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DENOISING OF ECG USING COMBINED WINDOW TECHNIQUE

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Abstract

Electrocardiography (ECG) is the process of recording the electrical activity of the heart over a period of time using electrodes placed on the skin. These electrodes detect the tiny electrical changes on the skin that arise from the heart muscle depolarizing during each heartbeat. ECG recording process is contaminated by power line noise because power line fluctuations from mains AC supply. This will create problem for doctors while analyzing the ECG graph to diagnose correctly the problems of heart as regular pattern of ECG is affected. Here an attempt is made to filter power line noise with a new concept combined conventional windows.

I. INTRODUCTION

Filtering is the process by which the frequency spectrum of the signal can be modified, reshaped or manipulated to achieve some desired objectives such as:

- To eliminate noise contaminated in signal
- To remove signal distortion due to imperfect transmission channel
- To separate two or more distinct signals which were purposely mixed for maximizing channel utilization
- To resolve signals into their frequency components
- To demodulate the signals which were modulated at the transmitter end
- To convert digital(discrete-time) signals into analog signals

II. CONCEPT OF WINDOWS

In signal processing, a window function (also known as an apodization function or tapering function) is a mathematical function that is zero-valued outside of some chosen interval. For instance, a function that is constant inside the interval and zero elsewhere is called a rectangular window, which describes the shape of its graphical representation. When another function or a signal (data) is multiplied by a window function, the product is also zero-valued outside the interval: all that is left is the part where they overlap; the "view through the window". Applications of window functions include spectral analysis, filter design, and beam forming.

III CONCEPT OF CONVENTIONAL WINDOWS:

Rectangular window:

$$w(n) = 1 \quad \text{.. (1)}$$

Hamming window:

$$w(n) = 0.54 - 0.46\ \cos\left(\frac{2\pi n}{N-1}\right)$$

- Note that:

$$w_0(n) \stackrel{\text{def}}{=} w(n + \tfrac{N-1}{2})$$
$$= 0.54 + 0.46\ \cos\left(\frac{2\pi n}{N-1}\right) \quad \text{.... (2)}$$

Triangular windows:

With non-zero end-points:

$$w(n) = \frac{2}{N+1}\cdot\left(\frac{N+1}{2} - \left|n - \frac{N-1}{2}\right|\right) \quad \text{.......(3)}$$

Bartlett window:

Triangular window with zero-valued end-points:

$$w(n) = \frac{2}{N-1} \cdot \left(\frac{N-1}{2} - \left| n - \frac{N-1}{2} \right| \right) \quad \text{.... (4)}$$

Parzen window:

the equation of parzen window is :

$$w(n) = \begin{cases} 1 - 6\left(\frac{n}{N/2}\right)^2 \left(1 - \frac{|n|}{N/2}\right), & 0 \leqslant |n| \leqslant \frac{N}{4} \\ 2\left(1 - \frac{|n|}{N/2}\right)^3, & \frac{N}{4} < |n| \leqslant \frac{N}{2} \end{cases} \quad \text{.......(5)}$$

Tukey window:

The equation of tukey window is:

$$w(n) = \begin{cases} \frac{1}{2}\left[1 + \cos\left(\pi\left(\frac{2n}{\alpha(N-1)} - 1\right)\right)\right] & 0 \leqslant n < \frac{\alpha(N-1)}{2} \\ 1 & \frac{\alpha(N-1)}{2} \leqslant n \leqslant (N-1)(1 - \frac{\alpha}{2}) \\ \frac{1}{2}\left[1 + \cos\left(\pi\left(\frac{2n}{\alpha(N-1)} - \frac{2}{\alpha} + 1\right)\right)\right] & (N-1)(1 - \frac{\alpha}{2}) < n \leqslant (N-1) \end{cases} \quad \text{...(6)}$$

IV ELECTRO CARDIO GRAM:

The electrocardiogram (ECG or EKG) is a diagnostic tool that measures and records the electrical activity of the heart in exquisite detail. Interpretation of these details allows diagnosis of a wide range of heart conditions. These conditions can vary from minor to life threatening.

