Noise Removal in Cardiac Signal by Shadow Digital Filters

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Abstract

Heart attacks mostly occur in people who suffer from heart or heart-relate diseases, if these diseases are not detected early enough and treated problem will be occurred. There is therefore the need for a reliable means of detecting these diseases to save the patients from these attacks which are increasing in proportion all over the world. Electrocardiograph (ECG), which measures the electrical activity of the heart, generates a signal referred to as ECG signal or simply ECG and the shape of this signal tells much about the condition of the heart of a patient. Naturally the ECG signal gets distorted by ***different*** *artifacts which must be removed otherwise it will convey an incorrect information regarding the patient's heart condition. One of the ways to eliminate ECG Artifacts is using* ***Digital filters*** *with* ***shadow*** *mechanism. We apply a specific filter which will allow only the desired signal to pass, thus the noise will be removed efficiently. In this proposed work we calculate the signal to noise ratio of ECG signal by different shadow factors of shadow filters.*

Keywords: *Digital Filters, shadow Mechanism, Electrocardiograph.*

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1. Introduction

Digital filter plays an important role in digital signal processing applications. Digital filters are widely used in digital signal processing applications, such as digital signal filtering, noise filtering, signal frequency analysis, speech and audio compression, biomedical signal processing and image enhancement etc.[1]. Traditionally, most digital filter applications have been limited to audio and high-end image processing. With advances in process technologies and digital signal processing methodologies, digital filters are now cost-effective in the IF range and in almost all video markets[2].Finite impulse response (FIR) digital filter impulse response is finite, so it can be used for Fast Fourier Transform (FFT) algorithm to achieve the filtered signal, which can greatly improve the efficiency of operation. In addition, FIR digital filter can be designed a linear phase digital filter which is convenient for image processing and data transmission applications [3]

FIR Filter banks are used to perform short-term spectram Analysis in a variety of speech processing systems[4]. Many Window functions

are widely used in digital signal processing for various applications in signal analysis and estimation, digital filter design and speech processing[5]. Heart rate frequency is very important for health status information. The frequency measurement is used in many medical or sport applications like stress tests or life treating situation prediction.[6]. The accurate extraction of the AA signal from the ECG of AF is of great interest for subsequent analysis, since it has been documented to provide significant information on the properties of AF episodes [7].Reduction represents another important objective of ECG signal processing. In fact, the waveforms of interest are sometimes so heavily masked by noise that their presence can only be revealed once appropriate signal processing has first been applied.[8] In the last two decades, spectral analysis of the residual ECG signal (rECG, i.e. an ECG signal in which ventricular components were canceled through beat averaging techniques) has been employed to characterize atrial activities[9].VF is raditionally described as a system of many chaotic in the myocardium wandering, electrical wavelets, ever changing in direction and number. In contrast, recent findings indicate that stable organized centers of rapid activity, called "*mother rotors*"[10].

2. ECG PREPROCESSING

Considerable attention has been paid to the design of filters for the purpose of removing baseline wander and power line interference, both types of disturbances imply the design of a narrowband filter. Removal of noise because of muscle activity represents another important

filtering problem being much more difficult to handle because of the substantial spectral overlap between the ECG and muscle noise. Muscle noise present in the ECG can, however, be reduced. Whenever it is appropriate to employ techniques that benefit from the fact that the ECG is a recurrent signal. For example, ensemble averaging techniques can be successfully applied to time-aligned heartbeats for reduction of muscle noise.

The filtering techniques are primarily used for preprocessing of the signal and have as such been implemented in a wide variety of systems for ECG analysis. It should be remembered that filtering of the ECG is contextual and should be performed only when the desired information

remains undistorted. This important insight may be exemplified by filtering for the removal of power line interference. Such

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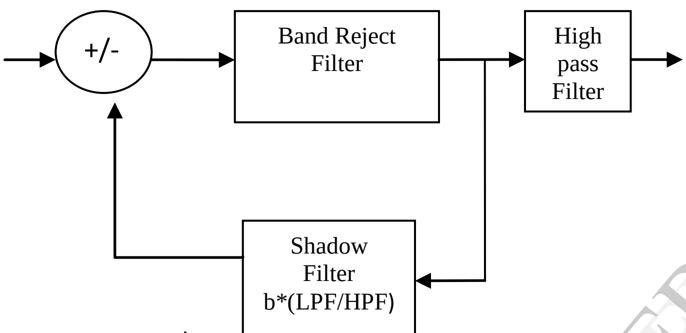
filtering is suitable in a system for the analysis of heart rate variability.

3. Shadow mechanism

In shadow filter mechanism the base filter output is feedback either positively or negatively by a shadow filter of same type or different type .Here we used the shadow mechanism to find best combination for different values of 'b' for which the side lobe attenuation is more.

Distorted ECG signal



H_d (z)

H_o (z) Noise free output signal

Figure: 1 Block diagram for Shadow filter mechanism

To achieve shadow filter we can use any combinations like band pass in main path and band stop in feedback path.

