Noise Elimination in the Cardiac Signal Using Hybrid Windows

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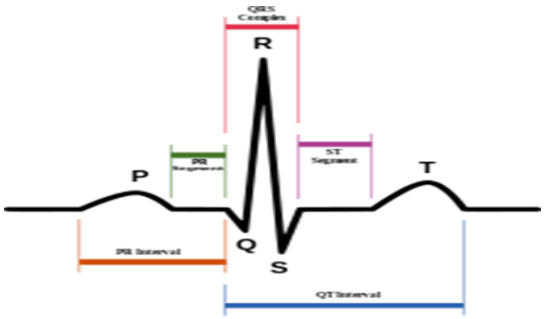
Abstract: **- Digital FIR filters are successfully used in signal processing, speech processing, image processing and radar signal processing etc. In bio-medical processing FIR filters are used for the Cardiac signal processing.In the process of diagnosing the ECG signal, it is effected by the different artifacts. These artifacts are removed by using digital FIR filters. Here our proposed method reduce power line noise by cascading low pass filter, high pass filter and band reject filter using HYBRID windows.**

Keywords: **ECG, Power line interference, FIR filters, Hybrid windows, SNR**

I. INTRODUCTION:

Digital FIR filters [1] are successfully employed in processing electrocardiographic signals for measurement. ECG which is a biomedical signal is naturally corrupt by various interferences such as 50/60Hz power line interferences (PLI) and some other biomedical signals like baseline wander [2], electromyogram (EMG) and electroencephalogram (EEG). ECG signal frequency is approximately between 0.5Hz and 100Hz. Baseline Wander frequency is below 1 Hz while that of EEG is above 100Hz.

Electrocardiogram (ECG) [4] represents electrical activity of human heart. ECG is composite from 5 waves - P, Q, R, S and T. This signal could be measured by electrodes from human body in typical engagement. Signals from these electrodes are brought to simple electrical circuits with amplifiers and analogue – digital converters.



Figure(1)Schematic representation of normal ECG

In the process of diagnosing an ECG signal different artefacts may get introduced like electrode contact noise, electro surgical noise, power line interference and baseline drift. These artefacts are due to electromagnetic induction, displacement currents in leads or body of the patient, effects from equipment interconnections, and other imperfections. Even though proper grounding or twisted pairs minimizes such interferences, but it can be more effectively done using digital filters.

In this paper we designed band reject filter for the removal of power line interference and for the reduction of base line wanders, we go for a high pass filter. ECG signal analysis is also done using above two types of filters connected in series with hybrid window (Hamming+ Kaiser, Triangular+ Rectangular) technique is used and calculated SNR values for different windows and compare it with Hybrid windows.

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II. PROPOSED METHOD:

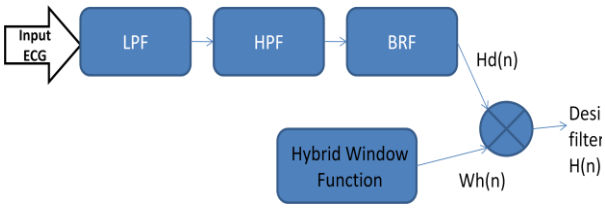

Figure (2) Block Diagram of PROPOSED METHOD

DESIGN OF LOW PASS FILTER:

III. DESIGN OF LOW PASS FILTER

The low pass filter removes the corrupting high frequency noises in ECG. The cut off frequency used here is 100Hz while the sampling frequency is 500Hz.Matlab is used for the design.

And the transfer function is

Hd(n)= sin(wc*(n))./(pi*(n)

IV. DESIGN OF HIGH PASS FILTER:

The high pass filter removes the Baseline Wander noise in the ECG signal. The cut off frequency is 0.5Hz and the sampling frequency is 500Hz.And the transfer function is

Hd(n)= (sin(pi*(n))-sin(wc*(n)))./(pi*(n))

V. DESIGN OF BAND REJECT FILTER:

The notch filter removes the powerline interference noise in ECG signal. The powerline frequency is 50Hz and sampling frequency is 500Hz.And the transfer function is

Hd(n)=(sin(wc1*(n))-
sin(wc2*(n))+sin(pi*(n))).(pi*(n))