ECG WAVE:

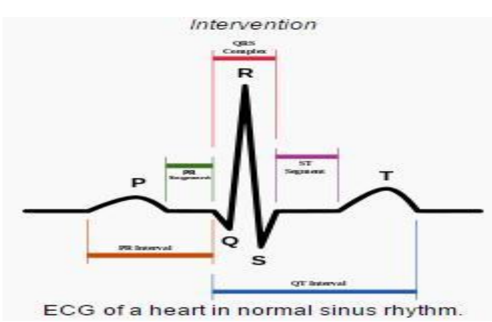

Figure-1 sample of ECG

The electrical cavity results in p, QRS, and T waves that are of different sizes and shapes. When viewed from different leads, these waves can show a wide range of abnormalities of both the electrical conduction system and the muscle tissue of the hearts 4 pumping chambers.

V PROPOSED CONCEPT:

Figure-2

Our ECG signal is applied to the NOTCH filter with 60 Hz where the power line interference is removed. The enhanced ECG signal with the removal of power line interference is collected at the output.

VI PROPOSED FILTER

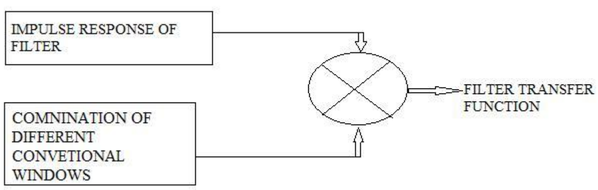

Figure-3

The required filter is designed by multiplying the impulse response of the filter with combination of different conventional windows like Bartlett and hamming,parzen and tukey,Bohman and nuttall window combinations etc . the filter is simulated filter transfer function. Now the noisy ECG [2] signal is allowed through filter for removal of power line interference.

VII BLOCK DIAGRAM OF COMBINED WINDOW TECHNIQUE:

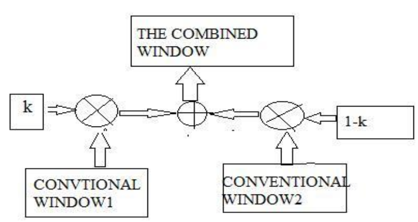

Figure-4

From figure-4 it is being observed that 'k' is constant, for different values k different conventional windows are evaluated and applied to filter impulse response. The response of filter is simulated using mat lab to observe the spectral characteristics improvement. The one good in improvement is applied to ECG filtering

VIII RESPONSE OF ONVENTIONAL WINDOWS:

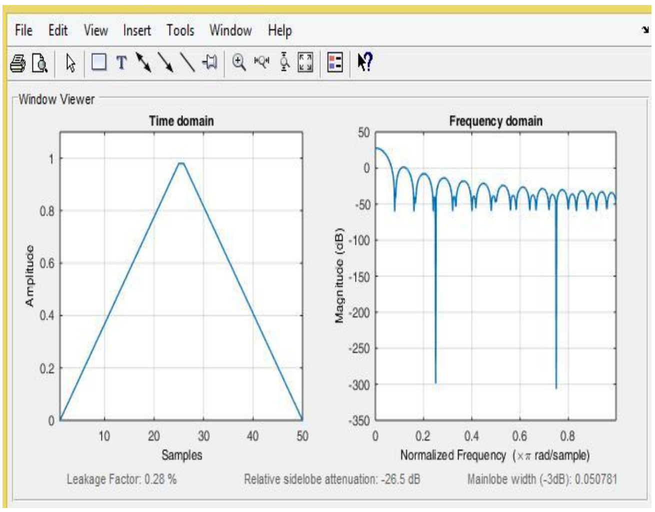

Figure-5 :Response of bartlett window

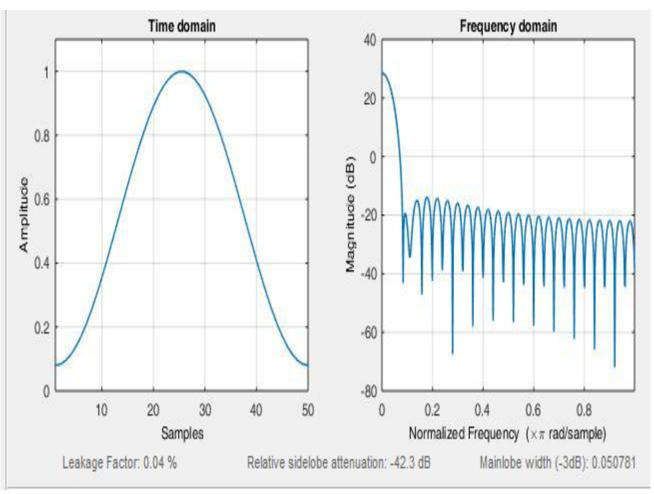

Figure -6: Combination of hamming window

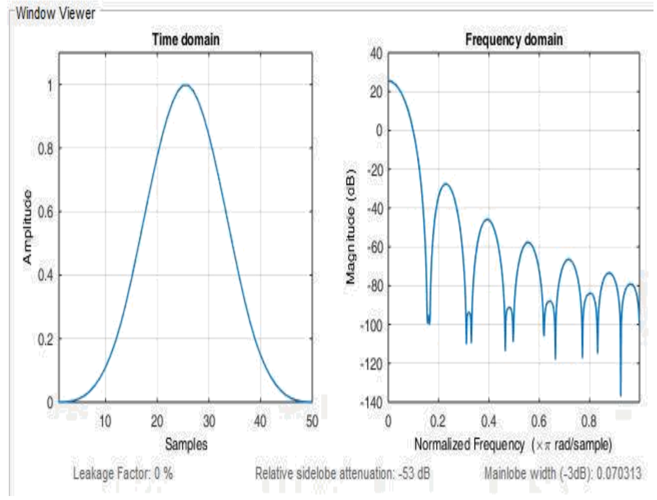

Figure-7: Response of parzen window

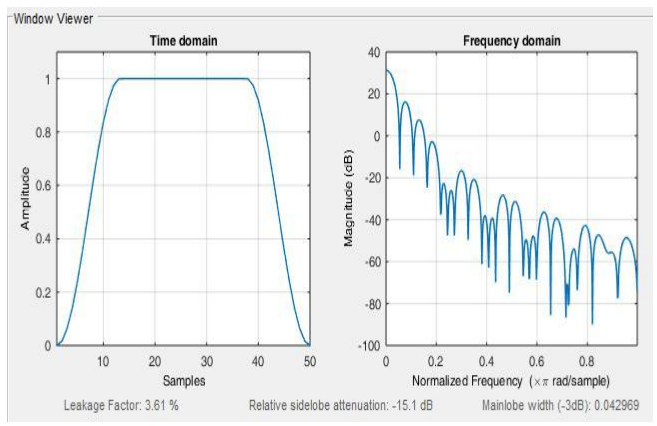

Figure-8 Response of tukey window

IX RESULTS:

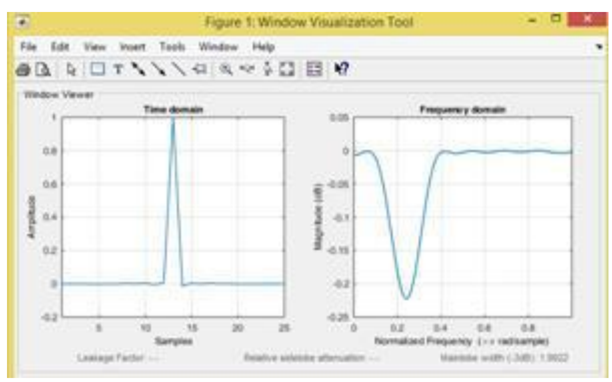

Figure -9 response of notch filter with combined Bartlett and Hamming windows

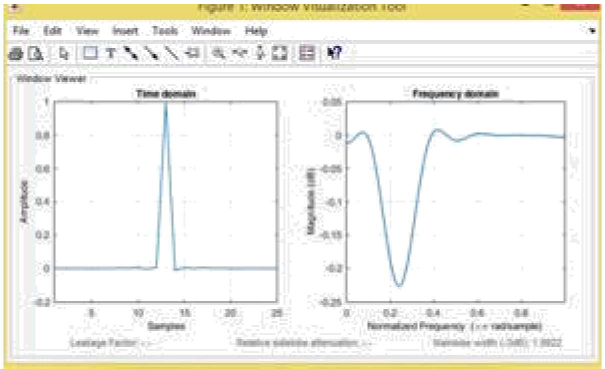

Figure-10 response of notch filter with combined Parzen and Tukey windows

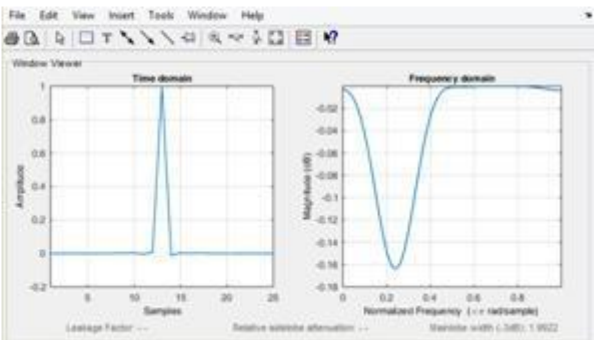

Figure-11 response of notch filter with combined Bohman and Nuttall windows

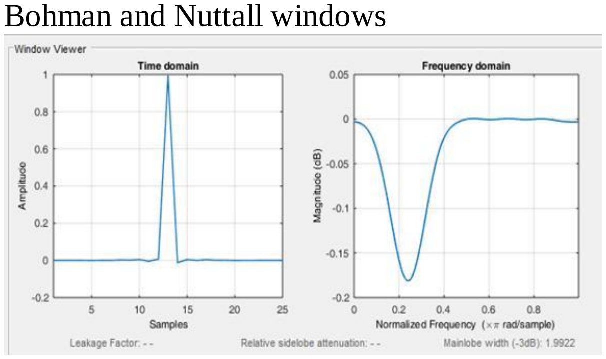

Figure-12 response of notch filter with combined Chebyshev and Gaussian windows

If we observe from figure-9 to figure 12, the response of notch filter for combination Bohman and Nuttall window is superior compared all other combinations as figured above, so the noisy ECG[2] with power line noise is applied Bohmann and nuttalll window combination.

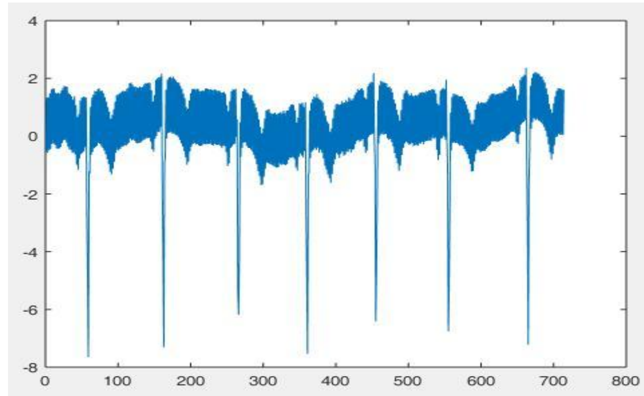

Figure-13: Noisy ECG signal

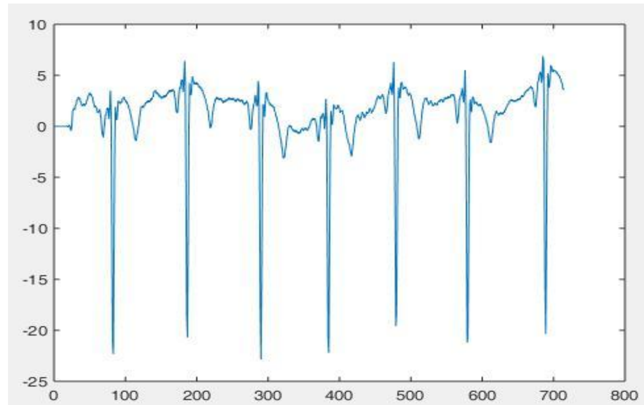

Figure-14: filtered ECG signal

CONCLUSION

In this paper combination techniques of few conventional windows are applied for the design of notch filter. There are many other conventional window techniques which can be applied to design notch filter. Similarly this technique can be applied equally to all the filters for finding the improvement of filter characteristics which help communication engineers to go for a better noise removal.

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