Hence we can derive expression of the transfer function for the shadow mechanism with positive feedback connection is,

$$H_o(z) = \frac{\text{The transfer function of Base filter}}{1 - b*(\text{transfer function of shadow filter})}$$

4. Design of Band Reject Filter

The Band Reject filter removes the corrupting power line frequency noise in ECG signal. The power line frequency is 60Hz and sampling frequency is 500Hz. The order of the filter is 25. **Steps to design Band reject filter:**

1) Lower cut-off frequency: 59.5 Hz
2) Upper cut-off frequency: 60.5 Hz
3) Sampling frequency : 500 Hz

The desired transfer function of filter is

$$h_d(n) = \frac{\sin \pi n + \sin 0.198\pi n - \sin 0.202\pi n}{\pi n}$$

By multiplying the desired transfer function with windows we can get transfer function of FIR band reject filter i.e.

$$h(n) = h_d(n) * w(n)$$

Where $w(n)$ represents is Transfer function of following windows

1) Hamming window
2) Hanning window
3) Kaiser window

4.2Design of High Pass Filter

The high pass filter removes the corrupting low frequency noises in ECG signal. The order of the filter is 25.
Steps to design High pass filter:

Lower cut-off frequency: 0.5 Hz

The desired transfer function of filter is

$$h_d(n) = \frac{\sin \pi n - \sin 0.002\pi}{\pi n}$$

By multiplying the desired transfer function with windows we can get transfer function of FIR band reject filter i.e.

$$h(n) = h_d(n) * w(n)$$

Where $w(n)$ represents is Transfer function of following windows

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1) Hamming window
2) Hanning window
3) Kaiser window

4.3 Design of Shadow Low Pass filter

Specifications:
1) cut-off-frequency:0.2π
2) Filter order:25

The desired transfer function of filter is

$$h_d(n) = \frac{\sin 0.2\pi n}{\pi n}$$

By multiplying the desired transfer function with windows we can get transfer function of FIR band reject filter i.e.

$$h(n) = h_d(n) * w(n)$$

Where $w(n)$ represents is Transfer function of following windows

1) Hamming window
2) Hanning window
3) Kaiser window

The Time response and frequency response is shown in below fig: 1

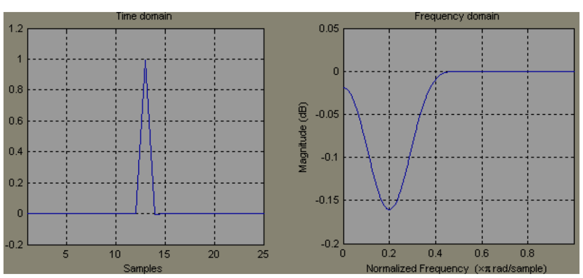

Fig:1 Frequency response of the Band reject filter

4.4 Design of Shadow High Pass filter

Specifications:
1) cut-off-frequency:0.2π
2) Filter order:25

The desired transfer function of filter is

$$h_d(n) = \frac{\sin \pi n - \sin 0.2\pi}{\pi n}$$

By multiplying the desired transfer function with windows we can get transfer function of FIR band reject filter i.e.

$$h(n) = h_d(n) * w(n)$$

Where $w(n)$ is represents Transfer function of following windows

1) Hamming window
2) Hanning window
3) Kaiser window

The Time response and frequency response is shown in below fig:2

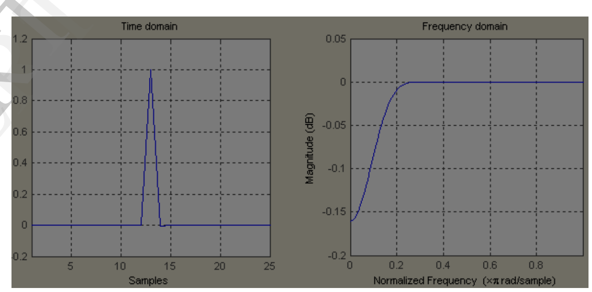

Fig2. : Response of the high pass filter

5. Results and Implementations

The results shows responses of the cascaded high pass filter and Band reject filter and compares the signal to noise ratio of ECG signal before and after the filtering for different Shadow filters.

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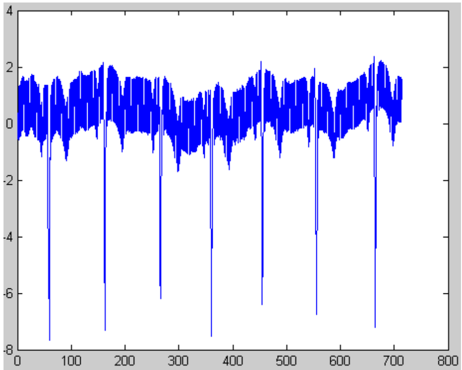

Fig3: Noised ECG signal

When the raw ECG signal of fig 4 is filtered with the two filters in cascade the whole noises were removed, producing a near clean ECG signal of fig:4 to fig:6 without shadow filters. and form fig:7 to fig:9 shows the same responses with shadow low pass filter with different factors.