VI. METHODOLOGY:

FIR FILTER: -

FIR filters have the impulse response of finite duration and can be implemented without feedback. Windowtechniques used in FIR filter are:-

A. Rectangular window :-

It is the simplest window function and is given by$W_R(nT_s)=\begin{cases} 1\,, for \frac{-(N-1)}{2} \le n \le \frac{(N-1)}{2} \\ 0, \quad otherwise \end{cases}$

B. Hanning and Hamming windows:-

Combined Hanningand Hamming window function is called generalized Hamming window function and it is given by the following expression

$W_H(nT_s) = \begin{cases} \alpha + (1-\alpha)cos\frac{2\pi n}{N-1}\,, & for \frac{-(N-1)}{2} \le n \le \frac{(N-1)}{2} \\ 0, & otherwise \end{cases}$

α= 0.50 for Hanning window function

α= 0.54 for Hamming window function

C.Blackman window:-

Blackman window function has one additional cosine term than Hann and Hamming window function and is given by

$W_H(nT_s)= \begin{cases} 0.42 + 0.50cos\frac{2\pi n}{N-1} + 0.08cos\frac{4\pi n}{N-1}\,, & for \frac{-(N-1)}{2} \le n \le \frac{(N-1)}{2} \\ 0, & otherwise \end{cases}$

This additional term in Blackman window function leads to further reduction in the amplitude of Gibb 'oscillations.

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D.Kaiser window:-

To get the desired transition width, the order of the filter N is increased to an unnecessarily high value. This can be overcome by using Kaiser Window [3].

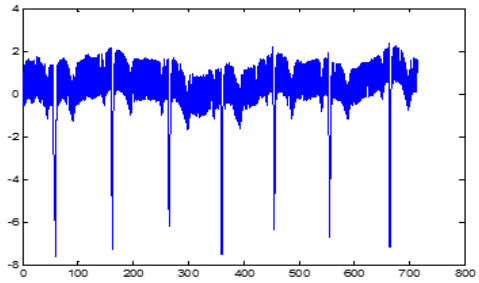
Kaiser window function is given by

$$W_K(nT_s) = \begin{cases} \frac{F_0(\beta)}{F_0(\alpha)}, for \frac{-(N-1)}{2} \leq n \leq \frac{(N-1)}{2} \\ 0, \quad otherwise \end{cases}$$

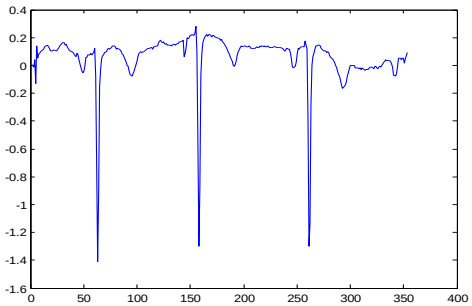
Where α is an independent parameter and β is a dependant parameter

VII. RESULTS:

We are well known that the digital FIR filter with Kaiser Window removes the artifacts from ECG with less modification in the waveform. We propose to apply Hybrid window and the series of LPF, HPF, BRF for pre-processing on ECG signal. The original signal having artifacts are given as input to low pass filter as shown in figure(3).And the filtered cardiac signal is the output of band reject filter as shown in figure(4)



Figure(3)Original ECG



Figure(4) Filtered ECG signal

VIII. COMPARISON OF SNR VALUE FUNCTIONS:

Window Technique	SNR value
Triangular window	0.0396
Kaiser window	0.0397
Bartlett+Rectangular window	0.0596
Kaiser+Hamming window	0.0597

IX. CONCLUSION:

Here we conclude that the effect of series of LPF,HPF,BRF and FIR filter for the pre-processing of an ECG signal which is more significant and very efficient rather than using single filter. This combination of FIR and frequency selective filters in pre-processing of an ECG signal removes not only baseline drift but also removes power line interference which is major problem in ECG processing. By proper choosing of cut-off frequencies of the filter, one can reduce the noise to a large extent. Table 1 shows the comparison of the output SNR of the filtered ECG for different window techniques and hybrid window techniques, which shows that a slight increase in SNR takes place at combination of Kaiser and Hamming windows.

X. REFERENCES:

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