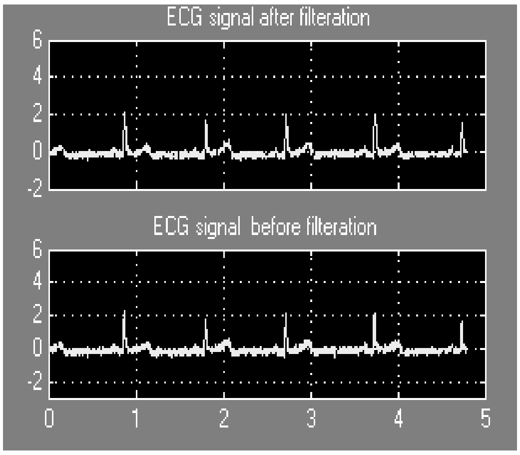

Figure 9: Low pass filtering of Lead I Combination for ECG

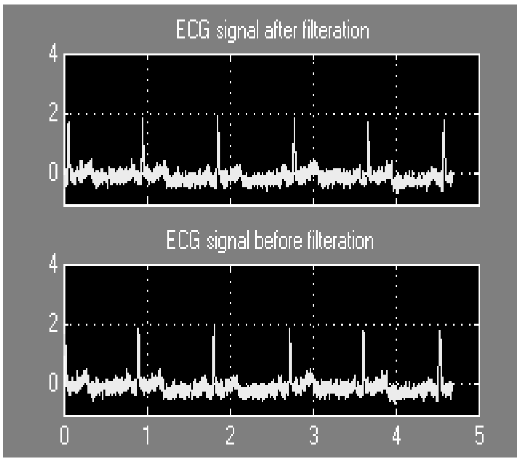

Figure 10: High pass filter Lead I combination of ECG Signal

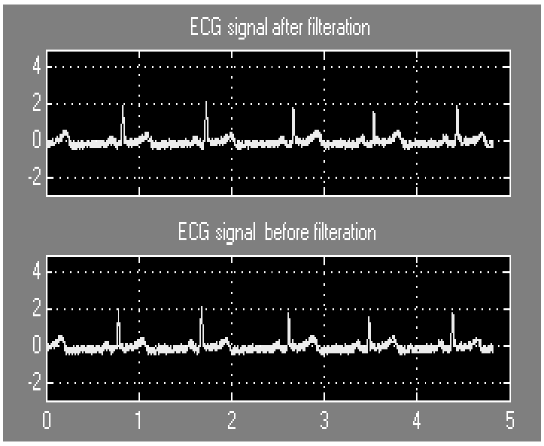

Figure 11: Notch filter application for lead I combination For ECG signal

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