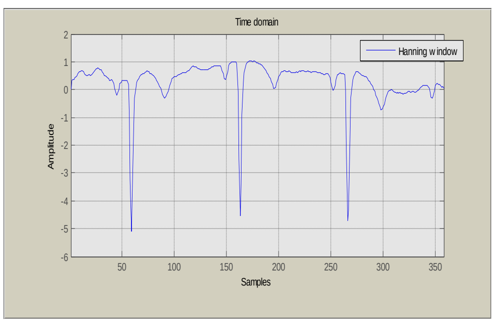

Fig4:Response of cascaded filters with hanning window

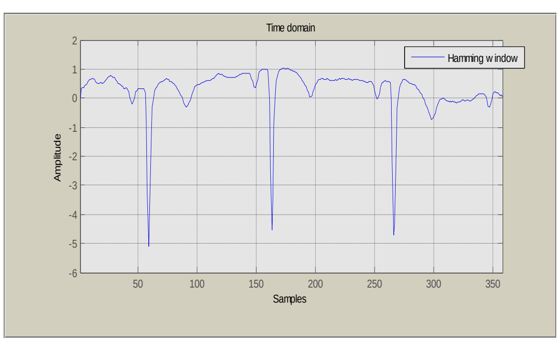

Fig5: Response of cascaded filters with Hamming window

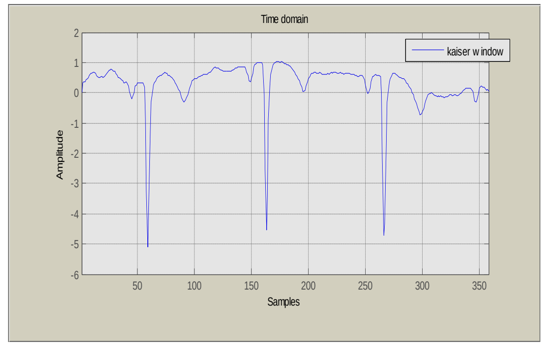

Fig6:Response of cascaded filters with Kaiser window

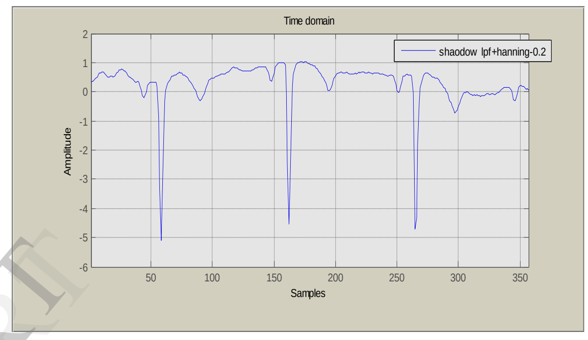

Fig7:Response of cascaded filters with shadow lpf+hanning and factor:0.2

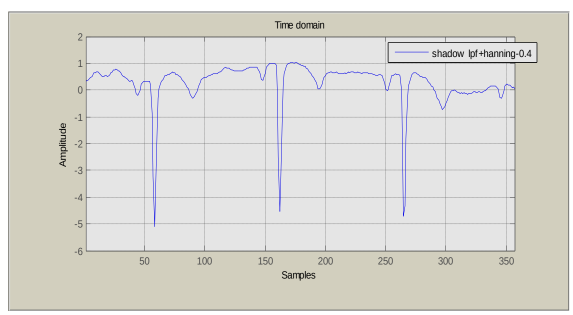

Fig8:Response of cascaded filters with shadow lpf+hanning and factor:0.4

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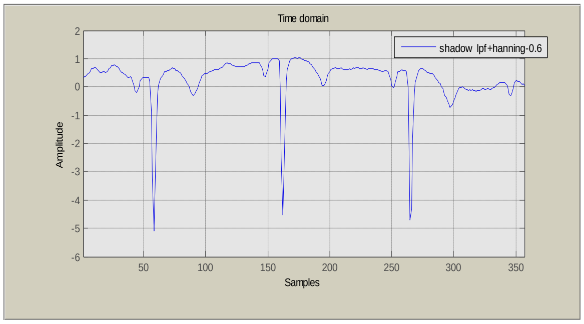

Fig9:Response of cascaded filters with shadow lpf+hanning and factor:0.6

Table1: Without shadow Filters

WINDOW	SNR in dB
HAMMING	17.3018
HANNING	17.3021
KAISER(10.5)	17.3048

Table2: with shadow LPF

FEED BACK FACTOR	WINDOW	SNR in dB
0.2		18.0549
0.4	HAMMING	18.7800
0.6		19.4790
0.2		18.0552
0.4	HANNING	18.7802
0.6		19.4793
0.2		18.0580
0.4	KAISER(10.5)	18.7831
0.6		19.4822

6. Conclusion

In this paper we are using shadow based FIR filters to remove power line interferences 60 Hz of ECG signal .Here we attains different SNR values by varying feedback factor and observing the Table-1 and table-2,it is clearly observed that SNR of clean ECG signal is improved (Table-2) for different feedback factors' of shadow filter compared to digital filters without shadow filters(Table-1).

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